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Evaluating the Impact of 3D Visualizations on Website Usability and User Experience

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Abstract: This study investigates the usability and user experience of integrating 3D visualizations and short 3D animations into the website interface of a marketing agency. The research evaluates how computer-generated 3D elements influence user interaction, perception, and overall website performance. The experimental phase documents the design process, including software selection, web interface development, and the creation of 3D assets. Target user groups were defined and represented through personas, which informed the specification of website functionality, content structure, and information architecture. Wireframes were designed to determine the spatial organization of interface components, while parallel development focused on producing 3D models and animations intended for web deployment. Usability testing was conducted using the standardized User Experience Questionnaire (UEQ) supplemented with domain-specific questions. Participants interacted with a functional prototype to assess system usability, visual engagement, and navigational efficiency. The findings provide an analysis of user experience outcomes associated with the incorporation of 3D elements into web interfaces. The results offer practical guidance and best-practice recommendations for designers, developers, and content creators seeking to implement 3D visual content as a functional and aesthetic component of modern website design.

Keywords: 3D visualizations; 3D graphics; user-centred design (UCD); user experience questionnaire (UEQ); usability testing; website interface design.

1. Introduction

A company's online identity represents the initial point of contact between users and its digital presence, making it essential that this identity conveys a high standard of user experience. By applying established levels of user experience design, core design principles, and other user-centred strategies, organizations not only increase the likelihood that prospective users will convert into active customers but also streamline communication and collaboration between key stakeholders involved in website development, such as designers, programmers, and project managers. The growing intensity of online competition further accentuates the importance of crafting a distinctive and memorable identity. Consequently, designers continuously explore emerging technological advancements and aesthetic trends to differentiate brands within increasingly saturated digital environments. One notable trend is the integration of 3D visualizations into websites and applications, made feasible by the rapid development and accessibility of 3D design software in recent years [1, 2].

Don Norman defines user experience as encompassing all facets of interaction between the end user and a company's products, services, and systems [3]. To align digital products with user expectations, it is imperative to adopt a user-centred design (UCD) approach, wherein user needs, behaviours, and goals guide every stage of development. In this study, we applied Jesse James Garrett's framework for user experience design, which structures the development process across five conceptual layers: strategy, scope, structure, skeleton, and surface [1–5]. This methodological approach ensures that design decisions are systematically

grounded in both functional requirements and experiential outcomes.

The integration of 3D visualizations into web interfaces has demonstrated potential to elevate usability and enhance overall functionality. 3D assets may serve as focal points for digital communication, evoke emotional responses, communicate brand personality in compelling ways, guide user attention to key interface components, and increase interactivity within the browsing experience [1, 6, 7]. A survey of current applications of 3D visual elements reveals broad adoption across corporate websites, service-based platforms, mobile technology presentations, product showcases, artistic portfolios, leisure and sports websites, and entertainment-oriented digital environments [7–11].

The present research examines the usability effects of incorporating 3D visualizations and animations into web interfaces, with the objective of optimizing user experience and refining the graphical aspects of a marketing agency's website. The study investigates the relationship between 3D content, interface aesthetics, and user perception, aiming to determine whether such integrations enhance the website's appeal and usability [1, 2]. To this end, we formulated the following hypotheses:

- **H1:** Creating 3D animations using a foundational 3D computer graphics, modelling, and texturing program (e.g., Blender) will be simpler, more efficient, and more cost-effective than alternative solutions such as three.js, while also supporting more seamless collaboration between designers and programmers.
- **H2:** Incorporating 3D visualizations into the website will result in a more satisfying user experience.
- **H3:** 3D visualizations will provide additional functionality, including redirection to related UX elements, page-spanning scrolling interactions, and increased user retention time.
- **H4:** 3D visualizations will improve recognition and understanding of website content or services.
- **H5:** 3D animations and 3D elements can be designed to achieve visual harmony with other user interface components of the website.

2. Experimental Part

In the website planning phase, we employed Adobe XD for prototyping, enabling the creation of wireframes, the design of user interface layouts, and the incorporation of interactive elements without requiring any programming. The 3D assets and animations were developed using Blender, an open-source 3D computer graphics software, while post-processing and visual effects were executed in Adobe After Effects and Adobe Photoshop [1, 2, 5].

