

A design model proposal for digital learning platform based on interactive e-books

Emre Karagöz, Bülent Çavaş, L. Özge Güney, Aylin Dizdaroğlu

Abstract

One of the most important factors in the successful results of electronic learning environments is the strengthening of student-content interaction. In creating this interaction structure, it is of great importance that the content used is interesting by the student. The digital transformation in the traditional publishing industry allows the use of electronic books in different formats. The possibilities brought by new technologies allow students to use Interactive Electronic Books (IEB) as an educational material, independent of time and place, through smart devices. The IEB is a program that can be accessed with new digital devices such as computers, tablets, smartphones, and students can use Augmented Reality (AR), 3D animation, video files, etc. It is a technology in which it is integrated with electronic media and technologies. The use of interactive e-books as an educational material can also enable instructors to monitor student activities on these books. This study has been developed to convey the design and development processes of IEB, AR applications in IEB and a simple LMS in which IEB can be integrated, which is thought to contribute to student-content interaction. In the study, first the theoretical approach of the integrated system, then the development processes of LMS, IEB and AR applications are presented within the framework of the System Development Life Cycle (SDLC) approach.

Keywords: Electronic books; student-content interaction; digital learning.

Submitted:
2023 – 05 – 28
Accepted:
2023 – 08 – 11
Published online:
2023 – 09 – 30

© E. Karagöz
© B. Çavaş
© L. Ö. Güney
© A. Dizdaroğlu

This work is
licensed under a
["CC BY 4.0"](#) license.

INTRODUCTION

Since the beginning of the 2000s, breakthroughs have been made to cover a large part of human life thanks to web technology. In such a period, the concepts of e-learning and web-based education have become extremely popular. E-learning is a learning environment that takes place electronically, via computers and mobile devices, and often via the Internet. Today, it is accepted by almost everyone that this education model has many advantages (Arkorful & Abaidoo, 2014; Stecuła & Wolniak, 2022).

The intensive use of education in the digital world has necessitated that the level of interaction of the students with the transferred educational content should be satisfactory. Especially in e-learning environments, digital education content should be prepared in a structure that will contribute to the learning processes in the consciousness of students. When formal education structures are considered, interaction plays an important role in a student's learning, whether face-to-face or online education (Flottemesch, 2000). Moore (1993), in the widely known

Transactional Distance theory, emphasizes the importance of interaction in eliminating the distance between the instructor and the student and for the student to be successful in distance education courses. Moore (1989) mentions three basic types of interaction. These are instructor-student, student-student, and student-content interaction. This theory, which is widely adopted in distance education research, is generally used as a framework to examine the interaction in distance education environments (Çebi, 2023). Berge (2002) states that interaction is at the center of the expectations of instructors and students in education by providing feedback, and to this extent, it is the primary goal of the education process. Bouhnik and Markus (2006) state that choosing the right content form will provide a better learning experience and this interaction will be more valuable for the student. There are two aspects in management of student's educational activity: content of activity choosing and time planning (Bilousova, Kolgatina, & Kolgatin, 2023). If students can control and access learning content, this may make students more willing to participate in online interactive activities and eventually affect students' experiences in the e-learning environment (Luo, Zhang, & Qi, 2017). The use of online technologies in education can take many forms and take on many different roles in an educational setting (Abulibdeh & Syed Hassan, 2011). Nandi, Hamilton, & Harland (2015) stated that student-content interaction can be achieved by reading informational texts, using study guides, watching videos, interacting with computer-based multimedia elements, and completing assignments and projects.

As in every field, with the transfer of printed materials to digital media, electronic books (e-books) have begun to replace printed books. E-Books can be used more efficiently than printed books in terms of storage, sharing, and accessibility (Lee, Guttenberg, & McCrary, 2002). They are designed to be read on compatible and smart devices such as tablets or personal computers. These books are stored as electronic files and are extremely easy to share and purchase. One of the important advantages of electronic books is that these books are comfortable, light, and incredibly comfortable to read, as well as have a huge storage capacity that allows electronic notes and character customization (Hardy, 2016). Notes can be taken, markings can be made, explanations can be added to the e-book, and it is possible to switch between them easily (Önder & Atılgan, 2015). In addition, an audio listening feature can be considered as one of the most important advantages. Electronically produced content can be used with a voice command and can be read with a voice-over, fonts can be enlarged or reduced, font type, page settings, and colors can be changed, and it provides access and ease of use to disadvantaged and disabled individuals (Bozkurt & Bozkaya, 2013a). You can continue your daily work while listening to audio e-books at the same time. As there is no need for cutting trees for e-books, it also has ecological benefits (Önder, 2010). E-books are used to read electronic data in specially developed portable electronic devices (Morgan, 1999). In e-books, it is seen as a great advantage to store many books in electronic devices and to use them on demand. They are more convenient to use than printed books. The desired words can be easily searched, thus saving time (Rukancı & Anameriç, 2003). Many e-book readers find that one of the advantages of e-books is that they allow reading in poor light sources or at night due to the backlight they have (Anuradha & Usha, 2006). E-book means reader/user and e-book interact with each other. Therefore, it can also be defined as a book in which book developers interact

with each other and other users and can be used with many communication channels (Bozkurt & Bozkaya, 2013b).

With the widespread use of interactive e-learning projects, books, which are one of the basic learning materials of the traditional education-teaching process, have become a part of education as electronic books by passing to the digital environment (Kara & Keş, 2016). Some results have been obtained, such as students who study science or engineering, feel better about e-book technology after a long period of use and can overcome minor technical and procedural difficulties more easily, whereas those who are less familiar with technology may feel distressed. Portability is an important advantage for e-books and students are positive that they can carry dozens of e-books without any additional weight (Lam, P., Lam, S. L., Lam, J., & McNaught, 2009). Students can find e-books through search engines (such as Google), the library catalog (OPAC), or the publisher platform. Therefore, the main difference between printed books and e-books is that e-books are visible and accessible to a wider audience. Books are less accessible in the traditional book subscription model. In general, it is seen that people use e-books more than printed books (Van Der Velde & Ernst, 2009). The most used e-book formats today are MOBI, AZW and AZW3, EPUB, IBA, and PDF. Different platforms have different standards for e-books developed with different approaches and methods, and it can be said that there are some disadvantages due to the absence of a single international standard. The presence of some graphical disorders, eye strain, and headaches in the long-term use of e-books, the need for special training for the use of e-books, and copyright confidentiality are some of the disadvantages (Rukancı & Anameriç, 2003). In addition, it can be seen as a disadvantage that there is a need for special labor in the preparation of electronic books and the development of some content.

E-books, which used to be equipped with content only in text format, have gained a more interactive structure with various multimedia tools such as audio, video, 3d and pictures. It can be said that one of the most effective technologies to improve student-content interaction is Augmented Reality. Basically, this technology, which is stated as the display of computer graphics in the real world environment (Silva, Oliveira, & Giraldi, 2003), provides a level of depth by mixing it with the virtualized real world at different rates (Zlatanova, 2002). Students will develop their abilities to use AR technology in laboratory environments where they experience real systems. It also provides motivation for the development of vocational education and for students' experimental and educational research work (Mintii, 2021). This situation can provide support to students' processes of structuring knowledge in their minds.

The teacher needs in special system for management of students' independent learning activity instead of traditional intuitive management of learning process (Kolgatin, Holubnychi, & Kolgatina, 2022). With the help of the programming codes integrated to IEBs, the activities of the users who review the books can be followed and educational progress reports can be obtained.

When the literature is examined, it is seen that there are studies on the use of e-books. Li, Chen, and Yang (2013) examined how the process of developing a conceptual map structure integrated into e-books would be in order to read and navigate e-books more effectively. Ludovico and Mangione (2014) reported the design and implementation stages of an e-book prototype to be used in the education of music students. Choi, Lee, and Kim (2014) examined the HTML5-based interactive

and integrated e-book reader system in their study. Thanks to this system, it is stated that user interaction is strengthened with actions such as 3D modelling and multimedia use. Hori, Ono, Yamaji, Kobayashi, Kita, & Yamada (2016) evaluated a learning platform called “CHILO” that develops e-books with rich media elements. They stated that with this platform, especially developing and residing in rural areas will support equal opportunities in higher education. Ogata et al. (2017) introduced a system called “BookLooper” where electronic books can be read in environments such as web browsers, personal computers and mobile devices. Min (2022) mentioned subsystems for the use and design of a dynamic and interactive e-book system. These subsystems are defined as mechanical, electrical and mathematical subsystems and are covered by a basic main system. Wang (2023) presented an interactive platform that allows e-books and other media tools to be read aloud. He stated that with the sounding of the books, the perception power and interaction level of the reader will increase.

