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CONTEXT-DEPENDENT TOOLS AND MODELS IN CULTURAL HERITAGE EDUCATION

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ABSTRACT. This paper includes an overview of different tools and methods used to present cultural heritage resources in e-learning contexts – storytelling, serious games, digital libraries, and virtual museums. It introduces a model and several components for providing context-dependent education in cultural heritage topics. The model defines key criteria for the educational process – effective presentation of resources, different contexts, interaction, and the need for the environment to support interactivity between children in learning. The created instruments are based on the basic requirements identified and implemented in an online system for designing and providing educational content in e-learning. They include a component for 3D learning environments, allowing the creation and visualization of three-dimensional scenes in which users can examine cultural and historical artifacts in different settings.

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Key words: e-learning games, 3D learning environment, context-dependent models.

This paper presents the principal results of the doctoral thesis "Tools and methods for context-dependent use of digital cultural resources for educational purposes" by Alexandra Nikolova (Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences), successfully defended before a Scientific Jury on 18 October, 2021.

1. Introduction. For decades, cultural heritage has been associated with monuments, museums and archeology. The connection between cultural heritage and education has been in the form of passive visits to monuments or museums and to the point of following historical monuments or objects. Very often this has included tours with a tour guide focused on the chronological history of events unrelated to students' life experiences; often there have been brochures telling about all the details of the monument, without regard to its context or the students' prior skills and experience. The technological progress allows the development of numerous online catalogs and repositories for the management and promotion of cultural heritage. After the digitalization of cultural and historical sites, it becomes important to reach a larger audience of students, for whom interaction with these sites would be an important element in building national identity and patriotism, in the most appropriate and accessible way. This problem introduces the need to develop new and different tools and methods through which digital cultural resources can reach more and more diverse categories of audiences and be used for educational purposes. This study aims to examine the approaches used in teaching cultural heritage and to propose tools and models that are appropriate for children's education.

2. Overview of Tools and Methods in the Field of Cultural Heritage Education. This section reviews some models and tools for context-dependent use of digital cultural resources with learning purposes.

2.1. Models Used in the Learning Process. Learning in the field of cultural heritage as a process is based on the theory and specific methods of achieving real interaction and user participation, of preserving heritage and using it responsibly, as well as of improving communication between cultural values and society (consumers).

Certain specific models for this process [21]:

- Teacher-centered models are focused on traditional methods of teaching and are characterized by increased liability of the learning process conducted by the teacher.
- Student-centered models are focused on learners and consider their specific preferences and needs during the learning process. The role of the teacher in these models is to facilitate the learning process of students.
- Content-centered models are characterized by the fact that the content may vary or be updated with respect to the educational level of the children and the environment in which the content is presented.

- Context-centered models examine traits like characteristics of real-life educational scenarios, access device, and others, in order to determine the learning strategies (Fig. 1).

In addition to the models described, there are hybrid models [14] that integrate the basic principles of the models presented above. They are:

- Models combining content and context promote situational learning (from Latin "in situ").
- Models that combine teachers' expectations and learners' needs allow learning scenarios to be applied, taking into account their available content and interests.
- Learner-oriented and content-oriented models encourage the definition of knowledge-based content and other important characteristics of learners. In these models, the content changes with the development of the learning process; In student, content and context-oriented models, the content is organized according to individual learning needs; the context for personalizing the learning process is also taken into account.

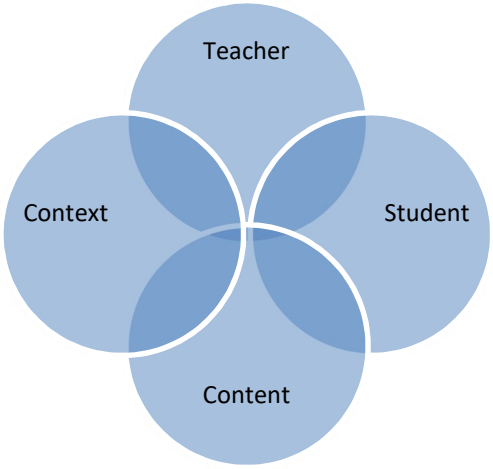

Fig. 1. Model for teaching in the field of cultural heritage [14]

2.2. Digital Storytelling. Digital storytelling conveys social and cultural activity through improvisation, theatricality and more. Each culture has its own stories or narratives, which are shared as a means of entertainment, education, preservation of culture or inculcation of moral values. Storytelling is a popular means of presenting information in many areas, including digital

cultural heritage, serious games and education [18]. In essence, digital history combines visual communication (slideshows, videos, or animations) with sound.

