IMPLEMENTATION OF 3D GRAPHICS ON THE WEB – A CASE STUDY OF EXPERIENCE DEVELOPMENT, OPTIMISATION AND QUALITATIVE EVALUATION

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Abstract: *The aim of the study was to develop a website with the main functionality of an interactive three-dimensional (3D) viewer. In the theoretical part, we present a brief overview of content management services (CMS) and their limitations; definition of usability and user experience (UX) with an explanation of the basic components of UX and the theoretical background of the User Experience Questionnaire (UEQ). The experimental part consists of the entire process that was used in the development of the website. We created the concept and design for the graphic identity of the website and developed the information architecture, defined basic and additional functions, created a low-fidelity wireframe and a high-fidelity prototype design. We developed the 3D viewer using open-source software model viewer, prepared and optimised the 3D models for the 3D view (Figure 1), followed by the rendering phase in Blender. We developed the final version of the desktop-first website and designed and developed mobile and tablet versions. Testing included qualitative usability testing using the User Experience Questionnaire (UEQ) and open-ended questions, followed by analysis of the results on three areas of usability (attractiveness, practical quality and hedonic quality). The results of the analysis served as guidelines for improving the current functionalities in terms of UX and technical aspects (with technical limitations). The results showed that creating a modern website that emphasises an interactive 3D model with a CMS platform is an extremely complex project that encompasses many areas. According to the UEQ test criteria, the final online solution scored above average in terms of practicality and attractiveness. The results also show the importance of iterative testing and website upgrades based on the results of the test analyses.*

Key words: 3d viewer, website development, web design, user experience (UX), measuring quality of usability

1. INTRODUCTION

A Content Management System (CMS) is a software platform designed to enable users to create, edit, publish, and store digital content without the need for coding skills. By providing a graphical user interface, CMS platforms simplify content creation, editing, and publication, making them accessible even to those with limited technical expertise. Despite variations in functionality among different CMS platforms, they generally share essential features such as intuitive indexing, search, and retrieval of published data through attributes like dates, keywords, and authors. They also include format management, which involves the organization and control of various content types, and revision tools that facilitate the updating and editing of published content while tracking changes over time. Content publishing is streamlined through the use of predefined or custom templates, enabling efficient and consistent presentation (Godbolt, 2016; Messenlehner, 2019). Additionally, CMS platforms support plugins, which are collections of code that enhance the platform's functionality for specific needs. A notable example is the WooCommerce plugin for WordPress, which extends the platform’s capabilities to support e-commerce activities such as product publication, inventory management, cashless payments, and advertising. The use of plugins allows users to tailor their CMS to suit specific requirements, making it a versatile tool for various digital content needs (Casey, 2023; Sahupala, 2024).

The primary advantages of using a CMS include ease of use, as the graphical interface makes it user-friendly even for those without technical knowledge. Efficient information retrieval is another benefit, with built-in search engines enabling quick access to content. CMS platforms also simplify content management, providing tools for organizing and maintaining digital assets effectively. Being web-based, CMS platforms allow users to access and manage content from any internet-enabled device, offering flexibility and convenience. Moreover, CMS platforms support collaborative workflows, enabling multiple users to work simultaneously on content management tasks with varying permission levels. This capability allows, for example, an editor to update product prices while a customer browses the online catalogue. The ability to