This study is about the introduction of model development steps, considering that the interactive elements in the IEBs will support the student-content interaction. IEBs, in which there is an interaction between the content and the user, refer to the electronic documents of the traditional printed book format, enriched with multimedia tools such as audio, video and made available on computers or portable electronic smart devices. A design model of a non-complex LMS in which IEBs are integrated has been realized. The proposed model is aimed to support educational activities by creating interaction among elements such as users, courses, course tools, and books, and to strengthen the level of interaction between the student and the asynchronous educational content.

METHODOLOGY

Systems Development Life Cycle (SDLC)

In the 1960s, the Systems Development Life Cycle (SDLC) was created for the first time to manage big software projects that were executed on corporate mainframes (Bourgeois, Smith, Wang, & Mortati, 2019). The abbreviation SDLC is used to refer to the lifecycles of either software or systems development. Despite the similarities in their concepts, one relates to the life cycle of software, while the other refers to a system that includes software development (Ruparelia, 2010). The systems development life cycle (SDLC) is a widely used methodology for systems development in various organizations. It encompasses multiple phases that signify the advancement of the systems analysis and design process. The number of distinct phases can range from 3 to approximately 20, and different authors and information systems development firms may employ slightly different life-cycle models. The life cycle can be thought of as a cyclical process that includes planning, analysis, design, implementation and maintenance phases. Once a system has reached the end of its useful life, another project is started that will either produce an upgraded version or completely replace the existing system (Valacich & George, 2017). Any life cycle may initially seem to have a series of phases that are sequentially ordered, however this is not the case. The particular processes and their order are intended to be modified as needed for a project. For instance, the project can go back to a previous phase during any given SDLC phase if necessary (Valacich, George, & Hoffer, 2015).

The proposed model consists of the development stages of three main structures. The first one is the development stages of the learning management system (LMS), the second one is the development stages of the IEBs and the third one is the development stages of the AR Application integrated with the IEBs. While developing the model proposal, attention was paid to the planning, analysis, design, implementation, and maintenance stages of the SDLC (Fig. 1).

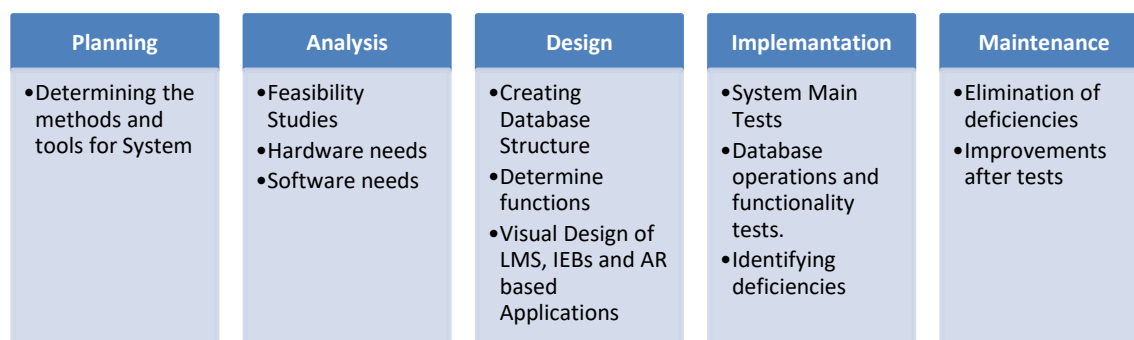


Figure 1. System development life cycle of design model

In the planning phase, the need for the LMS platform to be developed and the user groups were defined. Also, tools and resources were decided upon considering that a platform that will include different types of e-learning tools would contribute to the education processes. It was decided to create the platform to be developed by using web programming tools. At the same time, the tools to be used in the development of IEBs to be integrated into the LMS were also decided. It was decided to use YouTube links, 3D objects, questions, animations, interactive materials, URLs and AR contents as content in IEBs. Table 1 shows the usage purposes of the applications, programs, and programming languages used in the development processes of three different structures.

Table 1. Software, Programming and Markup Languages Used in Developing the Model Proposal

Structure	Software / Programming Lang. / Markup Lang.	Purpose of usage
Learning Management System	MAMP Html5, CSS Php, Javascript MySQL	Local Server Visual Design Preparation of functions and database operations Database structure
IEB (Interactive E-Book)	Adobe InDESIGN, Adobe Illustator Video – Camtasia; Visual Objects – Adobe Illustrator, Adobe Stock, Crello, Canva, Gitbooks; Interactive Contents – Articulate Engine FlipHTML5	Visual content design Create Interactive Content Conversion of prepared printed documents into IEBs
AR Application	AR Objects – Unity, Vuforia, C#, PHP	Create an AR App

In the analysis phase, needs and feasibility analyses were carried out to meet the needs determined during the planning phase. At this stage, it has been determined

whether the functions and the tools and methods to be used in the construction of the system structure to be developed are available. During the design phase, first of all, the basic features and functions of the LMS were developed, followed by the visual and functional designs of the IEB, and finally the design and functional structure of the AR application. In particular, the database structure, the development of the basic functional structure, the design of user authorizations and interfaces were realized at this stage. After the design phase, the tests of the LMS, IEBs and AR applications developed during the implementation phase were carried out. At this stage, especially database operations and the basic functions of the 3 structures were emphasized and deficiencies were determined. In the last stage, some deficiencies identified in the previous stage were eliminated and ideas and methods for strengthening the developed systems were determined. The detailed development processes of these 3 structures to be developed are presented under the following headings.

Learning Management System (LMS) development process

The LMS has been tried to be developed to support the teaching and learning process of instructors and students through elements such as courses, IEBs, questions, and course contents. HTML5 and CSS languages were used in the visual design of the LMS. In the preparation of functions, jQuery library, which is a JavaScript library, and AJAX methods are used extensively. In this way, it has been tried to prevent page refresh problems in data-sending processes with POST and GET methods in general. On the developed system, the resources on the local computer can be loaded, and the use of web links is especially emphasized. In this way, if the platform is used on a real server, it is thought to prevent storage space problems. PHP language was used for database operations. Many web operations for different purposes were carried out with PHP scripts. The “SESSION” feature of PHP language is used extensively in transferring information such as user, course, IEBs, messages, and exams between pages. In this way, data transfer problems have been tried to be avoided incase of redirecting to any other page or running different functions. The development process of the LMS is shown in Fig. 2.

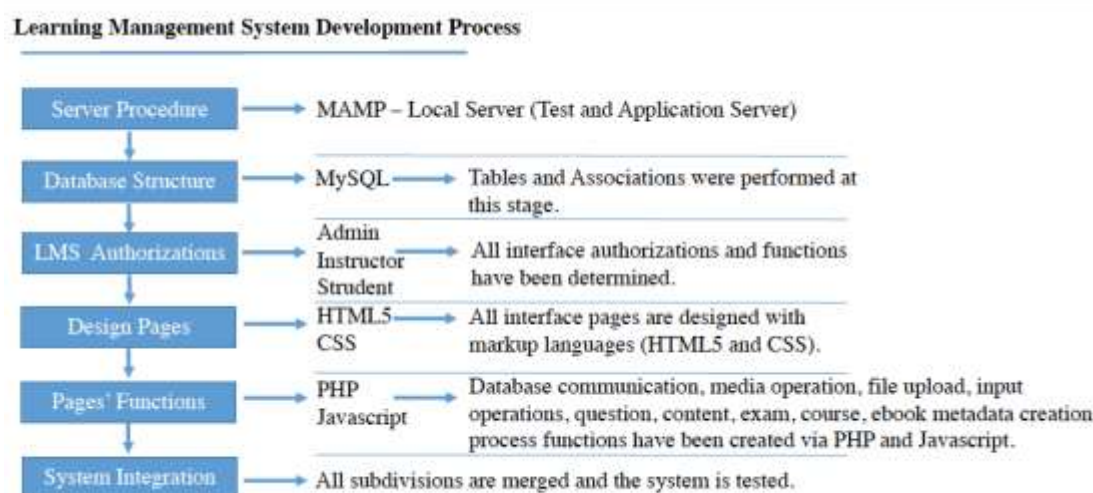


Figure 2. LMS development process

MySQL was used as a database in the developed LMS. The database consists of 17 interrelated tables in total. The connection and other operations between the database and the LMS were carried out with PHP scripts. The table names in English and the field names in the local language of the tables are shown in Fig. 3.