2.1. Strategy Level

On the first plane—the strategy level—we held a series of interviews and consultations with representatives of the client to identify their needs, concerns, and expectations for the website redesign. The client, a marketing agency, provides services in event planning, graphic design, social media management, online advertising, influencer partnerships, and marketing consultancy. The primary objective of the redesign was to establish a professional and contemporary visual identity for the website, while the integration of 3D elements was intended to create a distinctive and memorable digital presence. Secondary objectives included the logical structuring of information, a clearly organized navigation menu, and the implementation of a bilingual interface (Slovenian and English) to support the agency's planned expansion into international markets.

2.1.1. Target Audience

Based on an analysis of the company's existing and prospective clientele, users were categorized into four distinct target groups:

1. Ages 25–29: individuals who are single or in a relationship, seeking stable employment and housing, or working as self-employed entrepreneurs. They possess extensive technological knowledge and are proficient in the use of most social media platforms.
2. Ages 30–35: users who are partnered or married, newly employed, freelancers, brand owners, or project managers. While technologically literate, they do not actively use all available technologies and typically engage with at least two social networks.
3. Ages 36–45: predominantly married individuals with children, including business

and brand owners, department heads, directors, managers, and project managers. Due to careers connected to marketing or design, they are not only technologically knowledgeable but also experienced users of multiple social media platforms.

4. Ages 46–55: married or divorced individuals, often with children or grandchildren, occupying senior managerial or executive roles such as business or brand owners, department heads, directors, or project managers. They demonstrate intermediate technological competence, limited device familiarity, and minimal engagement with social networks, either due to lack of skill or interest.

Following this segmentation, we observed that most users occupied leadership roles or positions of influence. To better understand their needs and behaviours, we developed four personas aligned with each target group. Each persona was assigned a name, image, age, occupation, objectives, and level of technical proficiency—attributes that most clearly differentiated the user groups.

2.2. Scope Level

On the second plane—the scope level—we translated the previously defined business objectives and user requirements into concrete website functionalities and content specifications. The identification of target groups and the creation of personas informed decisions regarding the website's operational capabilities and helped assess the feasibility of the proposed solutions. Based on this analysis, we defined a set of core functionalities, including a clear and intuitive navigation menu supported by strategically placed call-to-action (CTA) buttons to facilitate seamless movement between pages; a "scroll back to top" feature enabling rapid return to the page header; content filters that categorize projects and blog posts to accelerate content discovery; a structured contact form with predefined fields; and sliding image galleries on project pages that enable the presentation of multiple visual assets while conserving space. Additionally, we implemented a bilingual interface—Slovenian and English—to accommodate domestic users and international visitors alike. The selected content types incorporated into the design consisted of animations, visual materials (illustrations, 3D models, photographs), and text-based information.

2.3. Structure Level

On the third plane—the structure level—we concentrated on establishing the hierarchy and organization of the website's content and functionality [5]. The information architecture, presented in Figure 1, illustrates the relationships between individual pages, their interconnections, and the overall clarity and simplicity of the navigational flow. To develop this architecture and design the accompanying navigational graphics, we used Adobe Illustrator.

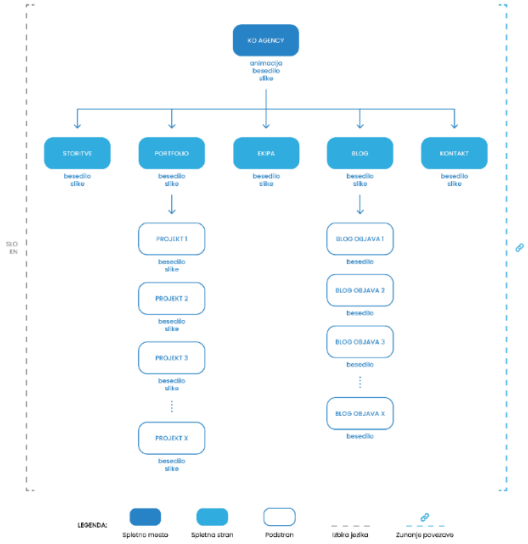

Figure 1. Information architecture of the website.

