



EVALUATION OF MATHEMATICS E-BOOKS FROM THE STEM STANDPOINT

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***Abstract:** Current research findings imply that e-learning, curricula, educational objectives and e-books should be aligned with the STEM approach to ensure correct implementation of STEM strategies. The use of ICT is recommended to make e-learning compatible with the STEM perspective in education. In this study, it is aimed to evaluate the integration of ICT and STEM perspectives through assessing middle school mathematics e-books. Middle school mathematics e-books approved by the Ministry of Education in Turkey are examined from the STEM standpoint. The findings of the study are discussed, and some recommendations are given.*

Keywords: STEM Education, E-learning, ICT, Mathematics Education

INTRODUCTION

In learning and teaching, e-learning has an important role in improving the quality of education. ICT recommended for the integration of e-learning with the education system. One of the contents that is the source of e-learning with using ICT is e-books. ICT is the abbreviation of information and communication technologies that are indispensable part of today's educational tools. ICT gives opportunities to individuals in order to have appropriate education in accordance with their readiness and needs. In this way, equal chance for everyone might be fulfilled. With ICT individuals can easily access all kinds of information they need about education. Therefore, the use of ICT is important for each individual to have an easy access to information and a wealth of opportunities in education (Yıldız & Usluel 2016). But sometimes the use of ICT can become a goal, not a tool. Therefore, in order to use these

technologies correctly in education and to integrate to the education system, portals are created, and educational contents have been loading. ICT components used in teaching information make this virtual environment suitable for e-learning. Due to the importance of ICT at the centre of education, educators concentrated on specializing in this area (Noskova, Pavlova & Yakovleva 2018).

E-learning offers individuals the opportunity to learn and develop themselves in an environment of their choice and within the appropriate time frame. Consequently, developing e-contents is becoming an important issue. The contents include videos, e-books, educational interactive games, manipulations. These e-contents are being kept up-to-date.

E-books are the most well-known e-contents that provide information in a regular planned way to make learning efficient. Due to cost and easiness of access, e-books save time and are shared by people all over the world so that they make learning diverse and meaningful by enlarging the boundaries of the educational environment. E-books are content related to e-learning. E-books also make it easier to learn about preferred trends and innovations in education at any time and at different locations. The methods and techniques used in learning and teaching are expected to be up-to-date and to meet the needs of individuals, so countries follow the latest trends and approaches in their educational policies. Since e-books have valuable potential in success of these polices, their features need to be assessed.

One of the latest innovative approaches in education is the popular trend called STEM (Science, Technology, Engineering and Mathematics), which aims to make education more productive with a realistic point of view and unites the scientific fields. STEM is an approach that aims to enable individuals of all levels to understand realistic problems and to produce useful, target-oriented solutions to these problems from an interdisciplinary perspective that combines science, technology, engineering and mathematics (Altunel, 2018). STEM is increasingly being adopted and internalized. Because STEM aims to make learning meaningful and to acquire the skills that individuals need in real life with an interdisciplinary understanding, it is getting attention of policy makers. According to Morrison (2006), STEM adopts a more transdisciplinary understanding rather than an interdisciplinary approach due to its integrative structure.

STEM's interdisciplinary structure connects information and makes learning in education focused and meaningful (Smith & Karr-Kidwell, 2000; Fitzallen, 2015). According to Yildırım and Altun (2015), STEM is a type of education that prioritizes quality and effective learning and aims to help students construct knowledge in life-based areas by supporting high-level thinking skills. Teachers' points of view are as important as the needs of students in STEM. According to the STEM report (MEB, 2016), 91.97% of teachers think that it is necessary to adopt the STEM approach which requires questioning in education. According to this report, the majority of the participants (95.54%)