Figure 3. LMS database tables

There are three different user types in the LMS: “administrator”, “student” and “instructor”. Three different interfaces have been created for these three user types. The fields in the interfaces of different user types are shown in Table 2. Username and password information can be created from the administrator interface or the instructor interface.

Table 2. Interfaces of different user types

Admin*	Instructor**	Student
Dashboard	Dashboard	LogIn page
User Account Create	Student Account Create	Home page
Course Creation	Adding Resources	IEBs (Books)
Adding Resources	Adding Announcements	Contents of Course
Adding Announcements	Messages	Resources of
Messages	Quiz Creation	Course
Quiz Creation	Adding Content	Messages
Adding Content	Adding Students	Announcements
Adding Students	Creating IEBs Information	Exams
Creating (IEBs) Information	Adding Objects to IEBs	Reports
Adding Objects to IEBs	Adding a Question to IEBs	
Adding a Question to IEBs	Viewing IEBs objects	
Viewing IEBs objects	Reporting	
Reporting		

* For all courses

** Only for self-instructor courses

In the LMS, information such as the name of the IEB, the category of the IEB (scientific, memoir, story, biography, etc.), the content of the IEB, the creator of the IEB, the course to which the IEB is related, must be filled in the IEB information creation field. Likewise, the picture of the cover page of the IEB (.jpg extension) is uploaded to the system from this area. When this information is entered, the IEB is defined. However, after the IEB format is completed, IEB files are uploaded from the dashboard screen and become available on the system.

The created IEB information is stored in the "project_books" table in the database. In this table, there are fields such as *bookid*, *name*, *category*, *content*, *adding the e-book*, *course of the e-book*, *picture of the e-book*, and *source of the e-book*. Each of the interactive objects in IEBs is created from the "Adding object to IEBs" area. Object extensions added from this area are used in the process of converting to an IEB. For IEB to be followed and monitored within the LMS, it is necessary to determine the elements to be added to the IEB from this field. First of all, the name of the object must be determined from this field. Then, the selection is made for which IEB the related object will be created. In the following process, the content type should be determined. The object type can be determined as a YouTube link, URL, 3D object, local video (from the computer), audio, or image file. After making this choice, the user can complete the object creation process by uploading a file or adding the internet extension link of the existing object from the screen that appears. Afterward, these object metadata are used in the process of integrating into the IEB. The process of adding objects to the IEB is shown in Fig. 4. The information created in this field is stored in the "project_objects" table in the database. In this table, there are *random value*, *object name*, *name of the IEB to which the object is added*, *type of added object*, *source link*, *created link*, and *qrcode name* information. The link field in this section indicates the link to be added to the IEBs.

Generating IEB (Interactive Electronic Book) Metadata

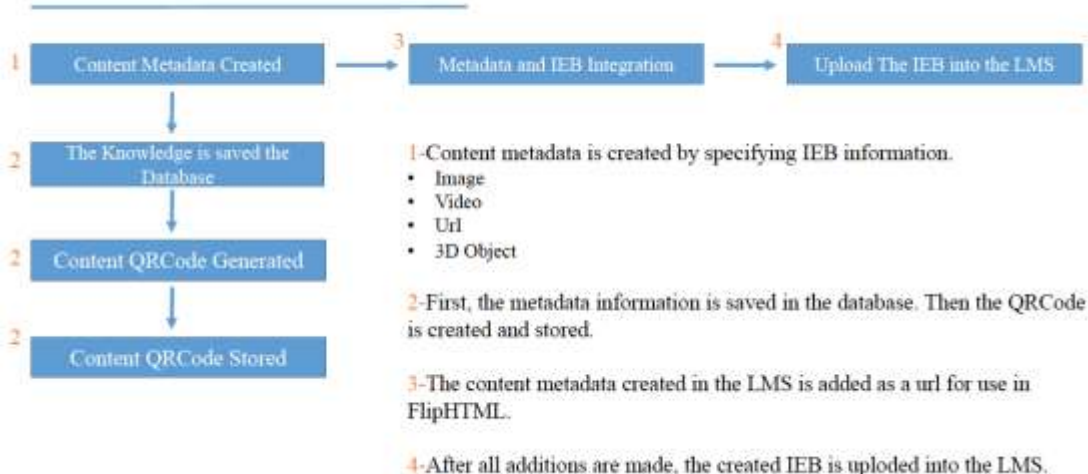


Figure 4. The process of adding objects to an IEB

When an object is created in the LMS, a QR code is also created. In this way, objects in IEBs can also be viewed with QRcode reader applications on users' mobile devices. However, if the objects are created from a local video, audio, or other local document, the system must be running on a real server. Similarly, the questions to be used

in the IEBs are first created in the LMS, and then the question links created are integrated into them. Basically, in the LMS, a process that proceeds in the form of courses in which IEBs will be followed, then IEBs, and then the creation of objects and questions in the IEB is used. Then, student accounts are created by the administrator or instructor through the LMS and assigned to the relevant courses.

By login into the system, students interact with the content through IEBs added in the course they are enrolled in and follow the activities both in the course and the IEB. Instructors, students, or administrators can have information about the activities that the student has done in the process by viewing the student activities in this course as reports.

IEB (Interactive E-Books) development process

There are many web-based digital software such as Crello, Canva, Gitbooks, and design programs such as Adobe InDesign, and Adobe Illustrator, which help to write, design and publish printed e-books. With these programs, ePub or mobi format can be preferred as output, or documents in pdf format can be converted to html format. The process in Fig. 5 was followed in the creation of IEBs.

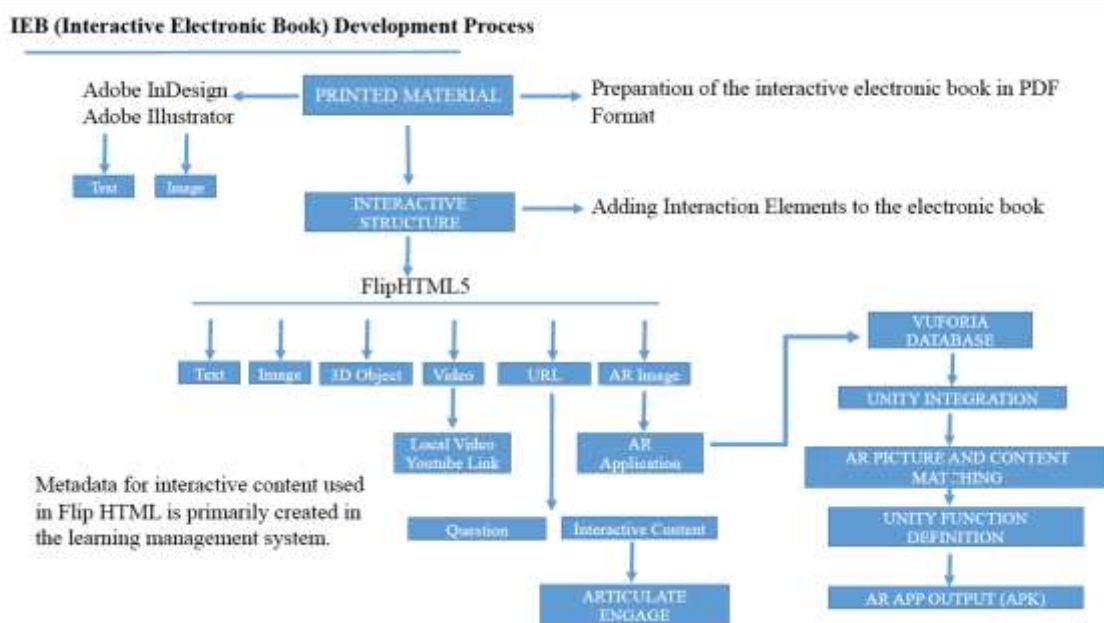


Figure 5. IEBs creation process

To convert the created text into a ready-to-publish IEB, the following steps were followed by using Adobe InDesign, Adobe Illustrator and FlipHTML5 software;

- 1) Document Creation and Layout operations
- 2) Adding Visual and Textual Content
- 3) Creating the Book Cover
- 4) Sharing
- 5) Making Printed Materials Interactive

For “Document Creation and Layout operations”, first, the dimensions to be used in the program are selected and a new document is created with the File > New option. It is possible to choose from different templates compatible with print, web, or mobile environments. The process is shown in Fig. 6.