quickly update content, add new pages, and implement new functionalities as the site evolves ensures scalability and adaptability for future growth (Godbolt, 2016; Casey, 2023).
Usability and user experience (UX) are crucial considerations in the development and refinement of a CMS. Usability refers to the quality and simplicity of the user interface, which directly impacts how effectively and efficiently users can achieve their goals. It encompasses aspects such as learnability, efficiency, memorability, error management, and satisfaction. Meanwhile, utility addresses whether the design's functionalities meet the user's needs. Together, usability and utility define a product's usefulness, with a successful CMS being both easy to use and capable of fulfilling user requirements (Albert & Tullis, 2022). A CMS is a robust platform for digital content management, and emphasizing usability and user experience is essential for creating an effective and engaging system that meets user needs and facilitates efficient content management.
User experience encompasses all interactions between the user and the design, going beyond basic functionality to include the seamless integration of development, marketing, graphic design, and user interface design. Usability testing is a vital part of the design process, helping identify strengths and weaknesses in the current design, exploring competitive approaches, and refining ideas through iterative testing of prototypes. This process involves observing users in real-world settings, comparing designs against usability guidelines, and continually testing and improving the final product (Garrett, 2010; Albert & Tullis, 2022).
Empirical measurement of UX can be conducted through standardized questionnaires such as AttrakDiff, UEQ, and meCUE, with the User Experience Questionnaire (UEQ) being particularly effective for capturing immediate user feedback. The UEQ assesses aspects like attractiveness, perspicuity, dependability, efficiency, novelty, and stimulation, providing valuable insights for interpreting usability tests and enhancing the overall design experience (UEQ, 2022).
The aim of the work was to design, develop and publish a website that focuses on a three-dimensional object. The special feature of the implementation is the use of the CMS platform and open-source functionalities for viewing the 3D models. This allows the user to view a 3D object from any angle, to zoom in or out and to experience it interactively. The implementation of this type of work is challenging as it requires a multidisciplinary approach and a certain degree of complexity. In practice, this is solved through group work, where each member takes on a specific role based on their expertise. After the creation and publishment of the website, the subjective usability metrics based on the standardized UEQ questionnaire was used to analyse and evaluate the information on possible improvements, shortcomings, additional features and the quality of the user experience.

2. METHODS

The experimental part included following phases, which overlap at certain points: analysing the existing websites to determine the core functionalities and layout of the pages; definition of end users and target groups, determining the basic functionality and information architecture of the website; design wireframes of the website; design of a non-functional website prototype, development of a website for a personal computer (desktop), checking, correcting and finalising elements; development of a website for a smartphone (mobile) and a tablet computer (tablet), usability test with the UEQ questionnaire.
The tools and software used were: Adobe Illustrator (creation of CGP and vector graphic elements); Figma (creation of the information architecture, a rough wireframe of the original and final website and an accurate (high-fidelity) prototype of the website); Blender (editing, rendering, import and export of 3D models); Wordpress.org (website development and publishing models); Elementor and Elementor PRO, Wordpress.org plugin (website template development and creation); WooCommerce, Wordpress.org plugin (management and control of 3D model catalogs); Modelviewer (display and rendering of 3D models on the website); Advanced Custom Fields, Wordpress.org plugin (creation and embedding of dynamic data in an Elementor template); other plugins for Wordpress.org (the functions of this platform were only required for performance-specific tasks without the need to write additional code):

- WP File Manager (for advanced navigation within the website's database),
- Unlimited Elements for Elementor (for a larger number of additional website components),
- Limit Login Attempts Reloaded (to prevent access to the website by brute force when logging in),
- File Upload Types (to extend the permitted file types that can be uploaded to the website),
- Elex WooCommerce Catalog Mode (to extend the Woocommerce catalog tool) and
- Big File Uploads (to increase the maximum size of files that can be uploaded to the website).

Usability was measured using a combined method. i.e. standardised quantitative usability metrics and open-question questionnaire. The actual user experience was measured with a standardized UEQ questionnaire and open-ended questions were used to search for problem areas. The test examined the quality of the user experience in six areas (UEQ, 2022): Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation and Novelty. The questionnaire already contains a tool for analysing the results and a benchmark. Questionnaire with two open questions provided us with information that directly indicated problems with the use of the website, i.e "Comment on your experience of using the website" and "Suggest improvements and/or new functionalities that you think would improve the performance of the website".
The web solution with the integration of 3D viewer was tested on a PC and with browsers: Google Chrome, Safari, Mozilla Firefox, Microsoft Edge; and on mobile devices and with browsers: Google Chrome, Safari, Vivaldi.