Storytelling with cultural historical content can be used as a means of teaching ethics, values and cultural norms. Learning by telling children's stories helps to facilitate the perception of the content and learning resources [15], because at a later stage in the study of history the emphasis is on factology without including any attractiveness. Storytelling to children includes stories about national sites, monuments, heroes and more. The goals of learning through digital storytelling are related to the development of the children's value system, forming an understanding of the ancient past and the diversity of cultural and historical tradition, developing the children's skills for mastering and applying specific techniques of historical knowledge and more.

2.3. Serious Games in Education. Gamification in children's education is a method of increasing students' motivation and engagement by using elements of games in the educational environment. The inclusion of cultural and historical heritage in the field of education through gamification and serious games serves as a learning tool and a basis for a modern, innovative approach to motivate students and enhance their academic achievement. Serious games are modern technological solutions that are actively implemented in the educational process as tools for research, teaching or assessment. They stimulate the curiosity, motivation and engagement of students and increase the efficiency of the learning process. New perspectives for research and applications of modern teaching methods such as learning-by-doing, learning-by-authoring, research approach, understanding-by-design are revealed and practices for creative thinking [13]. As a tool for studying cultural heritage, serious games have incredible potential thanks to the offer of free choice of training place, flexible time management, choice of time and speed of learning, autonomous learning in the context of the game, self-controlled learning, problem solving, systematic thinking and willingness to cooperate. Serious games have the potential to improve the user experience through multimodal interaction [2]. It can be in different contexts such as education, training, healthcare or interpersonal communication. Most research agrees that digital serious games contain different media, which can be a combination of text, graphics, animations, audio, haptics [2], etc. In addition, the term "serious" in serious games comes from their role in conveying a message or contribution, be it knowledge, skills or, in general, some content to the player. This means that the player is exposed to an environment that provides content derived from know-how or experience. This experience is related to the specific context of serious play such as well-being, education and

health. Therefore, serious games are defined as applications with three components: experience, entertainment and multimedia.

The use of digital cultural resources in digital storytelling requires specific tools for structuring, processing resources, editing, enriching and publishing. These tools provide a set of features designed to edit and present multimedia content – text, images, sound and video. Digital storytelling provides teachers with a powerful tool to use in teaching children [16]. Storytelling offers an opportunity to provide new ways of learning and teaching cultural heritage sectors. By experimenting with content, it offers wide access to information and knowledge in an easy-to-use way and the opportunity provided by some tools to collaborate on content enrichment. Digital storytelling is also a powerful tool for children who have been taught to create their own stories. After reviewing sample digital stories created by their teachers or other story developers, students can be given assignments in which they are first asked to explore a topic and then choose a specific point of view. This type of activity can generate interest, attention and motivation for students of the "digital generation" for a more in-depth study of cultural and historical resources.

2.4. Other Context-dependent Tools in Cultural Heritage Education. A digital library, also called an online library, digital repository, or digital collection, is an online database of digital objects that may include text, still images, audio, video, digital documents, or other digital media formats, or a library accessible through the Internet. They combine technological and digital resources to allow remote access to educational content.

Digital libraries can contain voluminous archives and are designed to share cultural heritage for research, learning and enjoyment. An example of such a digital library is Europeana [25]. It provides access to books, music, artwork and more. Part of Europeana is Historiana [7], a tool designed to challenge and support teachers to create, adapt and use digital cultural resources for e-learning that promote historical thinking. Historiana is an online educational multimedia tool that offers students many promising historical sources to supplement their knowledge of history. The tool provides access to historical content, ready to be used in learning activities and innovative digital tools created by and for history teachers across Europe. The materials available in Historiana are largely provided by Europeana's collections. E-learning activities are carried out in Historiana's eActivity Builder and provide teachers with ready-made materials that link directly to historical sources, as well as the opportunity to modify existing e-learning activities or create new ones to share with learners. Historiana

focuses on the model of historical thinking and the creation of learning activities that develop it.