believe that the lesson activities and programs should be integrated according to STEM principles. This situation reveals the importance and necessity of carrying out our research. On the other hand, OECD (2017) stated that the employment of innovative societies adopting this understanding in STEM fields will increase success of students in workplace. This claim is also supported by different researchers (Lantz, 2009; Turner, 2013). Therefore, STEM can be considered an approach that will contribute to development not only in education but also in all areas of society in the long term. As TÜSIAD (2017) stated, in order to produce and implement practical solutions in STEM fields and to respond to the requirements of innovation, it is necessary to have an innovative, inquisitive and technological perspective. From this point of view, the tools at the centre of the training carried out in order to have the necessary skills should be aligned with the mentioned approach. Since e-books have a significant role in the use of ICT, it is important to evaluate the suitability of e-books that support the STEM approach. The principles and skills on which the STEM perspective is based are important. Aybat (2015) lists these principles and skills:

- 1- STEM lessons are based on real life issues and problems.
- 2- STEM lessons guide engineering design steps.
- 3- STEM engages students in an applied inquiry and open-ended research.
- 4- In STEM classes, students take part in a productive teamwork.
- 5- In STEM classes, students apply the math and science content they have learned.
- 6- STEM allows multiple correct answers and sees it as part of learning to reconsider the error.

E-books that are effective in e-learning should be examined not only in terms of STEM principles but also according to the skills that this approach aims to develop. 21st Century Learning Partnership (P21) is an international organization created to bring the education experts, teachers and leaders in the business life together by providing the necessary support in education, while defining the knowledge and skills that individuals need (P21, 2019). These skills have been confirmed by many studies and described by P21 (2018). These skills are defined as Critical Thinking, Communication, Collaboration and Creativity with the 4C abbreviation. Within the framework of this approach, all STEM areas should be carefully considered and combined to develop targeted skills.

Within the STEM fields, mathematics is both compelling and remarkable because of its content and depth (Becker & Park, 2014; Schmidt & Houang, 2007; Fitzallen, 2015). Mathematics forms the basis of this approach since it is a common language that unites STEM fields (Schmidt ve Houang, 2007; Fitzallen, 2015). Therefore, according to Shaughnessy (2013), if mathematics is not considered within STEM education, this approach cannot develop

the language, so interaction between them cannot be achieved and becomes meaningless. When STEM fields are linked to mathematics education, problem solving, and literacy are added to these skills. The question then arises: How can mathematics education align with STEM? Mathematical modelling and realistic problems based on modelling come into prominence in ensuring the compatibility of mathematics education with the STEM perspective. In order to reach the principles and skills determined within this scope, e-learning contents may be arranged within the scope of mathematics education. According to the STEM report (MEB, 2016), necessary ICT materials can be provided to ensure compliance with this approach, interactive board, tablet and EBA portal can be used in accordance with the STEM principles, and most importantly, efforts can be made to bring the e-content included in the EBA portal into STEM. Education Informatics Network (EBA) "Turkey's Social Education Platform" is an online and interactive platform created to raise awareness of sharing information among teachers (Yılmaz, 2013). For this reason, it is important to find means to combine EBA with STEM approach.

In this study, the appropriateness of middle school mathematics e-books was evaluated which are parts of EBA and are an important component for the success of the STEM approach. Although there are many studies related to STEM, the relation of ICT and e-books are not investigated at middle school level.

1. METHOD

1.1 Research Design

In this study, since it was aimed to reveal the status of e-books used in secondary school mathematics education according to the STEM perspective, content analysis was conducted using a qualitative research method. In qualitative research, the process of acquiring data means more than acquiring various data (Creswell 2017). Since the design of the research will be examined in depth and the contents of the e-books will be revealed, a case study is created. Case study is a qualitative research approach in which various data are examined in depth and the existence of themes related to the situation is investigated (Creswell 2007).

In this research, eight e-books which constitute the centre of e-learning in secondary school mathematics education were examined. STEM approaches are taken into consideration while examining those books. Document analysis was implemented.