3. RESULTS

The website was designed in Wordpress.org platform. The functionalities offered by the website platform were divided into two categories: 1. The main functionalities represent the goal of the website: 3D model that the user can interactively view and zoom from any angle and a gallery with static photos and renderings of the objects. 2. Auxiliary and secondary functionalities that enabled the user to learn and navigate the website or the 3D model, i.e. Presentation and purpose of the website; Selection gallery from which the user can choose any 3D model; Description of the facility.
The object page contained several different components: Address or name of the 3D model, first and last name (or pseudonym) of the author, additional options and the possibility to share on social networks; Functional and interactive window with 3D model; Accompanying text (Slovenian and English description of 3D models created with artificial intelligence); General rendering of the model; Gallery with front, side and roof profile of the model; List of software used to create the final 3D model. Information architecture, basic wireframe and short code with CSS component of the 3D object that displays the website logo are presented in Figure 1.

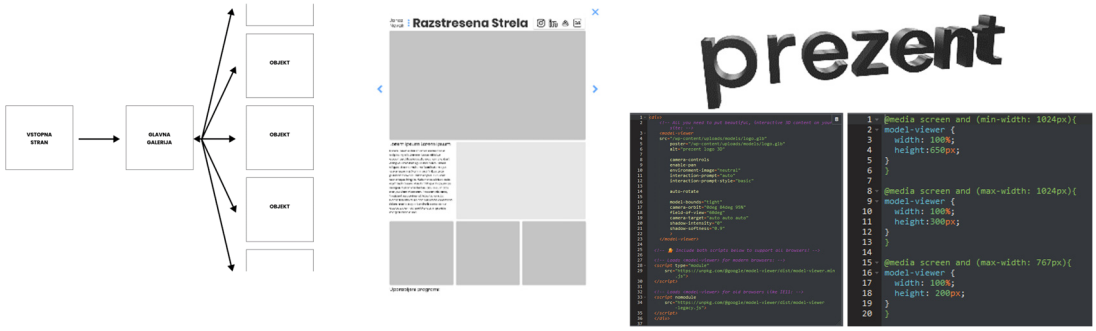

Figure 1: Information architecture, basic wireframe and the short code and CSS component of the 3D object that displays the website logo

The main purpose of the gallery was to support the model viewer and extend the accessibility of the bottom to view objects. Unlike the model viewer, the image gallery was part of the basic set of Elementor components. WooCommerce plugin. Therefore, the component did not have to be subsequently adapted in the program code for the dynamics within the template. Figure 2 shows the appearance of the final form of the rendering gallery on a selected 3D model within the editor in the Elementor plugin.
The creation of a functional version of the website for personal computers was followed by the creation of a format for cell phones and tablets. For all components (with the exception of the model viewer, where responsiveness was defined in the component's CSS field), we created a new, device-specific version of the component that was optimized for a mobile device. Within the template, we then adjusted the appearance of the page according to the screen width of the display device, which can also be filtered in the CSS field. The dimensions of the filtering were defined as follows: Personal computer (screen width at least 1024 px); Tablet computer (screen width between 767 px and 1024 px); Cell phone (screen width maximum 767 px).