Virtual museums offer the opportunity to explore cultural resources through remote access to a digital copy, allowing detailed viewing of fragile artifacts in a personalized way [23]. Virtual museums containing digital cultural resources have different purposes, functional characteristics and a very different audience. The term "virtual museum" is an information system containing a conceptually unified electronic collection or set of collections of objects with metadata, which has the characteristics of a museum and which facilitates research, education and discovery activities in cyberspace [17].

Virtual museums using digital cultural resources are divided into several categories [24]:

- **Virtual museums** that provide access to high-resolution images to provide as much information as possible about virtual exhibits.
- **Virtual reality** (VR) exhibitions are simulations of a real or imaginary environment generated in 3D that is experienced visually and provides the illusion of reality [6, 4].
- **Augmented Reality** (AR) museums enhance the experience by visualizing, interacting, and navigating museum collections, or even by creating galleries of museums in an AR environment using software or specialized devices.
- **Virtual museums in mixed reality** (MX) rely on a combination of VR, AR and the real environment to improve the social experience and perception of users in the museum environment regarding cultural artifacts and related contexts.
- **Haptics museums** include the modality of touch and the sense of shape and texture that the visitor experiences when exploring virtual objects.

2.5. Analysis and Evaluation. To study the applicability of technological solutions and the impact of cultural and historical heritage on children, a comparative analysis of tools and methods for context-dependent use of digital cultural resources for educational purpose is prepared. It is discussed in the preceding section. The specific objectives of this analysis are:

- To analyze the relationship between the standards of quality of education and educational environments for cultural and historical heritage;

- To distinguish the quality of the media according to whether they are public or private property;
- To analyze to what extent these environments are accessible and suitable for context-dependent use of cultural resources for educational purposes for children;
- To analyze the interaction and social opportunities of the environment;
- To analyze to what extent the environments are suitable for children, etc.

The approach of this study is based on the fundamental standards for the evaluation of educational systems in the field of cultural heritage education, which contributes to improving the rigor of environmental assessment.

The indicators used in the study are: reuse and modification, content adaptability, cloud functionality, resource creation and organization, microlearning, interactivity, interaction with different environments, teacher-student interaction, social opportunities, feedback, assessment of knowledge, accessibility, publicity, multilingualism, storytelling, entertainment and play, suitable for children, promoting academic freedom.

The analysis showed that the existing tools and methods for context-dependent use of digital cultural resources for educational purposes do not cover all the necessary indicators and do not support 100% of the specific requirements and functionalities that they need to have. The functionalities that support all analyzed tools are cloud functionality, interactivity and interaction with the environment. None of the analyzed tools supports resource organization, micro-learning, knowledge assessment, accessibility and multilingualism.

3. Context-dependent Tools and Models in Cultural Heritage Education.

3.1. A Model for Context-dependent Use of Digital Cultural Resources. The use of digital cultural resources in education can be seen as a process that focuses not only on knowledge but also on the recognition and importance of common cultural heritage. Learning traditionally takes place in learning scenarios in which teachers offer children predetermined learning resources using traditional curricula, teaching methods and strategies. Nowadays, learners have many learning opportunities through the use of mobile technologies in context. They can be used to enable children to become aware of the values of humanity's cultural heritage and its importance for the future. In order to achieve a comprehensive interpretation of the resources, several criteria were

taken into account when creating the model – their effective presentation, context, interaction and the need for an environment that supports the interactivity between children in learning. Fig. 2 illustrates the model for context-dependent educational use of digital cultural resources. The model is designed to improve user interaction and communication, content and cultural artifacts.