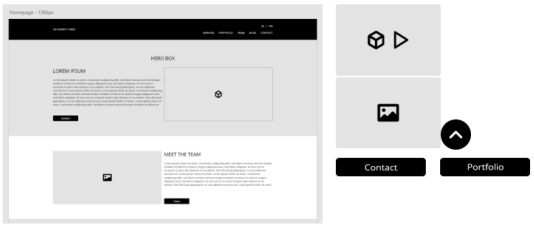

Figure 2. Low-fidelity wire frame and navigation elements, i.e., 3D element, 3D animation, image, CTA buttons, button to scroll to the top of the page.

2.4. Skeleton Level

On the fourth plane—the skeleton level—we developed wireframes that defined the website's navigation and layout. This stage focused on structuring interface elements and determining how users would interact with the site. Adobe XD was used to present this layer and visualize the arrangement of components.

During this process, we designed the website's header and footer and organized various content types across individual pages, including icons and other graphical elements (Figure 2).

2.5. Surface Level

On the surface level of UX design, we dealt with the visual design of the elements we had previously arranged in the skeleton [1, 4]. Visual inspiration for the user interface was graphic designer Peter Tarka [10], who uses 3D graphics in his work in media such as social networks, mobile applications, websites, print products, and augmented reality environments. His style is characterized by contrasts between geometric figures and more abstract images of real things, contrasts between models with few and many details, contrasts between textures, rounded edges, soft highlights and shadows, and eye-catching colours [8].

2.5.1. 3D Elements and 3D Animation

We initiated the creation of 3D animations and models by developing a core concept and corresponding storyboard (Figure 3). The models were categorized into two groups: marketing- or design-related elements, such as a brush, palette, megaphone, and "like" icon, and basic geometric forms, including a cube, sphere, diamond, cylinder, spiral, and similar shapes [5].

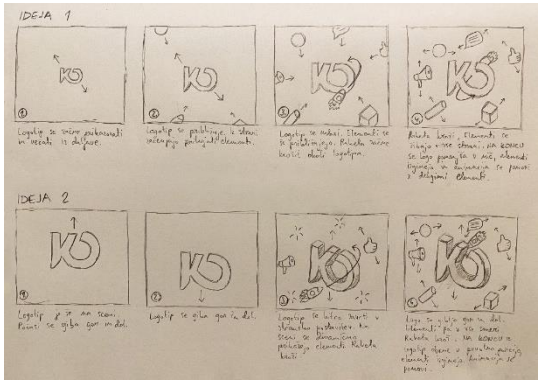

Figure 3. Sketch of one of the animation ideas.

The 3D models were produced in Blender, employing basic primitives, simple tools, and more advanced operations to support the modelling workflow. Guided by stylistic references [10], we applied textures resembling soft, plastic, and metallic surfaces. In addition, we defined the composition and lighting for each animated scene to enhance visual coherence. The models and animations were rendered using the Eevee engine, and their final appearance was refined through post-processing in Adobe Photoshop and Adobe After Effects [1, 2].

2.5.2. User Interface

In parallel with developing the 3D visualizations, we refined the final design of the user interface. The colour scheme was derived from the company's existing brand identity and incorporated light blue (#31ACDF), light orange (#FFA500), black (#000000), and white (#FFFFFF). To complement this palette, we added a darker shade of blue (#0088DC) and introduced grey as a neutral accent. Blue was used predominantly, as it communicates values such as trust, security, and responsibility—qualities central to the company's brand. For typography, we selected the Poppins font (#6E6E6E), chosen for its suitability in both digital and print applications. To complete the interface, we incorporated ready-made graphical elements, including headers, footers, visuals, and buttons, ensuring sufficient spacing between them to achieve a clean, minimalist, and professional appearance.

2.5.3. Prototyping

We finalized the website design by integrating all pages into an interactive prototype created in Adobe XD, which was subsequently used for user testing (Figure 4).

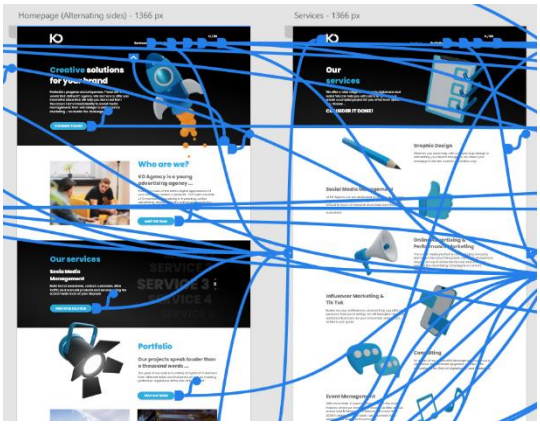

Figure 4. Segment from a prototype in Adobe XD.