1.2 Research Sample

Middle school mathematics e-books in Education Informatics Network (EBA) are analysed. These books are approved by the Ministry of National Education. Suitability of these e-books with STEM approaches was assessed. Eight books on four different levels which are sources of e-learning in middle school mathematics were included in the research. Among these books, two of them were for the 5th grade, three of them were for the 6th grade, one of them was for the 7th grade, and two of them were for the 8th grade. These books were examined according to the basic principles of STEM. At the same time, it has been investigated how much it contributes to the development of critical thinking, problem solving, communication, literacy, collaboration, creativity skills required by the 21st century.

1.3 Research Procedures

The findings were compared with the results of STEM reports and workshops conducted within the scope of international studies and attention was paid to similar and different aspects. The findings are compared with different studies (Altunel 2018; Fitzallen 2015; MEB 2016; Aybat 2015; Çakıroğlu & Dedebaş 2018; PWC CEO SURVEY 2016; TÜSİAD 2017; OECD 2017). Within the scope of these principles, instructional contents in e-books were examined. These principles are as follows:

1. Being appropriate to the readiness of students and responding to their needs.
2. Compliance of problem situations with the principle of open-ended research questions.
3. Being consistent with STEM fields.
4. Compliance with engineering-based design, including teamwork, testing and evaluating ideas and approaches of individuals.
5. Reflecting mathematics topics in depth.
6. Being able to be connected to technology and suitable for developing coding and algorithms.

Furthermore, according to P21 (2018), the 21st century skills targeted by STEM education were also examined through sub-themes created by the actions in e-books (e.g. review, search, model, explain) and the main themes obtained by coding them. The frequencies of the themes are grouped and presented in figures.

1.4 Data Analysis

The actions included in the e-books were listed and grouped according to skills. In the next stage, the frequencies of these actions were investigated and analysed at for all grades. The consistency of the findings of the research with the data

obtained was checked by a mathematics education specialist and the reliability of the study was ensured.

2. RESULTS AND DISCUSSION

The e-books for each grade used in middle school mathematics education are explained in detail in terms of compliance with STEM principles. In the e-books, explanations that lead to the development of STEM skills are examined through actions. The frequency of actions taking place in e-books is presented in Table 1.

Table 1.

Data on 21st century STEM skills in e-books.

STEM Skills	Themes	5 th Grade	6 th Grade	7 th Grade	8 th Grade
Critical Thinking-Problem Solving Patterns	“Evaluate”				
	“Discuss”				
	“Apply”	934	1525	422	564
	“Guess”				
Communication-Literacy Patterns	“Solve”				
	“Examine”				
	“Search”	173	331	120	50
	“Explain”				
	“Say”				
Collaboration-Patterns	“Comment”				
	“Create”	229	369	198	119
Creativity patterns	“Produce”				
	“Modelling”	173	120	51	12
	“Design”				

Source: Own work

According to the data in the table which can be interpreted that the actions that lead to critical thinking and problem solving are used more frequently and there are very few actions that improve creativity skills at all levels. In PWC CEO Surveys covering many countries, the skills are examined, and it is seen that the problem-solving skill are given the most important one. According to the results of the global PWC CEO research, the rate of difficulty

and creativity skills is 77% globally (TÜSİAD, 2017). This difficulty rate in Turkey is 84% and assessed as “very hard” and “hard” (TÜSİAD, 2017).