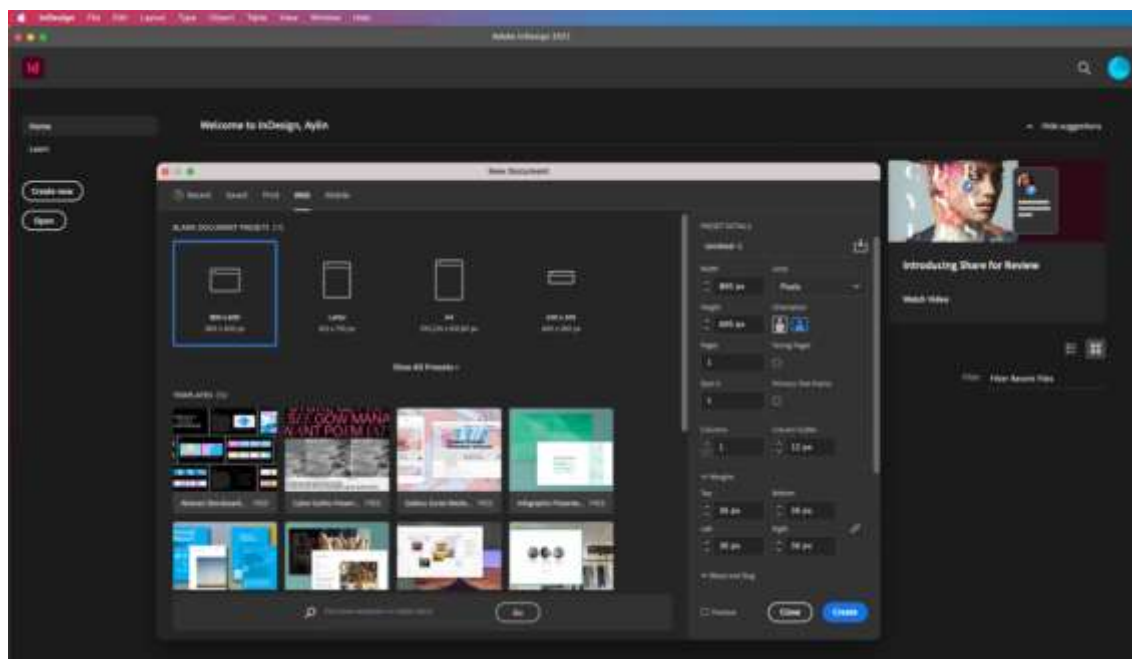


Figure 6. Screenshot of creating and laying documents

To add visual and textual content to the books, the processes of creating text, determining typography, editing the text, defining references, giving styles, and creating tables and graphics are performed respectively. First, a text field is created, the text is added, and rows and columns are created for the text. Afterward, font selection and character spacing were determined for typography. Relevant references are added after aligning with the object in necessary places in the text. Text styles are set. Finally, the tables and graphics were arranged. In the process of creating the front and back covers of the book, remarkable fonts and visuals that provide integrity to the subject were used. Social sharing buttons and a website have been added to the back cover. Feedback was received by sharing with the Publish online feature of the Adobe InDesign program to get the opinions of other project members about the book that was formally ready. In addition, it was shared in pdf format using the Adobe Illustrator program. After the feedback, the book developed within the scope of the project was printed with the Adobe Illustrator program.

After the above-mentioned processes have been carried out, the book is now ready for printing. After this stage, the FlipHTML5 program was used to add digital content to the book and finalize the IEB. Digital contents and questions should be defined as objects and questions in the LMS to integrate the added digital contents with the LMS and to record the extent to which the users follow, use, or engage these digital contents in the IEB. After these definitions, a URL of each digital content is created by the system (LMS), and then these URL addresses are added to printed book documents through the FlipHTML5 program. After all the additions are made, IEB is converted into a form to be uploaded to the LMS with the FlipHTML5 program. What needs to be done now is to log in to the system of the administrator or instructor and upload the IEB folder from the area under the heading "IEB Uploads and Available Books" in the dashboard area in the LMS. Before producing IEBs, the metadata of the IEB must be defined in the LMS. Afterward, objects such as YouTube links, URLs, and animation links to be used in the IEB should be matched with the relevant book, and then the link addresses given by the system to FlipHTML5 should be located.

Students can interact with the content by following these developed IEBs on the LMS, and the instructors can monitor the students' activities on the LMS. All interactive content in the IEBs is primarily stored in the LMS, and in this way, these contents can be used as metadata in many different IEBs.

Augmented reality (AR) application development process

UNITY Platform and Vuforia library were used in the development of the AR mobile application. AR application development steps are shown in Fig. 7.

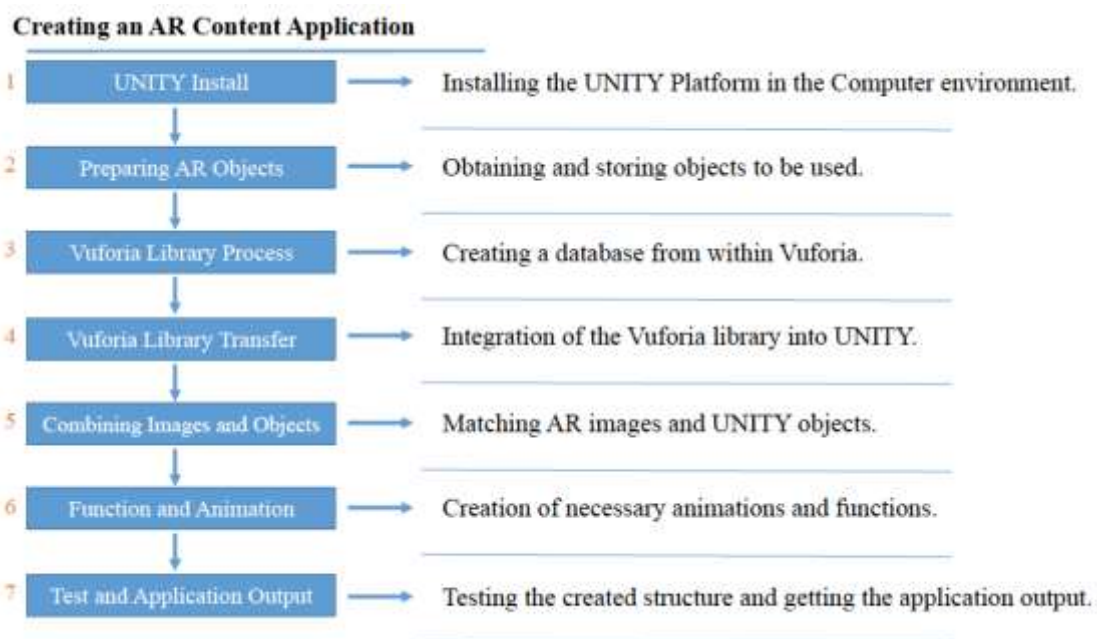


Figure 7. **Augmented reality development stages**

Before starting the development, it is necessary to install the UNITY platform on computers. The UNITY platform can run on computers with both Windows and Mac operating systems. It can be installed via the platform's website or by downloading the desired version from UNITY HUB, which is the facilitating interface of UNITY for installation.