2.6. Testing

The first section of the survey addressed the prevalence and users' general perceptions of 3D elements on websites, while the second

section included a user experience questionnaire along with questions specifically related to the visual identity of our website and the integration of 3D visualizations. The survey was created using the 1KA platform [11], which supports questionnaire design, result review, data comparison and analysis, and visual representation of findings in various graphical formats. The full survey is available in the attachments of the reference [1]. To assess usability and user experience, we additionally employed the standardized UEQ methodology [13].

3. Results and Discussion

Figure 5 presents the graphical interface of selected website pages featuring integrated 3D visualizations and animations.

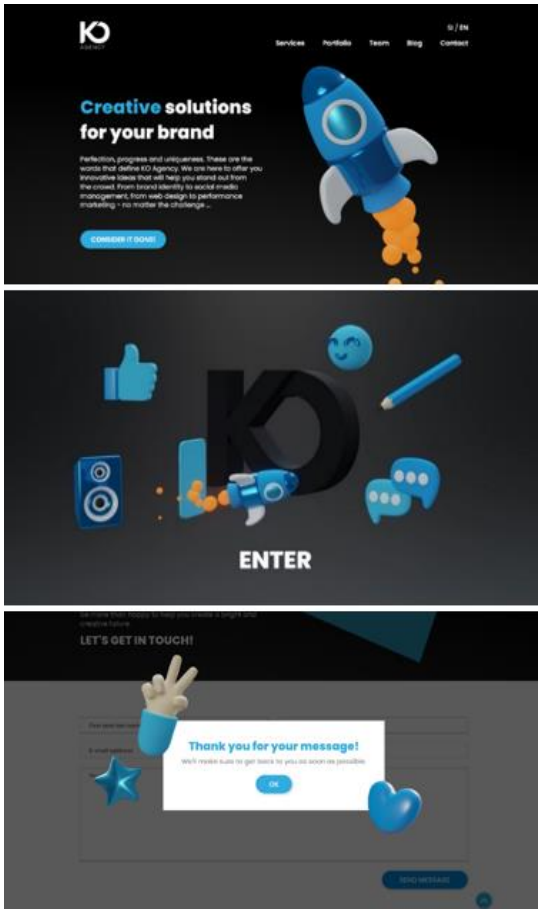

Figure 5. Website interface with the inclusion of 3D visualizations and animations.

A total of 118 respondents participated in the survey, 13 of whom submitted incomplete responses. Consequently, 105 fully completed questionnaires were included in the analysis. Participants filled out the survey in their home environments and took part voluntarily. Data collection was conducted over a one-month period, from 13 January to 13 February 2023.

3.1. First Part of the Survey: Demographics and Analysis of the Use of 3D Web Graphic

The questions in the first set related to the respondents' basic data, such as age and gender, as well as their impression and knowledge about the use of websites containing 3D visualizations. The age categories of the respondents were 18-24 years, 25-29 years, 30-35 years, 36-45 years, and 46-55 years. Most respondents were in the 25-29 age category (31 respondents; 29.52%), with the fewest in the 56 or older age category (only two respondents; 1.90%). In the other age categories, the number of respondents was even, ranging from 10.48% to 20.00%. There were 49 (46.67%) females and 55 (52.38%) males responding to the survey. One answer was "other" with 0.95%.

In the survey, we showed three examples of websites' interfaces with 3D graphics. As answers, we added various characteristics with which we wanted to see what the respondents' first impression was about such interfaces. Respondents could choose several answers (Figure 6). "Modern" and "fun" prevailed as the most chosen features, with 82 votes each (78.10%), followed by "visually attractive" with 79 votes (75.24%). When reviewing the overall results, we noticed that more positive traits from opposing pairs predominate. The exception was the answer "artificial" with 30 votes (28.57%), for which we believe that the reason was the materials used that replicate the appearance of plasticine and plastic.