2.1 5th Grade Mathematics E-Books

Two different e-books were examined for this grade. E-books for this grade begin with some informations and questions to measure students' preliminary knowledge and determine their readiness levels. For example, in the field of number learning, individuals were asked about the geometric shapes that make up patterns on the architectural structures they see in daily lives. The fact that these shapes are formed in an order by drawing attention to how they are formed depends on the association with the concept of pattern. In the next step, 2, 5,8,11 are given numbers with equal differences between them and they are asked to form pattern rule by counting back and forth. At the next stage, by giving shape patterns, they are asked to establish a relationship with numbers and find the rule that forms the pattern. At the last stage, there are activities for the development of reverse thinking and modelling skills by asking them to estimate the number of patterns by missing and to form the models that make up this pattern. These activities have been linked to other disciplines. For example, information about the Turkey Basketball Federation is given and some questions related to this information is asked. From a STEM perspective, information should be linked to realistic life situations (Yıldırım 2018). Problems based on mathematical modelling in the books, the data is presented in a complex way. The use of tables or graphs to interpret the problem situation is limited. Reading paragraphs describing the problem situations are kept short. There are two or three questions related these paragraphs. After the information given in the reading paragraph, mathematics related questions are formed by establishing a relationship with mathematics. There are similar questions that guide individuals to think critically: “If Yavuz had calculated 500 instead of 534 boxes and 20 eggs instead of 25, what difference would there be between the actual value and the estimate?”.

“Why is zero added or deleted when practically multiplying or dividing with the number 10 and its multiples?”, “If you are a policy maker for the government, what could be your research problem to start with?”. The expressions mentioned are indicative of problem solving. It leads individuals to think and question with open-ended questions such as “what can be?” and “why is it like this?”.

The number of activities requiring group work among students is limited. One of them is given in Figure 1.

Build Millions!

Materials: Colored cardboard, scissors, jars.

- ✓ *Cut the colored cardboard into small pieces with scissors and write down the numbers 1-10 and add to the jar.*
- ✓ *Each of the six people you selected create a number by pulling a number from the jar.*
- ✓ *Include another person in this group takes number to write to the left of the generated number.*
- ✓ *Is it possible to read the resulting number? How many digits?*

Figure 1. Example of Group Activity from E-Book

Source: Own work

There is no activity involving engineering design applications of the STEM approach. Although reading paragraphs are combined with other science, technology and engineering knowledge from other STEM fields, they are lacking in creating new ideas, modelling, prototyping and guiding new product creation. Determined STEM skills in the e-books are analysed and given in Figure 2.

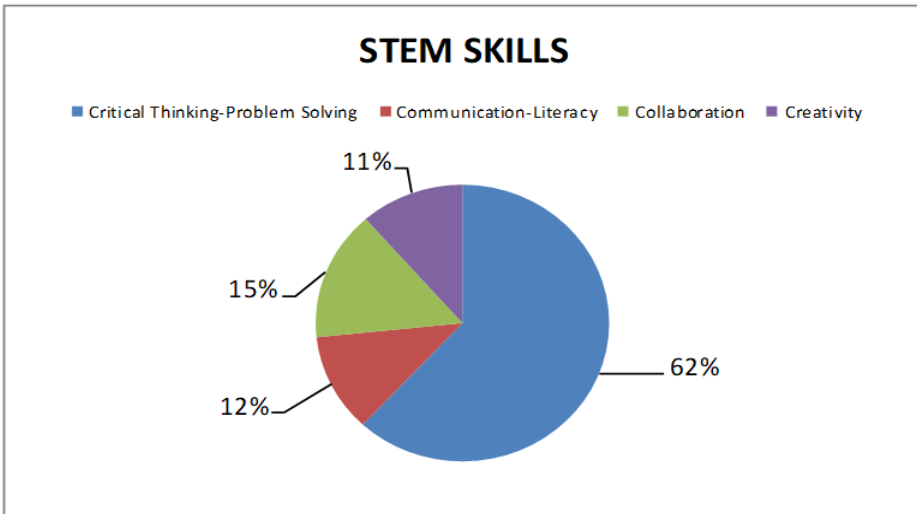


Figure 2. STEM Skills in 5th Grade E-Books

Source: Own work

When e-books are analysed in terms of STEM skills, they use a language that encourages critical thinking and problem solving in order to solve the problems at hand. Different chapters require literacy skills. For example, “Research-Think: Let's research scientists who influence their contributions

to mathematics by doing research on natural numbers”. However, it can be said that e-books for this grade are lacking in planning activities or actions for engineering education from integrated STEM fields.

