Developing an augmented reality textbook for Bachelor and Master programmes "Design, technology and management of the fashion industry"

Tanya Borisova, Vanya Stoykova, Zlatina Kazlacheva, and Krum Videnov
Trakia University of Stara Zagora,
Faculty of Technics and Technologies, Yambol, Bulgaria
38 Graf Ignatiev str., 8602, Yambol, Bulgaria
e-mail: tanya.p.ivanova@gmail.com

Abstract. Augmented reality is a modern technology that can be used in universities, providing conditions for learning in an interactive virtual environment and achieving a high level of visualization through the means preferred by today's digital students. AR creates conditions for easier and more accessible studying of the taught material, acquiring more knowledge in a short time, developing creative thinking of the students. AR application can increase the quality of education. In the engineering disciplines is of great importance to view the studied objects from all sides. Instead of multiple 2D images, in the textbooks could be used markers for generating AR with an interactive 3D models, providing full visualization. Students can use their mobile devices for 3D visualization of the considered objects, which makes AR easily accessible. The aim of the research is to develop topics from a textbook on "Design and modelling of women's dresses in different silhouettes" for students majoring in "Design, technology and management of the fashion industry" using augmented reality (AR).

1. Introduction
Over the last decade, access to and perception of information has changed at an extremely rapid pace, which in turn has changed the teaching and learning process in the education system. Schools and universities are not the only source of knowledge and skills in today's open information society with rapidly evolving online resources, social networks and more. [1]. This creates a huge amount of available information with an unclear degree of truth. In the context of the rapidly evolving modern technological and information society, the role of accredited information is more important than ever. The speed of human knowledge changing turns familiar and traditional teaching methods and education supplies into irrelevant information sources. There are a number of methods for optimizing training materials - development of digital ones that are easier to maintain and change the content, in accordance with the latest developments in the scientific community.

The application in the education system of learning content using augmented reality and 3D visualization technologies, is considered as one of the most effective tools in solving the problems of the education system related to the learning style of today's students. Teachers in the higher schools and in the universities should take into consideration that “Virtual (V) generation” is to be taught - with a preferred learning style - autonomously, “24/7”, remotely, everywhere, by using interactive technologies [1].
This paper examines the development of topics in a textbook for students majoring in "Design, Technology and Management of the Fashion Industry" at the Faculty of Technics and Technology with the application of augmented reality (AR).

2. Augmented reality and its application in teaching at universities

2.1. Augmented reality. Applications.
Augmented reality is a technology that "enhance" the real world around us. The technology superimposes virtual objects on the real image, most often, but not only, on the screen of a mobile device. Augmented reality is the integration of digital information into the user's environment in real time.

AR can be displayed on various devices: screens, glasses, mobile phones, head-mounted displays. It includes technologies such as simultaneous localization and mapping (SLAM), depth tracking (sensory data that calculates the distance to objects), and the following components: cameras, sensors, projection, and reflection. Cameras and sensors collect data about user interactions and send them for processing. Device cameras scan the surroundings, and with this information, the device locates physical objects and generates 3D models. They can be special cameras for work, as in Microsoft HoloLens, or ordinary cameras on smartphones to take photos and videos.

There are different ways to enrich the reality around us with AR, and each has certain advantages and disadvantages. Modern augmented reality can be divided into two main categories: marker-based AR and markerless AR.

2.1.1. Marker-based augmented reality
Markers are specific visual patterns that cameras can easily recognize and process. The markers are visually unique from the environment around them. The software, usually in the form of an application, allows users to scan bookmarks with a device using its camera. Almost any visualization can be used as a marker - from a printed QR code to special characters. In some cases, the AR device also calculates the position and orientation of a content positioning tag. In this way, the tag initiates digital animations that users can see (Figure 1).

Scanning a tag triggers an augmented reality experience, whether object, text, or animation, to appear on the device. Tracking plays an important role in this type of augmented reality because it allows you to move the marker or camera slightly without distorting or interaping the added effects.