Another key question in the first section concerned how frequently respondents encounter websites featuring 3D visualizations. Most participants reported seeing such sites only occasionally, indicating a medium or small presence of 3D-enhanced websites online. As illustrated in Figure 7, although 3D visualizations are present on the web, they are far from dominant within the overall digital landscape. Among the websites that do employ 3D elements, respondents most commonly associated their content with entertainment—such as video games, films, and music—as well as marketing and graphic design services.

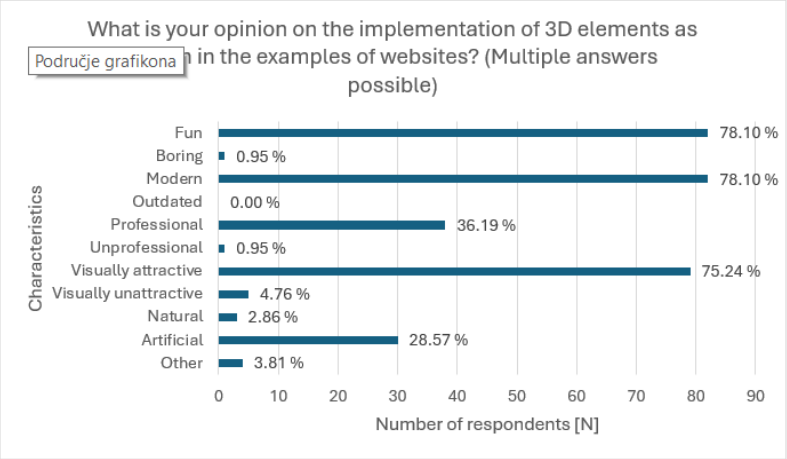

Figure 6. Responses regarding opinions of 3D element implementation in website examples (Number of respondents = 105).

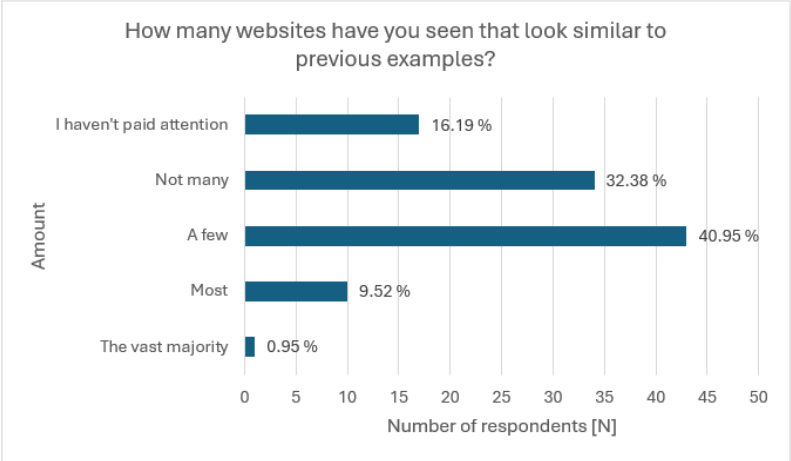

Figure 7. Responses about the number of websites containing 3D visualizations (Number of respondents = 105).