2.2 6th Grade Mathematics E-Books

Three different e-books were examined for this grade. Although appropriate information is given related to daily life situations, many problem situations are not suitable for the structure of mathematical modelling which enables integration of STEM. For example, the question, “*In hospitals, priority is given to the elderly, children and pregnant women. So, what is the priority of operations in mathematical situations?*”, aims to test readiness of students, but it does not lead to any mathematical modelling. There are some questions that measure reading comprehension. For example, “*Seda wants to make cakes and goes to market. She buys flour, yogurt, milk, eggs and cocoa, chocolate. Which ones will you need when making cakes?*”. Problems encourage students to question their knowledge with open-ended questions with words like “How” and “Why”.

The STEM approach requires to combine and to relate scientific and mathematical content with technology (Bryan, Moore, Johnson & Roehrig 2015; Çakıroğlu & Dedebaş 2018). Findings indicate that there are no activities involving engineering design.

Although one of the three books is more intertwined with science education, there are no questions that measure the information targeted by science. There are mostly questions that ask for use of critical thinking through games (see Figure 3).

GAME

- Seven friends share the cards created according to certain rules that are related to division of numbers.
- The numbers on these cards are added to a bag by writing and read by a person.
- The person who reads all numbers according to the drawn numbers wins the game.

Figure 3. Example of Game from E-Book

Source: Own work

Determined STEM skills in the e-books are analysed and given in Figure 4.

There is a similarity between the 5th and 6th grades as far as the critical thinking is concerned.

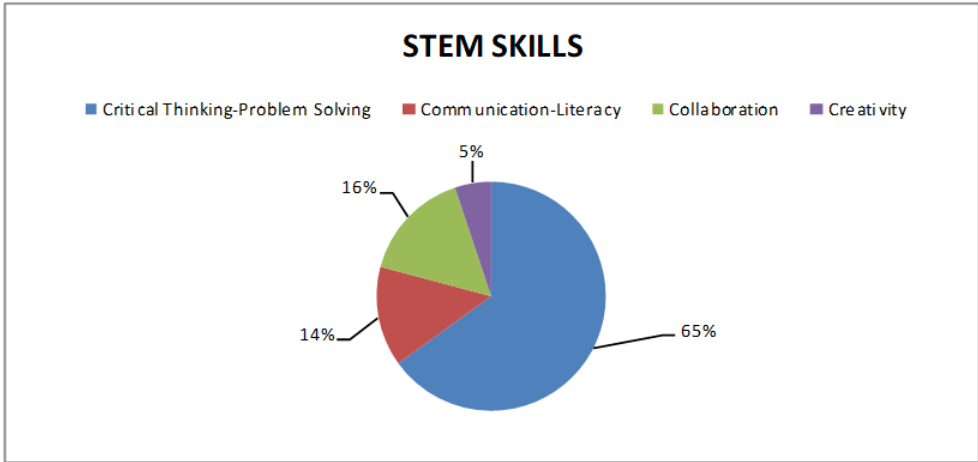


Figure 4. STEM Skills In 6th Grade E-Books

Source: Own work

2.3 7th Grade Mathematics E-Books

One e-book was examined for this grade. Problem situations are associated with real-life situations, but it is not appropriate to produce creative solutions because problems are strictly structured. Mathematical modelling defines daily life situations as the use of mathematics to solve in unstructured problems (Galbraith & Clotworthy, 1990; Ural, 2018). Two examples of these type of questions are as follows: “If Selim's ratio of the amount of money he paid to the potatoes he bought from the market to the mass of the potatoes was $20/4 \text{ ₺ / kg}$, what could be the price of one kg of potatoes?”, “In mine area, 8m excavations were carried out every day and the work was completed in 10 days. At the end of this period, how much depth has been descended?”.