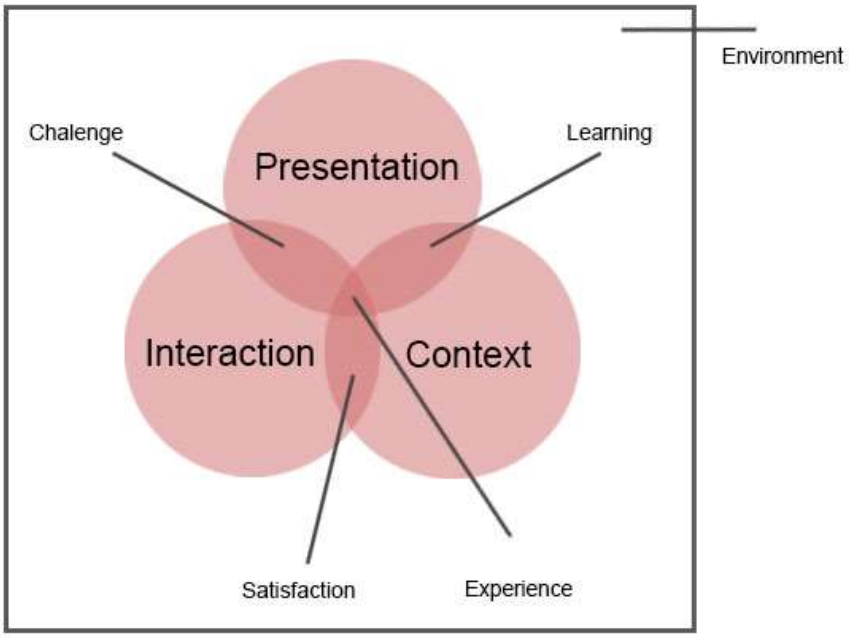

Fig. 2. Model for context-dependent educational use of digital cultural resources

The development of the model has taken into account the importance of the interaction between children and learning resources. It happens when students receive direct information from resources through text, image, video, three-dimensional object and more. Student-content interaction is the most important form of interaction, as this is how learning takes place. Once students have access to learning materials, they should be able to use it in their own way – to be able to pause during the training, to repeat parts of the learning material to master it better, or more.

The integration of the context into the developed model is of particular importance in teaching and learning through digital cultural resources and encourages children to acquire new knowledge, skills and civic values. Training in context contributes to the formation of a desire to participate in the preservation of cultural heritage and develops a sense of patriotism and belonging of students to the values of the common European cultural heritage.

The presentation of the digital cultural resources in the model is combined with the interaction and the context as it encourages the active participation of the children and thus contributes to the greater commitment and interest in the learning material. Presenting learning resources in an innovative and interesting way contributes to the greater motivation and engagement of children. By overlapping the interaction and presentation of resources in the model, students are provided with challenges that can stimulate interest in and commitment to the learning material. The overlap of the presentation and the context in the model provides an opportunity to improve the final learning outcome.

The detection of the interaction and the context in the developed model contributes to the greater satisfaction with the children's education.

3.2. Component for Creating Context-dependent Learning Games. To increase access to cultural-historical resources in a way suitable for children, we developed several software components for visualization of multimedia digital objects in mini-games in the web browser. Game resources are of three types – matching, ranking and selection. They are based on the basic requirements identified in the system for designing and providing educational content in e-learning [22], and have the following properties:

- Dividing the curriculum into smaller, autonomous units that can be used both individually and in combination. The properties that learning resources possess modularity, interoperability, reuse and accessibility;
- Description of the educational content and its learning resources through meta-data. Metadata provides information about additional learning resources. They define their context, properties and characteristics and description in JSON format. of metadata in the implementation of adaptive All components and facilitate the retrieval of information.

Digital cultural resources cover text, images and multimedia components such as hyperlinks, video and others, through which knowledge units from a relevant subject area are presented. A digital cultural resource can be modified into a learning game resource such as:

- Games of type "Matching" have one or more question-answer pairs, and an option to randomize the questions.
- Games of type "Ordering" have one question, multiple answers, the correct sequence of answers, and an option to randomize the answers.
- Games of type "Choice" have one question, multiple answers (one of which is specified as correct), and an option to randomize them.

All questions and answers from the typical game resources are composed of rich content – differently formatted text, background color, images, videos and hyperlinks. For this purpose, the rich text editing component of the Shield UI JavaScript library was used [10]. The component allows creating three types of interactive presentations that can be used for context-dependent use for educational purposes of digital cultural resources – games for matching, arrangement and selection.