The contents developed within the scope of the proposed model are in the formats of pictures, videos, 3D objects, information texts, and questions. Before proceeding to the programming phase, the object types to be used must be determined and stored in UNITY assets. At this stage, the content types to be used can be created by the user, as well as free-to-use content such as 3D objects, videos, and pictures can be obtained from the Internet.

Vuforia is a library often preferred by AR content developers. The uploaded images are defined by the AR camera provided by the UNITY Vuforia sdk and used to show the contents attached to them to the user. Vuforia creates a database to be transferred to UNITY via an online platform and makes the images and graphics received from the user in this database ready for content matching by the developer. To get Vuforia to work on the UNITY platform, it is necessary to do a few simple operations. First, when logging into UNITY, the Build Settings area must be entered from the File section. After this entry, the Player Settings area is clicked on and the Vuforia Augmented Reality window under XR Settings is activated from the right-

side area. If the Vuforia Augmented Reality option is not displayed in this field, the SDK must be downloaded from Vuforia's "<https://developer.vuforia.com/downloads/sdk>" and activated in UNITY. After these processes are done, AR tools from the GameObject option in UNITY and the Vuforia option in it become ready for use. AR camera, one of the most important of these tools, recognizes AR images and thus programmed operations can be performed.

To create the Vuforia Database, you must first become a member at "<https://developer.vuforia.com/>". If you have been a member before, you can log in with your user account and start the process. After logging in, the "Get Development Key" button is clicked on the License Manager area and a database is created by specifying a database name. When you click on the database name on the next screen, the "License Key" is presented to you for your use. After this stage, the "Target Manager" section is entered from the same page and the images determined for AR are added to the created database. After the adding processes are finished, the database is downloaded by saying "Download Database" and imported into the UNITY program. At this point, there are 2 parts to be added to the UNITY platform. The first of these is the database License Key, and the other is the Database files. When the UNITY platform is open on your computer, when you double-click the downloaded Vuforia database file, the codes are automatically included in the project you have opened. After these processes, the normal camera (Main Camera) should be deleted from the UNITY Platform and AR Camera should be added instead. In this way, the communication of the images in the database and the objects to be added to the UNITY platform is provided.

After the previous steps are completed, the images added to the Vuforia database are now matched with the desired objects. To activate images, an image target is first added to the scene. Then, the relevant database (transferred from Vuforia) and the related image are selected from the database and image target sections in the "Image Target Behaviour" option. Then, when the camera of the mobile device sees that picture, whatever object is desired to be shown, that object is included in the scene. These objects can be made animated by adding an animation feature. However, if desired, objects such as videos can be matched with images as AR content.

At this stage, the functions required by the scenario steps of the developed application are coded and these functions are assigned. In particular, the functions related to the buttons connected to the digital panels in the application are created in script files. In the developed system model, C# language was used in coding operations such as whether objects are on the scene, triggering animations, changing object colors, and determining button functions. Although UNITY allows the use of any editor as a coding environment, especially Microsoft Visual Studio works with complete integrity and makes things very easy. One of the most important issues at this stage is coding the relationship between AR content and the online Database. At this stage, the coding of the student's activities in the application, user approval, data updates, etc. take place.

One of the most active and productive features of the UNITY Platform is animation. Visual animations can be made in animative order for each created or added object, including camera and light. At the same time, many different animation triggers can be coded and assigned as functions to certain buttons on the controller. In general, animations are applied to related objects and sub objects of these objects. Visual

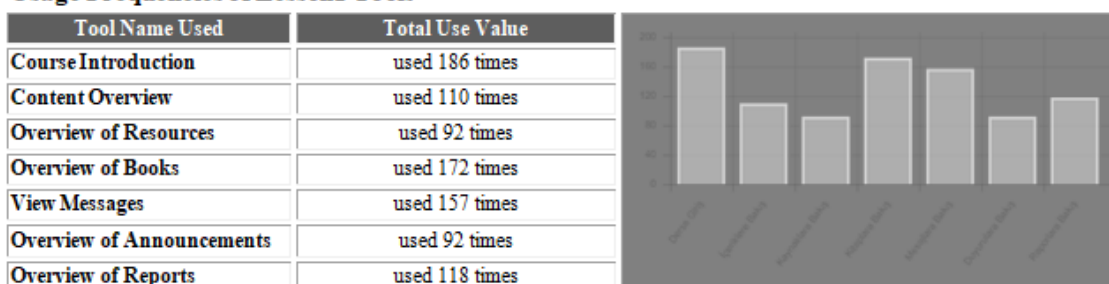
animations can be created by using the transform properties of these objects, especially location, and rotation. In the same way, visuality and cinematic effects can be applied by circulating the camera object from different angles in the scene. In short, animation on the UNITY Platform is one of the most powerful tools that can be used to strengthen visual richness.

After all previous steps have been completed, testing should be done. At this stage, factors such as whether the application works correctly, the results of the functions, the detection of logical contradictions, and whether a problem occurs if the application remains open for a long time are experienced. At this stage, the errors identified should be corrected and the final state of the application should be revealed. After the test phase of the application is completed, the final product output is taken. UNITY can produce output compatible with mobile devices for use in AR-based applications. It can be output in a format that can work on devices with both Android and IOS operating systems.

RESULTS

Within the developed LMS, "Instructor", "Student" and "Administrator" authorizations that will use the platform have been defined, and it has been verified that users can be created, the necessary data has been added to the relevant database table, and that these users can log in to the system and perform the functions defined within their authorization. It has been verified that users with administrator, instructor and student authority can see the total number of users, instructors, students, courses and IEBs via the Dashboard screen, and users with instructor or administrator authority can add the developed IEB files to the LMS via Dashboard screen. It has been verified that users with instructor and administrator authority can create courses, add resources in "URL" or "File" format to the created courses, and create announcements and messages within the course via LMS. In this way, it has been determined that instructor-student communication can be provided through the developed LMS. It has been verified that content in the form of "YouTube", "URL" and "Text" can be added on a section basis from the "Course Contents" field, and new content can be added by deleting these added sections or contents when necessary. It has been verified that the added announcement, message, resource and course content information have been successfully added to the relevant tables in the database. By adding student accounts to the created courses, it has been verified that users with student authorization can view the relevant courses on their own accounts. It has been verified that exams containing multiple choice or short answer questions can be created in the determined course via LMS and these exams become active on the LMS for students at specified times. It has been verified that IEB metadata (book title, book category, book content, book image, course related to the book, etc.) can be created via the LMS. It has been verified that all IEB metadata previously created on the system can be accessed, and editing and deletion can be made when necessary. On the LMS, it has been verified that the "Object" and "Question" plugins, whose metadata will be added to the IEB, can be created, the necessary information is added to the relevant database tables, and the previously created objects and questions can be edited/deleted if necessary. It has been verified that the activities of instructor and student authorized users on the LMS and IEB can be reported. An example report page of a student account displayed on the LMS is shown in Fig. 8.

Usage Frequencies of Lesson1 Tools



Lesson 1 Exam Results

Exam Name	Exam Entry Date	Score from the Exam
Exam1	2022-08-13 09:50:34	85

Usage Frequencies of Book1 Objects

Event Object	Total Usage
Object1	used 4 times
Object2	used 2 times
Object3	used 5 times
Object4	used 5 times
Object5	used 5 times
Object6	used 3 times
Object7	used 0 times
Object8	used 4 times
Object9	used 0 times
Object10	used 3 times
Object11	used 4 times

Book Completion Rate



Total and True/Incorrect Doing Frequencies of Book1 Questions

Question Text	Total Response	Correct Answer	Wrong Answer
Which is a feature of the space shuttle?	1 time	1 time	0 times
Which of the following is a space exploration?	1 time	1 time	0 times
Artificial artifacts used to study celestial bodies	1 time	1 time	0 times
Cartography designed and produced in Türkiye	1 time	1 time	0 times
Which is not a type of telescope?	1 time	1 time	0 times
Which of the following is an observatory?	1 time	1 time	0 times
Which of the following is true about the stars?	1 time	1 time	0 times
Which is not a constellation?	1 time	1 time	0 times

Figure 8. LMS report screen

As a result of the development, it has been seen that all functions thought to be realized by the LMS have been realized successfully. It has been verified that some database table operations, which were determined and corrected during the testing phase of the system, did not recur. Some screenshots of the developed LMS are shown in Fig. 9.