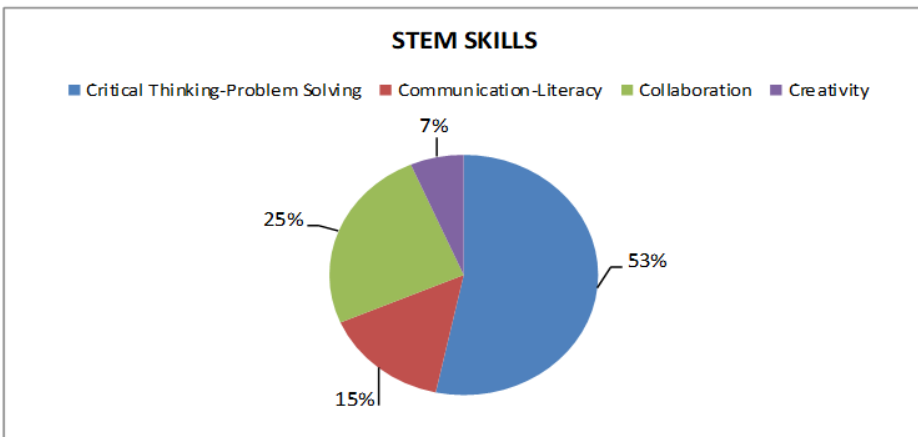


Figure 5. STEM skills in 7th grade e-books

Source: Own work

Immediately after the problem is given, mathematical questions are posed, and answers or solutions are expected. Some activities require teamwork but don't have potential of original solutions.

It is found that there are no connections with science curriculum. There is a limited number of questions that require estimation. The activities are aimed at measuring knowledge and skills on the subject and but not at asking for integration of different subject areas.

Determined STEM skills in the e-books are analysed and given in Figure 5.

Based on the findings, it can be concluded that communication-literacy skills are given more priority if they are compared to other three skills.

2.4 8th Grade Mathematics E-Books

Two different e-books were examined for this grade. Topics starts with realistic problems and these problems support STEM approaches. The contents of these activities are associated with engineering, science, astronomical and medical sciences. In addition, topics are presented with brief notes in order to stimulate prior knowledge of students.

It is found that there are no questions regarding the objectives of science curriculum, whereas there are open-ended which improve critical thinking and problem solving skills questions such as "How" and "Why" related to mathematics (e.g. *"Discuss with your friends how edge and angle information is used in drawing the triangle."*, *"Why is the area of the rectangle formed when the segmented circle shape is joined by opening is equal to the area of the circle? Can you tell that?"*)

Some activities include group work but are not called teamwork. Group work is not intended to create a new product but to create new ideas by discussing. Therefore, it would be appropriate to evaluate these studies within the scope of problem solving. Parts of the "project" in the e-book may be considered more appropriate for modelling and STEM, but there are only two project activities. In these projects, groups of four or five students are required. For the projects, groups are formed to carry out the project such as implement, report and present. Such sections are not suitable for engineering-based design and can be interpreted as lacking the development of creative skills. When students make mistakes, there are no guiding instructions. The aim is to gain knowledge not to integrate different fields. The lack of questions that characterize aiming to measure the objectives of science and other STEM areas is another aspect of these e-books that needs to be developed.

Determined STEM skills in the e-books are analysed and given in Figure 6. In one of the two books examined, there are sections in the Geogebra program that allow you to observe the geometry issues with tasks related to the use of ICT for mathematics teaching. In another technology related section, there are questions

that guide students to research on technology and to think about the relationship between mathematics education and technology. One of these questions is: “*Which number's exponents are used in the coding process in information technologies? Investigate and think*”. Determined STEM skills in the e-books are analysed and given in Figure 6.