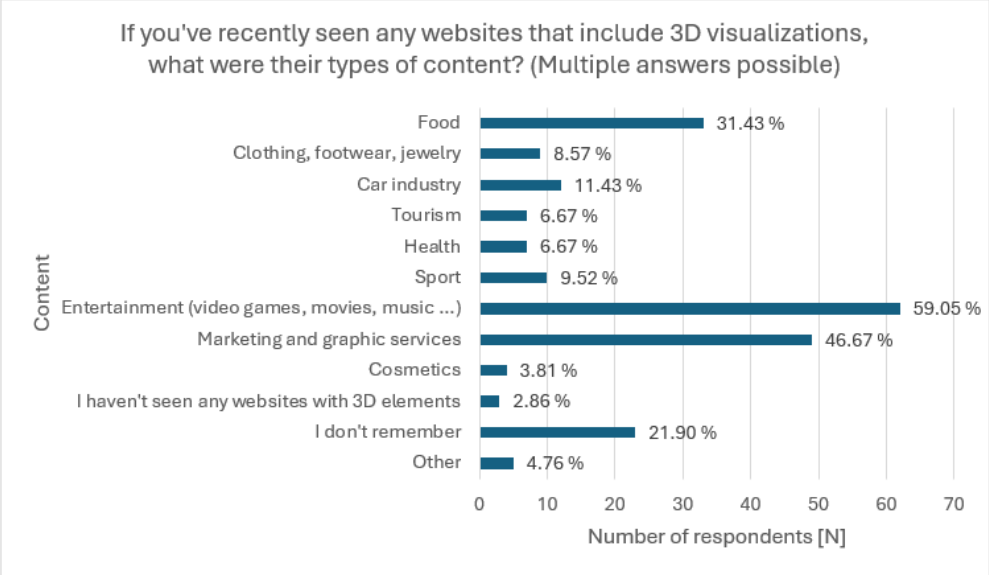

Figure 8. Responses regarding the types of content found on websites with 3D visualizations (Number of respondents = 105).

This question explored the types of content respondents most frequently encountered on websites featuring 3D visualizations. The results (Figure 8) indicate that entertainment-related content—such as video games, movies, and music—was by far the most reported category, selected by 59.05% respondents. The second most frequent category was marketing and graphic services, chosen by 46.67% respondents. Other notable mentions included food (31.43%), sport (9.52%), clothing, footwear, and jewellery (8.57%), car industry (7.14%), tourism (6.67%), and health (6.67%). Meanwhile, 21.90% respondents indicated that they "don't remember". These findings suggest that 3D visualizations are most prominently used in sectors where visual appeal, immersion, and brand engagement are key drivers of user interaction.

3.2. Second Part of the Survey: Prototype Analysis

In the second part of the survey, respondents were asked to examine our prototype and complete the UEQ questionnaire. In this UX evaluation method, participants choose between opposing pairs of characteristics to indicate which best describes the product—in this case, the website. Their responses were subsequently entered into an Excel file equipped with predefined formulas for calculating overall UX scores [13].

The UEQ algorithm initially identified inconsistent responses. To ensure the reliability of the results, data sets containing three or more inconsistencies were excluded from further analysis. The algorithm then recalculated the remaining valid responses and converted them into scores ranging from −3 (lowest) to +3 (highest). The evaluation classified user experience into three overarching dimensions: attractiveness, pragmatic qualities (perspicuity, efficiency, dependability), and hedonic qualities (stimulation, novelty). Our website prototype received strong ratings across all dimensions. Attractiveness achieved the highest score (2.01), followed by hedonic qualities (1.75), while pragmatic qualities received a slightly lower yet still positive score (1.72).

We then compared these results to benchmark data from other products included in the UEQ database [12]. The benchmark categorizes results into six descriptive levels. As shown in Figure 9, our prototype performed exceptionally well: it ranked among the top 10% of products in the categories of attractiveness and novelty, while in the remaining four categories—perspicuity, efficiency, dependability, and stimulation—it received a "good" rating. This indicates that although these scores did not place the prototype among the absolute top performers, it still outperformed more than 75% of the products in the database [13].

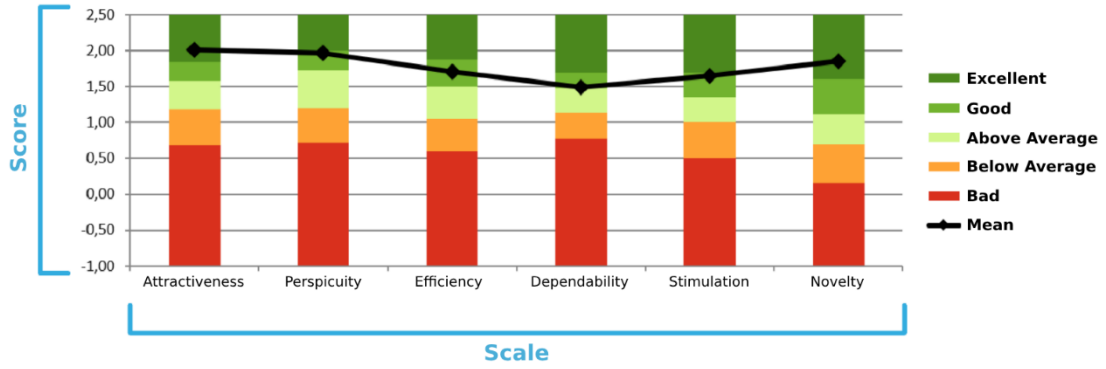

Figure 9. Graph of the results of our product compared to the database of other products [13].