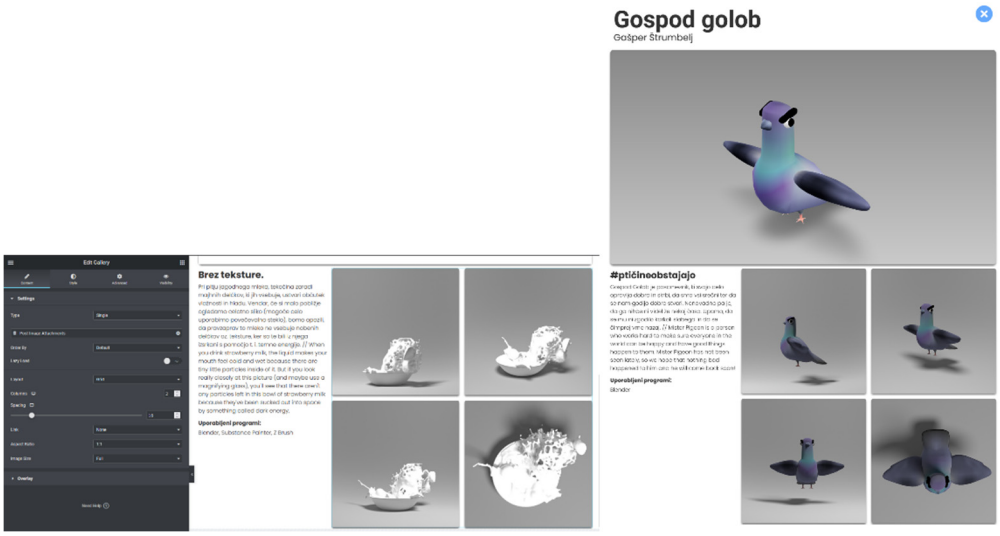

Figure 2: Image gallery layout of the Strawberry model in the Elementor plugin and the final layout of the object page

Table 1 presents summarized results of UEQ testing of the websites with the 3D viewer and Figure 3 the visualisation of the UEQ results.

Table 1: Summarized results of UEQ testing into areas obtained with the UEQ questionnaire data analysis tool (UEQ, 2022)

UEQ parameters	Average	Std. Dev.
Attractiveness	1,464	0,72
Perspicuity	1,286	1,35
Efficiency	1,000	0,77
Dependability	1,250	0,91
Stimulation	0,857	1,22
Novelty	0,786	0,80

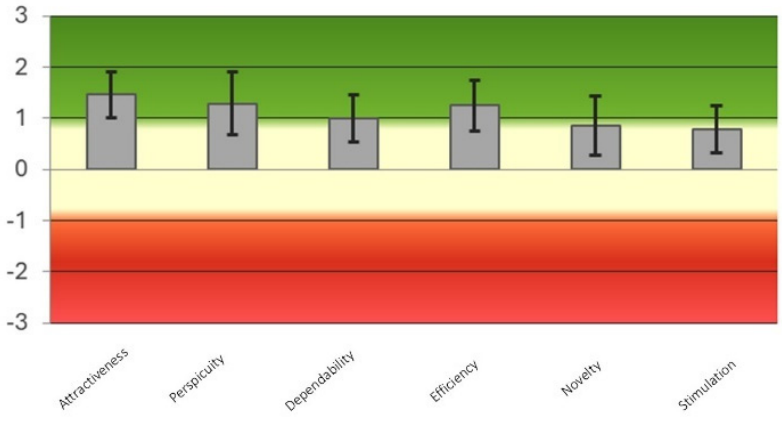

Figure 3: UEQ values of areas with standard deviation obtained with the UEQ questionnaire data analysis tool

The tool for analysing the UEQ results also contains a benchmark. The purpose of this benchmark is to compare the results with other usability tests that have already been completed. It is based on the results of 468 different tests conducted with a total of 21175 people (UEQ, 2022). The UEQ test performance is shown graphically in Figure 4.