2.1.2. Markerless augmented reality
This AR style is more versatile than marker-based augmented reality - it doesn't need an image to unfold. Instead, it relies on positional information gathered from the device's camera, GPS, digital compass and accelerometer. They collect data that builds an understanding of 3D space through the process of simultaneous localization and mapping. SLAM puts the content directly in the user's field of vision and "sticks" it to the environment.
Although more complex, the markerless method is becoming the preferred choice for high-end AR developers. Apple's ARKit and Google's ARCore are a set of software development tools that have given a big boost to the development of markerless augmented reality. Figure 2 shows the Apple Measure application (developed in ARKit), which works without tags.

![Figure 2. Point-to-point surface measurement with Apple Measure.](image)

### 2.1.3. Devices for augmented reality
For processing, AR devices have requirements such as sensors, cameras, accelerometer, gyroscope, digital compass, GPS, processor, display and more. Devices suitable for augmented reality fall into the following categories:
- Mobile devices (smartphones and tablets) - the most affordable and suitable for mobile applications for AR, ranging from games and entertainment to business analysis, sports and social networks.
- Special devices for AR, designed primarily for augmented reality experience. One example is head-mounted displays (HUDs), which send data to a transparent display directly in the user's view. Originally introduced for the training of pilots of military fighters, such devices now have applications in aviation, automotive, manufacturing, sports and more.
- Glasses for AR (smart glasses) - Microsoft HoloLens 2 Advanced - glasses for mixed reality, which are currently not available on the mass market, Vuzix blade glasses and more. These devices can show notifications from smartphone, support workers on assembly lines to access content without using hands, etc.
- Contact lenses for AR (smart lenses), which take augmented reality to the next level. Manufacturers such as Samsung and Sony have announced the development of AR lenses. Samsung is working on lenses to be an accessory for smartphones, while Sony is designing contact lenses as separate AR devices (with features such as taking pictures or data storage).
- Virtual retina displays (VRD), creating images by projecting laser light into the human eye. Aimed at bright images with high contrast and high resolution.

### 2.1.4. Possible applications of AR
Augmented reality can complement everyday activities in a variety of ways. For example, one of the most popular AR applications are games. Games with AR provide much better experience for players, some even promote a more active lifestyle (PokemonGo, Ingress).

In Retail AR can contribute to better engagement and customer retention, as well as brand awareness and more sales. Some features can also help customers shop smarter - providing product data with 3D models of any size or color. Real estate can also take advantage of augmented reality through interactive 3D tours of apartments and houses.

The U.S. military is using AR to create digitally enhanced military training missions. The technology, called "Tactical Augmented Reality" (TAR), is essentially an eyepiece that helps soldiers find their exact positions, as well as the location of other people - both friends and enemies (Figure 3).
Figure 3. AR image of the TAR system used by the US military.

In October 2018, Mural Arts Philadelphia created a giant interactive outdoor mural. Aiming their smartphones at parts of the mural, viewers can observe various holograms and listen to appropriate music for complete immersion in art.

Healthcare professionals can also rely on AR. Tissue Analytics has created an application that helps doctors and nurses to quickly identify specific types of wounds by use their phones for faster diagnosis and more effective care.

There is no sphere of life in which augmented reality is not present and develops its potential.

2.2. Application of augmented reality in the learning process

Despite the growing use of augmented reality in many areas of life, it is not widely used in the Bulgarian educational system. The place of AR in higher education is determined by the advantages of this technology in the process of teaching.

Augmented reality offers accessible learning materials - anytime, anywhere. AR has the potential to even replace paper textbooks, physical models and all kinds of printed training materials. The result of more affordable materials, both in terms of cost and mobility, is more accessible, interactive and flexible education.