Within the scope of the study, 4 IEBs were developed and their contents were enriched with pictures, text, YouTube videos, 3D objects, URLs, questions and interactive objects. It has been determined that the objects and questions created by the LMS and added to the IEB later on work correctly and it has been verified that

the student activities in the IEB have been recorded and successfully added to the relevant database table. Screenshots of the 4 IEBs are shown in Fig. 10 and the titles of the IEBs and the topics in them are shown in Fig. 11.

It has been determined that interactive content developed within the scope of IEBs has been successfully used by adding it as an object of IEBs. An example of the developed interactive content is shown in Fig. 12.

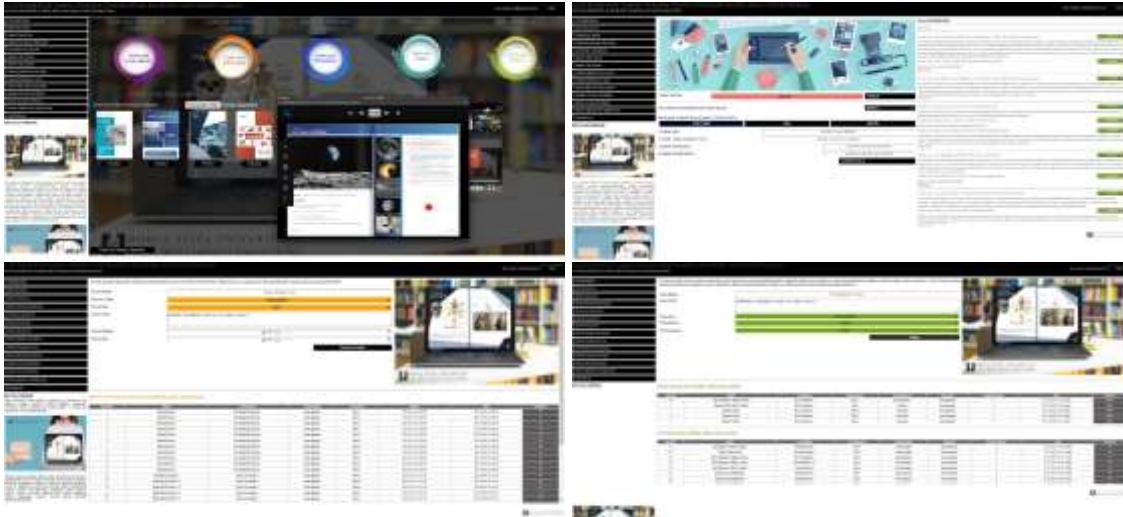


Figure 9. LMS screenshots



Figure 10. IEBs screenshots

Solar System and Beyond	Sun, Earth and Moon	Skeletal and Muscular System	Our Organs
<ul style="list-style-type: none"> •Space and Space Technologies, •Space Probe and Space Telescope •Artificial Satellite and Its Types •Satellites Sent to Space by Turkey •Space Pollution and Space Research •Light Pollution and Observatory •Some Western and Turkish Islamic •Light Year •Galaxies (Sky Island) •Galaxies (Elliptical, Spiral and Irregular Galaxies) •Views on the Formation of the Universe •Important Persons •Types of Nebulae •Space Station •Space Rocket •Space Shuttle •Telescope •Astronomy •Astronomer •Astronaut •Astronomers •Stars •Nebulae •Black Holes •Constellations •Pole Star 	<ul style="list-style-type: none"> •The phases of the moon •Main Phases of the Moon •Intermediate Phases of the Moon •Movements of the Sun •Movements of the Moon •Movements of the World •Structure of the Sun •Layers of the Sun •The Importance of the Sun •Galileo Galilei •Natural Satellite •Features of the Month •Movements of the Moon 	<ul style="list-style-type: none"> •Skeletal System •Bone Tissue •Hard Bone Tissue •Spongy Bone Tissue •Bone Types •Long Bones •Short Bones •Flat Bones •Cartilage •Joints •Muscle Types •Smooth Muscles •Striated Muscles •Heart Muscle 	<ul style="list-style-type: none"> •Eyelash •Ear •Nose •Tongue •Skin •Mouth •Esophagus •Stomach •Small Intestine •Large bowel •Liver •Pancreas •Heart •Veins •Nose •pharynx •larynx •Trachea •Bronchus •Lung •Diaphragm •Kidneys •Ureter •Bladder •Urethra •Penis •Testes •Uterus •Vagina •Brain •Forebrain •Midbrain •Hindbrain •Spinal Cord

Figure 11. The titles of the IEBs and the topics

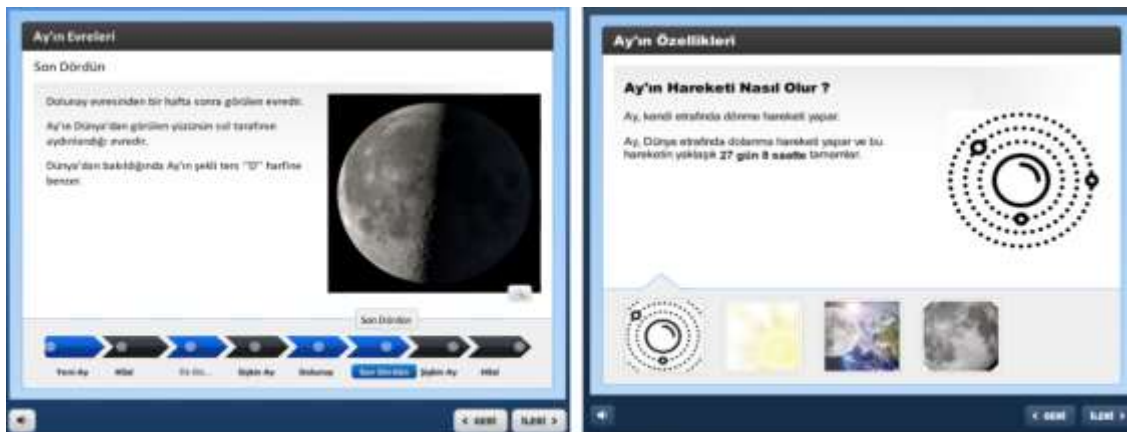


Figure 12. Interactive content prepared for IEBs

Within the scope of the study, 4 different AR applications were developed for 4 IEBs. It has been verified that the content in picture format in the IEB related to these applications successfully displays the content in 3d format with mobile devices. Applications are prepared according to Android Platform. Basically, applications include 3D AR objects as well as video, text and animation type content. Screenshots of these developed applications are shown in Fig. 13.

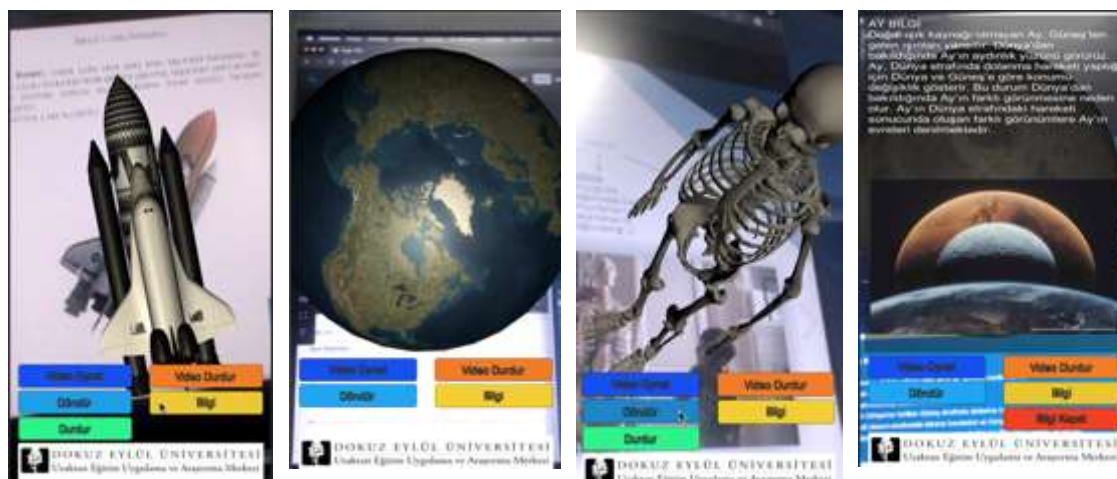


Figure 13. Example of IEB and Mobile AR Application screenshot

CONCLUSION AND PERSPECTIVES FOR FURTHER STUDIES

The aim of the study was to present the design and development processes of IEB, AR applications in IEB and a simple LMS in which IEB can be integrated, which is thought to contribute to student-content interaction.