The mini-game component is implemented as a hierarchy of JavaScript classes that can run on all types of web browsers and devices. The Assessment base class is an abstract class that contains the basic properties of the games and functions for their display and display of the game result. This class also contains a factory function for creating an object for a specific game from the inheriting classes – MultipleChoiceAssessment, MatchingAssessment and OrderingAssessment. The specific classes represent the different types of games and contain various implementations of the functions for displaying the configuration interface, retrieving the completed configuration data and displaying the user interface for the game resource. This interface contains HTML code for visualizing a game and JavaScript code for children's interaction with resources. Fig. 3 shows a UML diagram of the class structure of the component for creating and visualizing multimedia cultural resources for games.

The creation and operation data of a class for a particular game includes only its options. They are presented as a JavaScript object and can have different structure, type and number of properties, according to the needs of a particular type of game resource. For example, for the MultipleChoiceAssessment class, these options are text for the main question, the color of its background, a list of possible answers, one of which is marked as correct, and the ability to shuffle the answers when displaying them. The same format options are passed on to the class constructor and serve the RenderConfigSection and RenderPlaySection functions to display the interfaces, and the current values can be retrieved from the configuration section displayed by the object via the GetConfigData function.

In this way, the options defining a resource can be stored in a database or other data warehouse (web service, browser cookie, etc.).

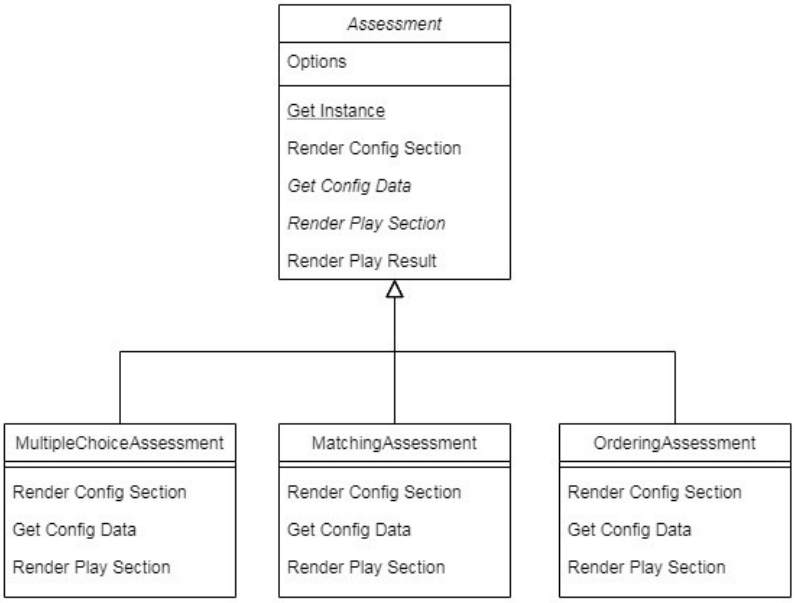

Fig. 3. UML class diagram of game resource classes

To improve the user interface and experience, the component for visualizing digital cultural resources for games in a web browser uses the jQuery [11] and Shield UI [10] libraries. This combination of client-side libraries is often used and [4] describes a detailed showcase of its integration in the field of medical education. jQuery is the most popular cross-platform JavaScript library, used by more than 60% of the most visited Web sites. It is open source and licensed to be used in any application, regardless of their purpose and target groups. Its syntax is designed to facilitate the work of the programmer and provide compatibility between different browsers through functions for navigation in the HTML document, selection of DOM elements, creation of animations, event processing, development of AJAX applications [3] and others. The functionalities used are standard for all versions of jQuery, which means that they will work in all modern web browsers.

To improve the user interface, the Shield UI library is integrated, which contains many components for the user interface, such as diagrams, progress indicators, complex tables that support sorting, grouping and filtering, which

are not present among the standard elements in HTML5. For the needs of the component for visualization of multimedia cultural resources for games in a web browser, the Shield UI components are used for editing richly-formatted text [1] and dragging and dropping (drag and drop) various elements of the page.

3.3. Component for Creating 3D Learning Environment. The component allows content authors to define multiple 3D objects and images that will be displayed on a single scene, introducing various configuration options such as level, position and size. If there is a stage, there are several properties that allow additional customization of the learning environment – title, description, sizing the scene in X, Y and Z and adding textures to the ceiling, walls and floor.

In addition to the visual and spatial characteristics of the objects, additional digital cultural resources can be viewed and displayed, which can be added to the objects or images from the stage – this information is provided in a new window through a developed software component for visualizing multimedia resources for web games browser when you click on a 3D object or image from the scene and can contain text, image, video, hyperlink or 3D object.