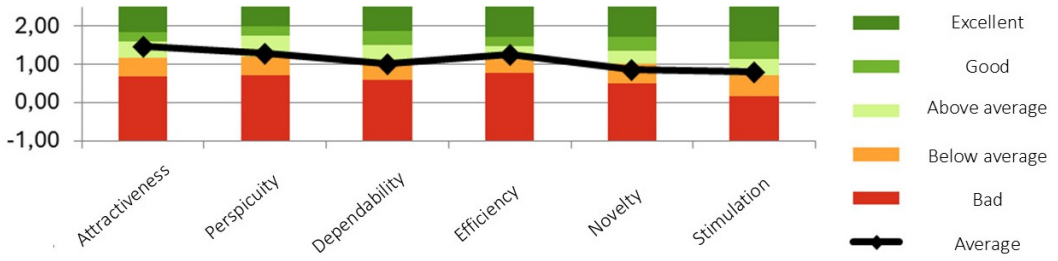

Figure 4: Graphic representation of the UEQ questionnaire test performance measure obtained with the UEQ questionnaire data analysis tool

The Cronbach alpha coefficient is used to measure the reliability or internal consistency of the results. Results greater than 0.7 indicate satisfactory consistency, but with a small sample (less than 50 people) this coefficient should be taken with a grain of salt. This means that we cannot use it independently. In this case, its values are a poor indicator of the consistency or quality of the responses, as the sample is small and very sensitive to changes.
Classification (appeal, practical, hedonic) of comments and suggestions that resulted from the two open questions that were asked the users are presented as follows in Table 2. Table 2 shows that most problems occurred in the category of practical quality, due to problems with individual webpage components, with the overall experience with the website or with a specific limitation of the browser.

Table 2: Classified qualities of the website according to UEQ test and open questions

Positive	Negative comments
Appeal and attractiveness: • engaging interactivity Practical: • intuitive navigation Hedonic quality: • responsiveness of the site Other: • fast loading of the models	Appeal and attractiveness: • visual sophistication • additional features within the viewer Practical quality: • unintuitive navigation • problems with the main gallery • problems with the browser • problems with more sophisticated models • difficult to launch Hedonic quality: • visual sophistication

4. DISCUSSION

Attractiveness. From the results of the questionnaire on comments and suggestions in the attractiveness category, we can conclude that users like the interactive 3D model viewer and that they would like to see additional features in this area, such as: 1. more options within the navigation, such as changing the pivot point and zoom level, 2. opening the viewer in an additional window, 3. technical inspections of installations (e.g. cross-sections of installations), 4. 3D objects with animation.
Practical quality. From the comments and suggestions in the Practical quality category, it can be concluded that users are largely satisfied with the use of the website in terms of transparency and manageability, but somewhat less so in terms of efficiency. This can be seen in both the positive and negative comments and suggestions from users where problems occur throughout the website: 1. problems with the browser, 2. problems with the main gallery, 3. problems with more sophisticated models, 4. problems with loading objects, 5. non-intuitive navigation.
Hedonic quality. From the comments and suggestions in the hedonic quality category, we can conclude that users are not surprised and are on average satisfied with the use of the website in terms of originality and stimulation. This can be seen mainly from the lower test score, as the results are much lower compared to the other two categories. The number of user comments and suggestions in this area, on the other hand, is very low and indicates a lack of both negative and positive reviews.

5. CONCLUSIONS

Creating a modern website that features an interactive 3D model using a CMS platform is a highly complex project, requiring expertise in multiple areas. Although the final website performs above average in terms of practicality and attractiveness based on UEQ testing criteria, adjustments are needed according to feedback received during testing. To improve the user experience, the development team must expand their technical knowledge, which may necessitate adding more members to the team.
The experimental part of the research work the website development with integrated 3D viewer is described. We began by analyzing existing platforms, we created the corporate image (CI), information architecture (IA), and prototype designs. After developing the 3D viewer and rendering models, we built the desktop-first website and its mobile versions, followed by user testing to evaluate UX aspects, which informed future upgrades. For further development, the team should include specialists in web development and technology, product and user experience design, user and market research, user interface and graphic design, 3D model preparation, and website testing for bugs and issues. Further, detailed research and quality measurement of user experience should be conducted through physical testing with a larger sample size. As the most exposed issues were in practical (and hedonic) properties of the webpage, continuous usability testing should be included each stage of development, and the target user group should be clearly defined using simplified user profiles, or personas.

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