As a result of many studies, it has been revealed that digitalization in education has gained importance with the developing technology and traditional teaching methods are not fully effective in learning and structuring knowledge. Elaboration and implementation of electronic educational resources and its main component electronic content is an integral part of information and communication technologies development (Tabler, 2019). It is possible to raise students' interest in and desire for different courses, as well as to ensure their active engagement in the teaching and learning process, by using IEBs created based on this condition. It is thought that especially IEBs will make significant contributions to countries in scientific, technological, and socioeconomic fields. Adding interactive resources to an e-book that will give the reader an active role in the reading process will turn the e-book into an educational resource where the learning strategy can be applied (Sarasa-Cabezuelo, 2020). Especially in digital education processes, applications to increase student-content interaction are thought to be valuable. Aydın (2021) revealed that student-content interaction, which is one of Moore's four different types of interaction, has the strongest relationship in terms of online satisfaction and instructors should consider these results in online education. The finding by Er & Er (2016) that student-content interaction has a positive effect on student success supports this result.

The use of IEBs will not only benefit the elimination of environmental problems but will also emerge as an alternative way to solve the financial problems that arise during the printing and distribution processes of printed books. In this context, there is a need for studies to increase the country-wide applicability of IEB design processes by handling them in a much more professional way. Within the scope of Quality Education, which is among the Sustainable Development Goals, it will be possible for everyone, including disadvantaged individuals, to have equal rights in accessing educational resources, through IEBs offered in the electronic environment.

The LMS, which was designed for the purpose of the study was developed in a structure that is not complex, allows IEBs to be integrated into and enables both

instructors and students to monitor their activities in these IEBs and the LMS. In this context, programming languages such as HTML5, Javascript and PHP were preferred in the development of the LMS. Likewise, developers can use languages such as JAVA, C# or PYTHON in common interaction with HTML5. As the database management system MySQL is used, database systems such as ORACLE can also be preferred. Professional learning management systems such as MOODLE or SAKAI can also be used as platforms to enable the use of IEBs with some database and programming operations inside them. IEBs developed within the scope of the study have a structure in which different types of multimedia tools (YouTube links, 3D objects, videos, AR elements, etc.) are integrated.

AR technology, which has been proven in various studies to be advantageous in its use in the field of education, has been prepared in a structure that can work integrated with the developed IEBs. In this study, UNITY game engine and Vuforia AR library were preferred as AR development environment. As a substitute for the UNITY platform, game engines such as UNREAL or GODOT can also be preferred, especially for creating code-based 3D scenarios. Libraries such as ARCORE can be used as an AR library. 3D objects are especially an important element of AR content. Platforms such as 3DMax and Blender can be used to develop these objects. However, as stated, it is possible to access free-to-use 3D objects from websites such as "https://open3dmodel.com/". Besides, if it is desired to develop content on space studies, it is possible to find very rich content on NASA's "https://nasa3d.arc.nasa.gov/models" web address.

In this study, a systematic development and use of IEBs, which are thought to strengthen student-content interaction especially in digital education environments was presented with this study. In parallel with the developing technology, enriching the content structures of these interactive books with popular informatics topics such as artificial intelligence, gamification and virtual reality will undoubtedly increase the attractiveness of these books. In the next phase of the study, a full field test of the developed system will be carried out and necessary revisions will be made in line with the benefits, disadvantages and users' opinions.

ACKNOWLEDGEMENT

This study was supported by Dokuz Eylül University Scientific Research Projects Coordination Unit (DEU, BAP, Project Number: 2019.KB.FEN.008).

REFERENCES

- Abulibdeh, E. S. & Syed Hassan, S. S. (2011). E-learning interactions, information technology self efficacy and student achievement at the University of Sharjah, UAE. *Australasian Journal of Educational Technology*, 27(6), 1014-1025. <https://doi.org/10.14742/ajet.926>.
- Anuradha, K. T. & Usha, H. S. (2006). Use of E-Books in an Academic and Research Environment: A Case Study from the Indian Institute of Science. *Program: electronic library and information systems*, 40(1), 48-62. <http://doi.org/10.1108/00330330610646807>.
- Arkorful, V. & Abaidoo, N. (2014). The Role of e-Learning, the Advantages and Disadvantages of Its Adoption in Higher Education. *International Journal of Education and Research*, 2(12), 397-410. Retrieved from <https://www.ijern.com/December-2014.php>.

- Aydin, B. (2021). Determining the effect of student-content interaction, instructor-student interaction and student-student interaction on online education satisfaction level. In W. B. James, C. Cobanoglu, & M. Cavusoglu (Eds.), *Advances in global education and research* (vol. 4, pp. 1–9). USF M3 Publishing. <https://www.doi.org/10.5038/9781955833042>.
- Berge, Z. L. (2002). Active, Interactive and Reflective Elearning. *The Quarterly Review of Distance Education*, 3(2), 181-190. Retrieved from http://www.acousticlab.org/dots_sample/module4/Berge2002_ActiveInteractiveReflectiveLearning.pdf.
- Bilousova, L., Kolgatina, L., & Kolgatin, O. (2023). How can we encourage students to manage their own learning? *Ukrainian Journal of Educational Studies and Information Technology*, 11(1), 55–65. <https://doi.org/10.32919/uesit.2023.01.05>.
- Bouhnik, D. & Marcus, T. (2006). Interaction in Distance-Learning Courses. *Journal of the American Society for Information Science and Technology*, 57(3), 299-305. <https://doi.org/10.1002/asi.20277>.
- Bourgeois, D. T., Smith, J. L., Wang, S., & Mortati, J. (2019). *Information Systems for Business and Beyond*. Open Textbooks.
- Bozkurt, A. & Bozkaya, M. (2013a, Jan 23-25). Etkileşimli e-kitap: Dünü, bugünü ve yarını [Paper Presentation]. *Akademik Bilişim 2013*, Akdeniz Üniversitesi, Antalya. Retrieved from https://ab.org.tr/ab13/kitap/bozkurt_bozkaya_AB13.pdf.
- Bozkurt, A. & Bozkaya, M. (2013b). Bir Öğrenme Malzemesi Olarak Etkileşimli E-Kitap Hazırlama Adımları. *Eğitimde Politika Analizi*, 2(2), 8-20. Retrieved from <https://dergipark.org.tr/tr/pub/epa/issue/48310/611621>.
- Choi, J., Lee, Y., & Kim, K. (2014). An HTML5-based Interactive E-book Reader. *International Journal of Software Engineering and Its Applications*, 8(2), 67-74.
- Çebi, A. (2023). How e-learning readiness and motivation affect student interactions in distance learning? *Education and Information Technologies*, 28, 2941–2960. <https://doi.org/10.1007/s10639-022-11312-0>.
- Er, N. F. & Er, M. (2016). The effects of student-content interaction on academic performance in distance-learning courses. *International Journal on New Trends in Education and Their Implications*, 7(3), 60-68. Retrieved from http://www.ijonte.org/FileUpload/ks63207/File/07.neslihan_fatma_er.pdf.
- Flottemesch, K. (2000). Building Effective Interaction in Distance Education: A Review of the Literature. *Educational Technology*, 40(3), 46–51. Retrieved from <https://www.jstor.org/stable/44428602>.
- Hardy, J. (2016, Sep 15). A History of eBooks. *History Cooperative*. Retrieved from <https://historycooperative.org/the-history-of-e-books/>.
- Hori, M., Ono, S., Yamaji, K., Kobayashi, S., Kita, T., & Yamada, T. (2016). Developing an E-Book-Based Learning Platform Toward Higher Education for All. In S. Zvacek, M. Restivo, J. Uhomoihi, M. Helfert (Eds.), *Computer Supported Education. CSEDU 2015. Communications in Computer and Information Science* (vol. 583, pp. 618–634). Springer, Cham. https://doi.org/10.1007/978-3-319-29585-5_35.
- Kara, M. & Keş, Y. (2016). Bir Öğrenme Aracı Olarak Etkileşimli E-Kitap. *Art-e Sanat Dergisi*, 9(17), 189-209. Retrieved from <https://dergipark.org.tr/tr/pub/sduarte/issue/24696/261173>.
- Kolgatin, O., Holubnychy, D., & Kolgatina, L. (2022). Systematicity of students' independent work in operating systems classes. *Ukrainian Journal of Educational Studies and Information Technology*, 10(4), 28–40. <https://doi.org/10.32919/uesit.2022.04.03>.