For the end user (learner) the component allows the viewing of the created virtual environment from the first person by free movement in the virtual scene with the mouse and keyboard. This makes it possible to see three-dimensional objects in their realistic dimensions from all possible angles and distances. For the displayed scene, the background color and texture for the exterior floor can also be configured, as well as different textures for the floor, walls and ceiling of the virtual room. Interactive 2D and 3D objects can be added to different positions in the scene, which can react to mouse events (pointing, pressing, etc.) and trigger specific actions. In order to distinguish the currently selected object, it becomes slightly transparent, which distinguishes it from the others and attracts the user's attention. By adding several light sources and shadows to each of the objects, the presentation of the outer and inner part of the virtual space becomes more realistic.

Objects in the 3D environment are interactive and can trigger various events when interacting with them. They respond to pointing and mouse clicks by the user, and this functionality can be used to navigate the learning material. Examples are displaying additional information related to an object in the scene, moving to another scene (virtual room), and launching a game resource (mini-game), test, or other interactive learning resource.

In order to make the learning content more interactive, interesting and engaging for the children, a model and software component for visualization of a three-dimensional learning environment in a web browser have been developed.

The component for visualizing a virtual three-dimensional learning environment in a web browser is implemented as a JavaScript class based on the Three.js library [20]. Three.js is a library for 3D graphics with a very low level of complexity, rich in many functionalities that allow you to create complex three-dimensional computer animations for the web browser. It includes support for a variety of industry-standard 3D formats, various lights and shadows, cameras and controllers for their movement on stage, controlled by mouse and keyboard and other tools. Using this flexibility, we selected Three.js to build the virtual 3D learning environment visualization component.

Even when using specialized libraries, the process of displaying 3D graphics in a web browser requires a lot of pre-configurations and specific logic implemented through JavaScript code. The first thing that is defined is the stage – it shapes the environment, which contains all the resources and their spatial characteristics, such as size and location. Then comes the addition of resources such as 3D models, the accompanying textures and materials from which they are made. The added lights are used to illuminate the stage and the objects in it, as well as to show effects such as shadows and reflections. To represent the three-dimensional environment on the two-dimensional screen, it is necessary to determine a camera that indicates the perspective and location of the observer. Finally, the rendering process is started, which, using complex mathematical calculations, converts the scene into a two-dimensional image, which is displayed on the user's screen in real time. In addition to drawing the 3D environment, such an application must respond to various events and reflect possible changes in this environment. This may include changing the location and direction of the camera when moving the mouse and keyboard, displaying effects or additional information about an object when pointing it, and any other complex features. Existing JavaScript libraries for working with 3D in the web browser greatly facilitate work with the complex programming WebGL interface. With their help, developers eliminate the need for complex mathematical calculations in 3D graphics. But even with the use of such libraries, the work of adding 3D content to web applications takes a long time and requires web programmers with specific knowledge in this field. To facilitate this process, the developed component allows the creation and configuration of a virtual room with interactive two-dimensional and three-dimensional objects, which can be used to present learning content from different areas.

The THREE.PerspectiveCamera class, representing a perspective camera (Fig. 4 [8]), is used in the implementation of the virtual 3D learning environment visualization component in a web browser – the most common projection mode for 3D scene rendering, designed to mimic the way in which the human eye sees. This type of camera is used to visualize a more realistic scene. The camera processes all objects in perspective projection, namely the farther the object is, the smaller it looks.

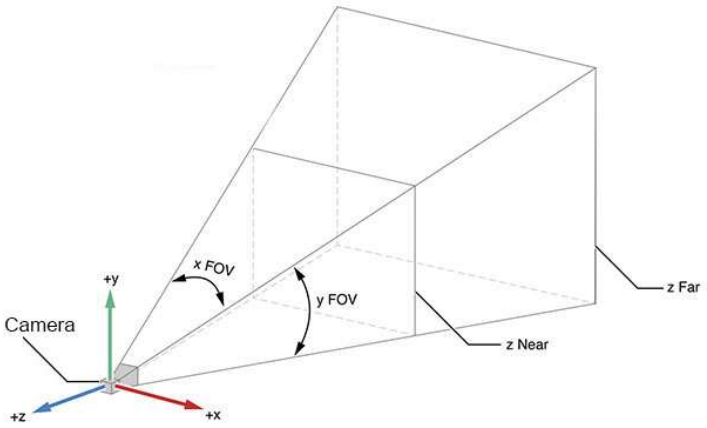

Fig. 4. Three.js PerspectiveCamera [8]