Among the advantages of AR is higher engagement and interest of students. Augmented reality applications offer opportunities to diversify and break monotonous hours. Interactive lessons, in which all learners participate simultaneously in the learning process, help to improve teamwork skills and teach students to cooperate. AR in education helps students achieve better results through visualization and full immersion in the topic. Thus, instead of getting acquainted with the theoretical part, students can see it with their own eyes, in action, which makes the acquisition of learning content a faster and more efficient process.

Augmented reality has a great advantage in practical training. In addition to theoretical training, vocational training can benefit significantly from the use of AR. Examples are applications that enable medical students to practice operations without endangering human life or acquiring skills to handle complex automated production systems without risking lives and high-value equipment.

Augmented reality is universally applicable to any level of education and training, it is not limited to certain disciplines or areas of higher education.

AR applications, used already in classrooms, help the teacher to explain an object to provide visualization of material and help students test their knowledge in practice. Using augmented reality, students can study outside the classrooms. Moreover, online or distance learning can be made easier and more effective with the help of AR learning materials.

Modly is a language learning application that offers an AR-based virtual teacher that helps users practice their skills as if they were in a real-life setting.
Google Translate now uses augmented reality to provide instant translations of any text targeted by the smartphone's camera. It allows learning more than 30 foreign languages (Figure 4).

![Figure 4](image)

**Figure 4.** Instant translation with Google Translate of text on a sign from Bulgarian to English.

Dinosaur 4D + is an AR application that works with a set of flash cards. Users scan flash cards to see 3D dinosaurs. With Dinosaur 4D +, students see dinosaurs in action, can look at them from all sides, zoom in on them. The app also gives information about each dinosaur.

Human Anatomy Atlas is an application that allows students to study the human body to understand how it works. The application shows 3D models of the body and allows students to interact with them (Figure 5). The Human Anatomy Atlas provides more than 10,000 anatomical models and information in several languages. The app also has a test section to help students test and improve their knowledge.

![Figure 5](image)

**Figure 5.** Human Anatomy Atlas 2021: Complete 3D Human Body.

In [5] are presented studies on the impact of AR systems on the process of acquiring knowledge and skills and their opportunities to improve the quality of education. Looking at various studies in the field, the authors report that with the help of AR, learners make sense of more information in less time.

An example of the application of AR in the education of engineering students in our country is presented in [3]. An experimental textbook with the use of augmented reality for students in the field of Mechanical Engineering has been developed at the University of Ruse.

2.3. *Use of augmented reality in the training of students majoring in "Design, technology and management of the fashion industry"*

Training in fashion design is closely linked to the visualization of educational content. Through the application of innovative technologies in higher education, in particular - specialty "Design, technology
and management of the fashion industry”, a better quality of education is achieved through interactivity, flexibility and process dynamics [2].

The authors support the thesis that the use of AR in fashion design education is the most appropriate technology for certain topics in textbooks and manuals for fashion illustration, design theory, fashion design and model making. For the purposes of the DR, the teaching aids are supplemented with augmented reality markers, and the teaching material is additionally visualized with 3D models that students can see on the displays of their mobile devices.

Augmented reality is extremely useful for the training of students majoring in "Design, Technology and Management of the Fashion Industry" (DTMFI) from FTT-Yambol, especially in disciplines in the field of clothing design. Through augmented reality, students get the opportunity to illustrate the material taught with three-dimensional realistic models. It creates an opportunity to introduce innovative interactive approaches in teaching, to mix traditional teaching aids and methods (from teaching aids on paper) with modern technical means and technologies [1].

The application of innovative educational and creative technologies in the teaching of fashion design, and in particular AR, provide easier and more accessible assimilation of the study material, acquisition of a larger set of knowledge in a short time, development of creative and visual thinking and design skills in students. Their use, in general, leads to an increase in the quality of training in this specialty.