As in the first part of the survey, the second part examined respondents' overall impressions of the 3D animations and elements implemented on our website. The findings again indicated a predominantly positive response (Figure 10). The most frequently selected descriptors were "fun" with 90 votes (85.71%), "visually attractive" with 85 votes (80.95%), and "modern" with 81 votes (77.14%). Additionally, just over half of the respondents—58 individuals (55.24%)—perceived the inclusion of 3D visualizations as professional.

The subsequent set of questions examined the impact of 3D visualizations on user experience. The results (Figure 11) indicated that 3D elements successfully attracted respondents' attention and, when accompanied by text, helped them identify and understand the type of content presented on the website. When asked specifically to what extent 3D graphics influence content recognition compared to text alone, the majority of respondents (61.43%) stated "a lot," followed by "somewhat" (30.00%).

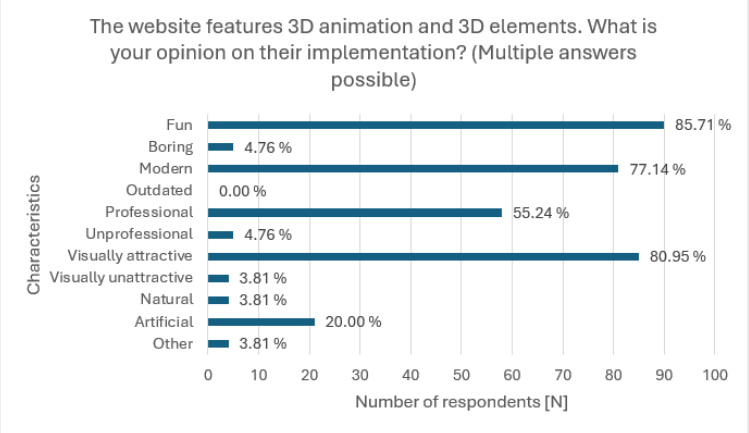

Figure 10. Responses regarding opinions on the implementation of 3D visualizations on the website (Number of respondents = 105).

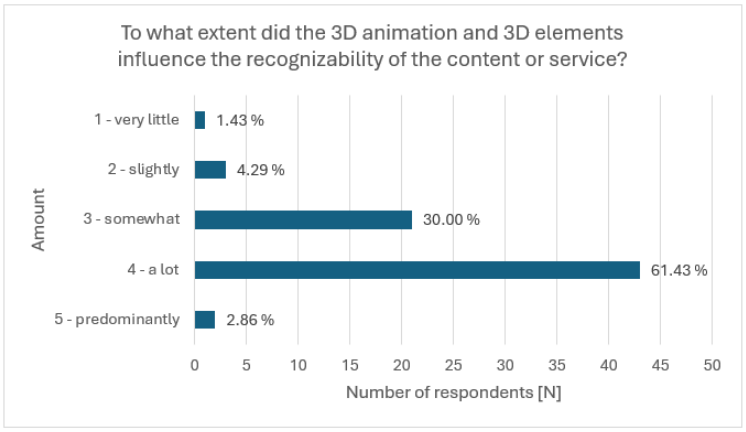

Figure 11. Responses on the extent of the influence of 3D visualizations on content recognizability (Number of respondents = 70).

The following question investigated how respondents perceived the role of 3D animations and 3D elements on the website. The results (Figure 12) show that the vast majority of participants viewed these elements as both decorative and informative, with 79 respondents (75.24%) selecting this option. A smaller proportion (18.10%) regarded the 3D components as purely decorative or solely informative (3.81%). These findings indicate that users generally recognize 3D visualizations not only as aesthetic enhancements but also as meaningful contributors to the communication of information on the website.

A particularly important aspect of the study concerned whether the 3D visualizations actively prompted user actions. Respondents were allowed to select multiple responses. The majority reported that the 3D graphics captured and maintained their attention. As a direct result of viewing the visualizations, 57 respondents scrolled through the entire page, 47 respondents shifted their focus to other interface elements such as text and buttons, and 36 respondents read the full page content. Only nine respondents indicated that the 3D elements did not influence their behaviour, while one participant selected "other" but did not provide an explanation (Figure 13).