- Lam, P., Lam, S. L., Lam, J., & McNaught, C. (2009). Usability and usefulness of eBooks on PPCs: How students' opinions vary over time. *Australasian Journal of Educational Technology*, 25(1), 30-44. <https://doi.org/10.14742/ajet.1179>.
- Lee, K-H., Guttenberg, H., & McCrary, V. (2002). Standardization aspects of eBook content formats. *Computer Standards & Interfaces*, 24(3), 227-239. [https://doi.org/10.1016/S0920-5489\(02\)00032-6](https://doi.org/10.1016/S0920-5489(02)00032-6).
- Li, L.-Y., Chen, G.-D., & Yang, S.-J. (2013). Construction of cognitive maps to improve e-book reading and navigation. *Computers & Education*, 60(1), 32-39. <https://doi.org/10.1016/j.compedu.2012.07.010>.
- Ludovico, L. A. & Mangione, G. R. (2014). An active e-book to foster self-regulation in music education. *Interactive Technology and Smart Education*, 11(4), 254-269. <https://doi.org/10.1108/ITSE-09-2014-0028>.
- Luo, N., Zhang, M. & Qi, D. (2017). Effects of different interactions on students' sense of community in e-learning environment. *Computers & Education*, 115, 153-160. <https://doi.org/10.1016/j.compedu.2017.08.006>.
- Min, L. (2022). Design and Implementation of Dynamic Interactive E-Book System. In *2022 3rd International Conference on Computer Science and Management Technology (ICCSMT), Shanghai, China* (pp. 64-67). <https://doi.org/10.1109/iccsmt58129.2022.00021>.
- Mintii, M. (2021). The STEM teachers' course "Development of virtual and augmented reality software". *Ukrainian Journal of Educational Studies and Information Technology*, 9(3), 46-57. <https://doi.org/10.32919/uesit.2021.03.04>.
- Morgan, E. L. (1999). Electronic Books and Related Technologies. *Computers in Libraries*, 19(10), 36-39.
- Moore, M. G. (1989). Editorial: Three types of interaction. *American Journal of Distance Education*, 3(2), 1-7. <https://doi.org/10.1080/08923648909526659>.
- Moore, M. G. (1993). Theory of Transactional Distance. In D. Keegan (Ed.), *Theoretical Principles of Distance Education* (pp. 22-29). New York: Routledge.
- Nandi, D., Hamilton, M., & Harland, J. (2015). What factors impact student-content interaction in fully online courses. *Modern Education and Computer Science*, 7(7), 28-35. <https://doi.org/10.5815/ijmeecs.2015.07.04>.
- Ogata, H., Oi, M., Mohri, K., Okubo, F., Shimada, A., Yamada, M., Wang, J., & Hirokawa, S. (2017). Learning Analytics for E-Book-Based Educational Big Data in Higher Education. In H. Yasuura, C. M. Kyung, Y. Liu, & Y. L. Lin (Eds.), *Smart Sensors at the IoT Frontier* (pp. 327-350). Springer, Cham. https://doi.org/10.1007/978-3-319-55345-0_13.
- Önder, I. (2010). *Elektronik kitap olgusu ve Türkiye'de durum* (Unpublished master's dissertation). Ankara Üniversitesi. Retrieved from https://dspace.ankara.edu.tr/xmlui/bitstream/handle/20.500.12575/30038/Isik_onder_elektronik%2520kitap%2520olgusu%2520ve%2520turkiyede%2520durum.pdf?sequence=1.
- Önder, I. & Atılğan, D. (2015). Elektronik Kitap ve Gelişim Süreci. In U. Al & Z. Taşkın (Eds.), *Prof. Dr. İrfan Çakın'a armağan* (pp. 175-183). Ankara: Hacettepe Üniversitesi.
- Rukancı, F. & Anameriç, H. (2003). E Kitap Teknolojisi ve Kullanımı. *Türk Kütüphaneciliği*, 17(2), 147-166. Retrieved from <http://www.tk.org.tr/index.php/TK/article/view/218/213>.
- Ruparelia, N. B. (2010). Software development lifecycle models. *ACM SIGSOFT Software Engineering Notes*, 35(3), 8-13. <https://doi.org/10.1145/1764810.1764814>.
- Sarasa-Cabezuelo, A. (2020). A Model for Creating Interactive eBooks for eLearning. *Future Internet*, 12(12), 223. <http://doi.org/10.3390/fi12120223>.

-
- Silva, R., Oliveira, J. C., & Giraldo, G. A. (2003). Introduction to augmented reality. *National Laboratory for Scientific Computation in Brazil*. Retrieved from <https://www.lncc.br/~jauvane/papers/RelatorioTecnicoLNCC-2503.pdf>.
- Stecula, K. & Wolniak, R. (2022). Advantages and Disadvantages of E-Learning Innovations during COVID-19 Pandemic in Higher Education in Poland. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(3), 159. <https://doi.org/10.3390/joitmc8030159>.
- Tabler, T. (2019). Using of interactive content in the electronic educational resources in the educational process of a modern school. *Ukrainian Journal of Educational Studies and Information Technology*, 7(1), 54–66. <https://doi.org/10.32919/uesit.2019.01.05>.
- Van der Velde, W. & Ernst, O. (2009). The future of eBooks? Will print disappear? An end-user perspective". *Library Hi Tech*, 27(4), 570-583. <https://doi.org/10.1108/07378830911007673>.
- Valacich, J. S. & George, J. F. (2017). *Modern systems analysis and design* (8th ed.). Boston: Pearson.
- Valacich, J. S., George, J. F., & Hoffer, J. (2015). *Essentials of Systems Analysis and Design, Global Edition*. Pearson Education UK.
- Wang, Z. (2023). Construction of Interactive Platform for Audio Reading From the Perspective of All Media Based on Vue Framework. In *2023 IEEE 12th International Conference on Communication Systems and Network Technologies (CSNT)*, Bhopal, India (pp. 602-606). <https://doi.org/10.1109/CSNT57126.2023.10134717>.
- Zlatanova, S. 2002. *Augmented reality technology*, GIST Report, TU Delft.

About the authors:

- Emre Karagöz**, Distance Education Application and Research Center, Dokuz Eylul University, Izmir, Turkey. ORCID: <https://orcid.org/0000-0002-4887-8168>. emre.karagoz@deu.edu.tr
- Bülent Çavaş**, Buca Faculty of Education, Dokuz Eylul University, Izmir, Turkey. ORCID: <https://orcid.org/0000-0003-4278-8783>. bulent.cavas@deu.edu.tr
- L. Özge Güney**, Distance Education Application and Research Center, Dokuz Eylul University, Izmir, Turkey. ORCID: <https://orcid.org/0000-0003-1717-5379>. lozge.oral@deu.edu.tr
- Aylin Dizdaroglu**, Distance Education Application and Research Center, Dokuz Eylul University, Izmir, Turkey. ORCID: <https://orcid.org/0000-0003-3075-1924>. aylin.dizdaroglu@deu.edu.tr