3. Applications for augmented reality and for 3d modeling. Selection of software for project implementation.

When creating a mobile AR applications or adding AR elements to existing software, the most common SDKs are those by Apple and Google. ARKit (Apple) and ARCore (Google) are a convenience for developers, and creating mobile applications for AR no longer requires a deeply specialized set of skills. Next to them, as part of the most preferred platforms for developing AR applications are Vuforia and AR Foundation [8].

The AR development industry is highly competitive and large technology companies are investing in their own AR software development kits (SDKs). However, ARKit, ARCore, Vuforia and AR Foundation are the four most preferred AR SDKs among developers [7].

ARKit is a set of tools created by Apple to help developers create augmented reality applications for iOS devices. ARKit can track, AR anchors, recognize planes and estimate light. Supports versions of iOS 11.0 or later. ARKit also offers 3D object scanning and world tracking, features that ARCore does not currently provide on Google. The latest version offers occlusion, motion capture, face tracking and joint sessions. Occlusion and motion capture are limited to iOS devices with the A12 chip or later (iPhone Xr or later).

ARCore has the ability to track traffic, "understand" the environment, ie. determines the size and location of vertical, horizontal and angular surfaces and estimates the light through the phone's camera. The platform supports devices with Android 7.0 or later and iOS 11.0 or later. ARCore distinguishes position and orientation relative to a particular plane, can track the position of an object.

Vuforia has developed a wide range of DR tools such as Vuforia Engine and Vuforia Studio. Vuforia Studio is a stand-alone drag-and-drop application used to develop AR that does not require extensive programming or design skills. Vuforia Engine is mainly used with Unity3D. Vuforia can work on both iOS and Android and even older iPhone models with which ARKit is not compatible. Both images and shapes can act as markers for AR. Several programming languages are supported: C++, Java, Objective-C and .NET through the Unity3D extension.

AR Foundation is a package that allows you to create AR applications for multiple platforms in Unity3D. This tool includes both ARKit and ARCore XR packages, which means you can develop your AR application in Unity3D and then build it for either Android or iOS. An advantage of the AR Foundation is that it can use ARCore and ARKit functions in the same project. This means that when developing an iOS DR application that uses the 3D object tracking feature, the AR Foundation makes it possible to add special "hooks" to the object. Thus, when the same application is developed for Android,
it will support the same features as the one developed for iOS, although the 3D object tracking feature is not available for ARCore.

Augment is an AR application that focuses on 3D modeling and is a marketing tool, as well as a tool for sales representatives and designers to simulate real-time 3D models in their real sizes and environments. 3D models can be exported to Augment by any 3D software. The Augment application is available on Android and Apple mobile devices [6].

Considering the wide choice of applications, we should choose the most suitable for us, so as not to enter into complex systems that can be avoided and which we do not need in the specific development. The choice of application for this project is dictated not by the popularity of the product or the most comprehensive functionality, providing many opportunities, but by the specifics of building an augmented reality to a textbook on design theory, in particular "Design and modeling of women's dresses in different silhouettes" by Zlatinka Kazlacheva. To this end, we should add to the 2D images of specific designs in the manual, visualization as augmented reality of their 3D models to fit into our three-dimensional reality. For this purpose, the most suitable and convenient for use by the user is Augment. Using the application does not require knowledge of a particular programming language, i.e. there is no need to generate program code to generate or visualize 3D models. 3D models can be exported to Augment by any 3D software in a few easy steps. The Augment app is available on Android and Apple mobile devices. Before we start generating augmented reality, we need to create the 3D models that we will use.

The goal we set is to create an accurate, detailed item of clothing to which we can easily add texture and, if necessary, animate. A model is needed that allows you to see all the irregularities, folds, features of the material used - leather, linen or other specific fabric, etc. There is a rich variety of software products for creating three-dimensional models, among them are Maya, Houdini, Sketchup, Daz Studio, Cinema 4D and specifically oriented to 3D clothing modeling CLO 3D, TUKA 3D, Rhino. Each product has a specific area to which it is oriented - game development, film industry, mechanical engineering, architecture, clothing manufacturing and more.