Lights of the THREE.AmbientLight and THREE.SpotLight types have been added to illuminate a virtual 3D scene (Fig. 5 [9]). The first light illuminates all objects in the scene equally, not adding shadows to the objects as it has no direction of illumination. This is the reason for adding the second type of light – THREE.SpotLight. This light is emitted from one point in one direction along a cone that increases farther from the light it receives and allows it to cast shadows.

An important part of a virtual three-dimensional scene are 3D objects. The developed component for visualization of a virtual three-dimensional learning environment in a web browser supports the most popular formats for 3D objects – GLTF, FBX and OBJ, which makes it flexible in terms of the objects that will be implemented in it.

The last resource needed to display 3D graphics is the rendering object. It performs all complex 3D calculations and draws the scene on the screen according to the current properties of the models, lights and cameras in it. The Three.js library offers several classes for initializing rendering objects, such as

SoftwareRenderer, CanvasRenderer, and WebGLRenderer. The fastest of them is WebGLRenderer, which uses the hardware capabilities of the device through the WebGL context of the HTML5 canvas element. If WebGL is not supported by the client's web browser, another but slower render can be constructed, such as CanvasRenderer using the Canvas 2D context, or even the slower SoftwareRenderer, which draws graphics pixel by pixel.

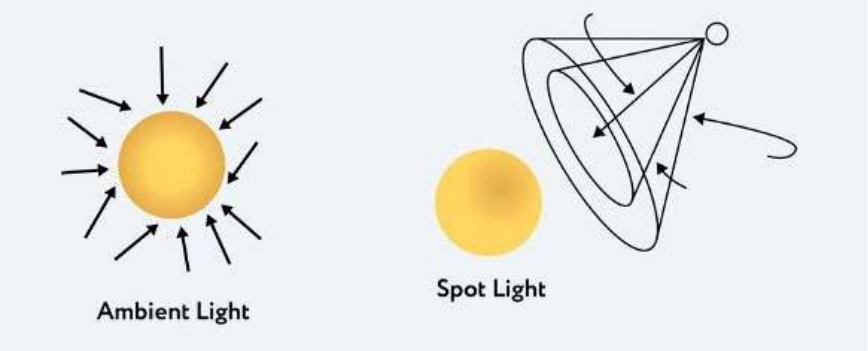

Fig. 5. THREE.AmbientLight and THREE.SpotLight [9]

In addition to painting the full 3D scene containing the virtual room and the objects in it, the component also handles the input from the user's mouse and keyboard. These commands are used to control the movement between objects and the free rotation of the camera direction. The position of the camera can be changed along the X and Z axes using the arrow keys. The direction of the camera is changed by holding down the right mouse button and moving the mouse in different directions. This type of control is very similar to that used in modern computer games and is ideal for virtual first-person 3D environments. To achieve full interaction with the respective objects, the component intercepts and processes the clicks with the left mouse button on the document. To calculate which object in the 3D space the mouse is currently on, at the current and 2D coordinates, the Raycasting method [14] and the class of the same name, part of the Three.js library, are used. The control of the camera and the reading of the object indicated by the mouse are performed in the rendering cycle.

4. Testing and Analysis of Results. The testing of the usability of the developed models and components is considered in terms of four main operational criteria: these are efficiency, learning ability, flexibility and satisfaction. This study includes testing of all four operational criteria [19] for software components and the environment.

- **Efficiency** – the percentage of users in the system having completed the tasks;
- **Ability to learn** – the degree of training in performing tasks;
- **Flexibility** – adaptation to changes in components and environment;
- **Consumer satisfaction with the system** – whether they would continue to use the components and the environment.