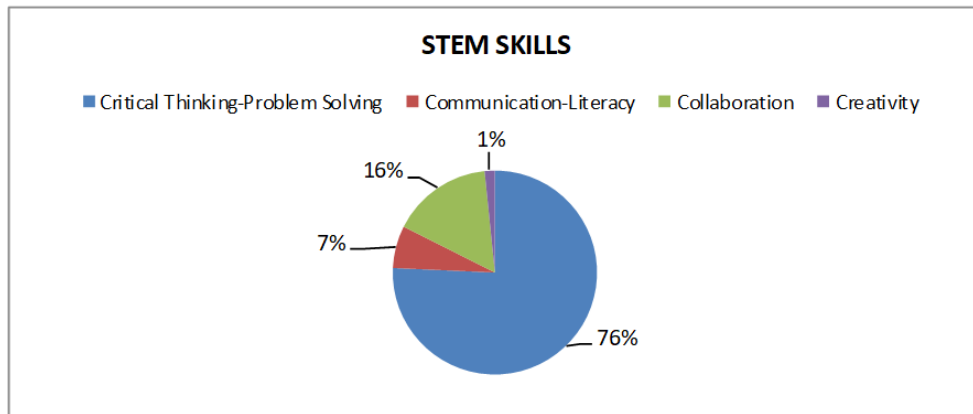


Figure 6. STEM skills in 8th grade e-books

Source: Own work

According to the findings, more action is used to improve the students' critical thinking skills and problem-solving skills in mathematics education. There are few or no activities to improve their creativity.

CONCLUSION

E-books are one of sources of e-learning. E-books have a potential of integrating ICT in the educational settings. E-books should be a real guide in students' knowledge formation through supporting STEM skills required by workforce. It is important to evaluate the relevance of e-books that provide integration between education and ICT to the STEM approach in terms of its role in teaching. The STEM approach has an important place in today's education. This study provides findings that take e-books into consideration from the STEM standpoint. According to the findings, presenting the mathematical contents in accordance with the problem-solving steps is not enough to include the engineering-based approach. Due to the negative attitude towards engineering, students should be given engineering and design education from an early year and on (Yıldırım 2018). The contents of e-books should be rearranged so that new ideas and new solutions developed after problem solving give an opportunity to produce new products. According to Çakıroğlu & Dedebaş (2018), in-class activities and contents applied in teaching may require a different approach when examined from the perspective of STEM. Problem solving

and critical thinking skills were prioritized in the e-books, but they are inadequate for projects involving teamwork and have no content to improve creativity.

Due to its suitability to the STEM approach, mathematical modelling activities should be taken into consideration in mathematics education (Çakıroğlu & Dedebaş, 2018). Although it varies according to grade levels, it is observed that realistic life problems in the e-book for the 6th grade don't support modelling and are lack of relationship with science education or other STEM fields (except mathematics). The need to understand mathematics in daily life situations and to use the information learned in the context of mathematics education in real life will be increasingly effective today (NCTM, 1989; Ural, 2018). The fact that the frequency of 'solve' and 'guess' actions come into prominence in the e-books does not mean that students do not need other skills. Considering that the contents of the e-book are organized according to the curriculum, STEM should be considered the only area by combining the aims of these fields. Placing the reading texts related to STEM fields at the beginning of the topics in e-books does not mean that they are integrating different fields in STEM. Immediately after these reading passages, questions about mathematical operations or mathematical issues leave STEM literacy skills in the background.

RECOMMENDATIONS

Based on the findings and conclusions of the study, following recommendations can be made:

- Both e-books and curricula, methods, techniques and resources used in educational settings should be aligned with STEM.
- Resources should be aimed to gain STEM skills while aligning with the mentioned educational approach and e-content and programs should use a language that is suitable for this purpose and guide and improve the creativity of individuals.
- While integrating the disciplines, the learning targets in curricula should be handled in accordance with the grade level and rearranged in a unifying manner.
- E-books should be examined in different ways, kept up-to-date and made more useful.
- E-books should be made interesting with rich content.
- Activities in e-books which involve collaboration and creativity can be used to acquire the skills required by the 21st century.
- E-books can be improved by reorganizing in order to support engineering designs.

- E-books should inform individuals about technological applications, not just technological knowledge, and include applications in this field.
- This research has been carried out within the scope of mathematics education in Turkey and therefore it can be examined in different areas in different countries.
- STEM portals can be created to shed light on e-learning.

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