In the context of the specific tasks that are placed in the development and considering the advantages and disadvantages of the most used products for 3D and AR, as the most suitable and for specific tasks are LLC - Marvelous designer to create 3D models of garments topics of the textbook on "Design and modeling of women's dresses in different silhouettes" and Augment for their visualization with application of augmented reality.

4. Development of 3d models and use of an augmented reality application in topics from a textbook on "Design and modeling of women's dresses in different silhouettes"

Before taking advantage of the capabilities of the application, an account is created in Augment manager (manager.augment.com). To be loaded and displayed in Augment, custom models must be created with one of the popular 3D design products (including Blender, 3ds Max, Sketchup, etc.) and exported manually or with a plugin in a supported format. Formats that Augment works best with: .dae, .obj, KMZ. AR software also offers ready-made free 3D models.

The current development includes the development of three 3D models of clothing, designed by the textbook "Design and modeling of women's dresses in different silhouettes", authored by Zlatinka Kazlacheva, and turning them into augmented reality for the manual.

The first development of a 3D model is a women's dress with an A-shaped silhouette, presented on page 4 of the textbook (Figure 6). The second 3D model of clothing that we will create is a women's dress in a tight-fitting silhouette (Figure 7). The third 3D model of clothing that we will create is a women's dress in a tight-fitting silhouette in a symmetrical composition with asymmetrical elements (Figure 8).
After adding the 3D models to the Augment profile, they can be viewed in several ways. It is possible to share the link generated for the model by Augment or to copy it. The QR code of the model, that Augment has generated, can be scanned. The Augment app is available for both Android and iOS. It allows synchronizing the information for the account from the online page www.augment.com with the installed application. The Scan button scans the QR code of the 3D model and the application loads it as AR.

Once we have created our 3D models, loaded them into our Augment account, installed the mobile application and checked if the generated QR code adds the corresponding model as AR, the codes is
used to add the models to the textbook. The QR codes, generated by Augment, are added to the digital textbook "Design and modeling of women's dresses in different silhouettes", using Adobe Acrobat, because of its current .pdf format. Figure 9 lists the process of developing a textbook for the specialty "Design, technology and management of the fashion industry" with the application of augmented reality.

Figure 9. Stages in developing textbook topics with the application of augmented reality.

In Figures 10, 11 and 12 are shown the pages of the digital textbook, which integrate the possibility of AR, along with visualizations of loaded 3D models as AR.

Using QR codes to generate 3D models allows us to easily add them as AR in other educational materials, printed or digital, in the field of design theory.

For example, augmented reality through three-dimensional visualization of a women's dress model in a tight-fitting silhouette can be applied not only in "Design and modeling of women's dresses in different silhouettes", but also in the textbook "Design Theory". The model can be used in the topic "Silhouettes" from the section "Shaping" of the textbook. The main principle used in the design of the dress is symmetrical clothing (relative to the mirror symmetry of the human figure) using parallel symmetry (type of symmetry). Therefore, the example of augmented reality shown can also be used in the topic "Symmetry and asymmetry" in the "Composition" section of the textbook.

The other type of composition is at first glance symmetrical, but some of the elements and details with smaller dimensions in it are not identical or mirrored on the right and left. As its name suggests, the composition of the dress is symmetrical with asymmetrical elements. The created model for augmented reality to the textbook "Design and modeling of women's dresses in different types of silhouettes" can also be used in the textbook "Design Theory". In addition to the topic "Silhouettes" from the section "Shaping", augmented reality with three-dimensional visualization can be used in the topic "Symmetry and asymmetry".
5. Conclusions

AR creates an opportunity for visualization of 2D models in printed or digital textbooks by 3D realistic models. The three-dimensional models can be seen in details and give possibility for learning of all design and constructional features of the proposed silhouettes and forms. The generated QR codes, used for visualization of 3D models, can be applied easily to other textbooks in the fields of fashion design and pattern making.

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