For the purposes of the study, two approaches were used to evaluate the effectiveness. In the first approach, standard evaluation questionnaires were used. The five-point Likert scale [12] is applied, which represents questions or statements that the respondent has to answer by noting his/her opinion on a scale from 1 to 5. By using the scale, it is possible to gather more precise and more accurate personal information from users, namely different degrees of attitude and opinion. The questions created for the evaluation of the developed models and components evaluate the following areas of usability:

- **Design** – to what extent the design is suitable for children;
- **Functionality** – to what extent the developed functionalities achieve the goals of the dissertation;
- **User-friendly** – how convenient and understandable the tools are for users;
- **Ability to learn** – how much the tools contribute to the context-dependent use of digital cultural resources for children;
- **Satisfaction** – how satisfied the users are with the use of the developed tools;
- **Future use** – to what extent users would continue to use the components and the environment;
- **Usefulness** – the extent to which the tools improve the quality of learning through the methods of context-dependent use of digital cultural resources for educational purposes.

The second approach involves testing the effectiveness of the developed models and components in real time. Fig. 6 shows the framework of the testing methodology used to assess usability.

The experiments and the implementation of the developed models and components were conducted online within one lesson.

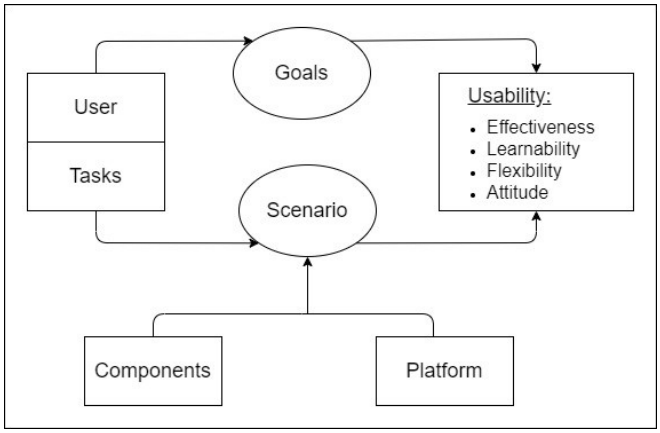

Fig. 6. The framework of testing methodology used to assess usability

It was attended by two teachers who independently prepared a three-dimensional virtual lesson to acquire new knowledge on *Bulgarian national symbols*, part of the training in the world around us. Three groups of students were included in the experiment – one control group (16 children aged 7) and two groups of children who had already used the platform (a group of 17 children aged 7 and a group of 19 children aged 9). The objectives of the lesson are:

- To expand the knowledge of national symbols;
- For students to recognize and distinguish Bulgaria's flag and coat of arms;
- For students to describe the meaning of the Bulgarian flag;
- For students to recognize and name some Bulgarian flags that have historical significance for our country;
- For students to recognize the anthem of Bulgaria and to state in which cases it is performed;
- To develop self-awareness of belonging to the homeland.

The key concepts are: motherland, symbols of Bulgaria – flag, anthem, coat of arms.

After completing the experiment and analyzing the data from the completion of the questionnaires, it became clear that:

- The developed models and components enable the integration of learning content in a user web interface and can be used for interactive presentation of digital cultural learning resources;

- Learning resources include rich multimedia content – text, images, video, audio, and three-dimensional virtual reality;
- Components are available to any user regardless of the device or operating system used and do not require the installation of additional software;
- Satisfaction, full interaction with users (teachers and students) with the tools, as well as flexible and effective learning are achieved through the use of the developed components.

5. Conclusions. The trend over the last few years has shown that context-dependent tools and methods in cultural heritage education have a huge potential in the field, but the wide audience has limited access to them. To reach more diverse categories of audiences and be used for educational purposes, specific tools, like the ones presented in this paper, need to be developed and integrated in online learning environments. The advantages of the developed components, presented in this article, are many. They can be used in cultural-heritage and other context-dependent education, delivered on any user device and operating system. The created learning resources can be updated, modified and reused at any time. The components allow both the creation of learning resources and the play activities, which allows greater flexibility and personalization of heritage education. They provide an opportunity to present detailed 3D artifacts. The components make objects and learning resources available across national borders by being translated into different languages, so that language does not act as a barrier for teachers and students in different countries. One aspect for further development is creating statistical instruments for assessing the outcomes of the learning process. Another potential direction is the automated generation of personalized and more relevant content, corresponding to the specific needs and interests of the viewers.

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