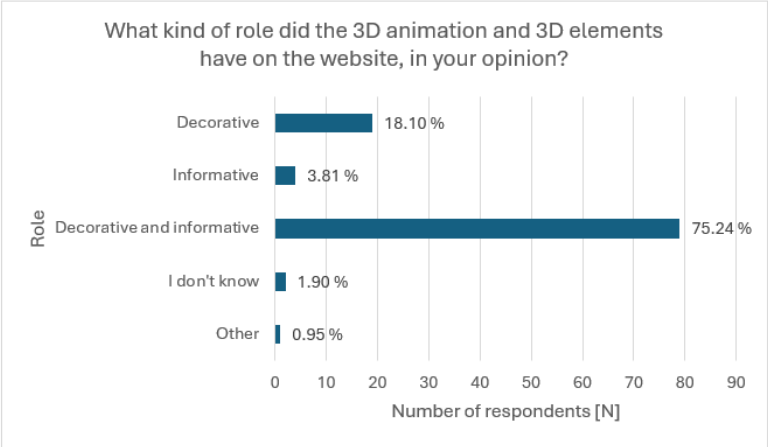

Figure 12. Responses about the role of 3D visualizations on the website (Number of respondents = 105).

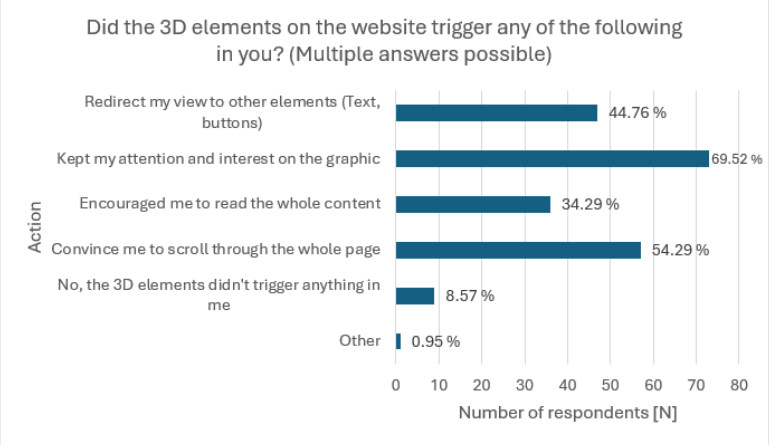

Figure 13. Responses about 3D visualizations affecting the users' actions (Number of respondents = 105).

When respondents were asked whether the inclusion of 3D visualizations caused them to stay longer on the website, 71 participants (67.62%) selected "yes", nine (8.57%) selected "no", and 25 (23.81%) chose "I don't know". We then examined whether these visualizations would encourage users to revisit similar websites in the future. A majority of respondents (66; 62.86%) again answered "yes", while 19 respondents (18.10%) answered "no" and 20 respondents (19.05%) selected "I don't know".

We further explored whether users desired additional interactive features on the site—specifically elements that react upon interaction. The largest share of respondents (43; 40.95%) indicated they would like "more interactivity", 35 respondents (33.33%) expressed "no" interest in this feature, and 27 respondents (25.71%) remained uncertain.

The final question assessed the perceived visual coherence of the website, asking participants whether the 3D graphics aligned with other design elements, such as colours, illustrations, and typography. An overwhelming majority (97 respondents; 92.38%) agreed that the 3D visualizations "fit with the overall visual design", while three respondents (2.86%) answered "no" and five respondents (4.76%) stated "I don't know".

4. Conclusions

3D visualizations on the website interface were shown to appeal to the majority of respondents and were evaluated positively. The findings indicate that these visual elements serve more than a purely decorative function. The 3D graphics increased user interest, encouraged visitors to explore entire pages, and directed their attention toward additional interface elements. Moreover, the presence of 3D elements and animations helped users recognize the website's content and motivated them

to spend more time on the site, with many expressing a willingness to revisit similar websites in the future. Respondents also expressed a desire for enhanced interactivity, particularly for interface components that exhibit motion and respond to user actions.

The use of the user experience questionnaire provided comprehensive insight into the overall evaluation of the website. Respondents rated the website very positively across all UX dimensions. Among the six evaluated categories, attractiveness and novelty achieved the highest scores, a result consistent with earlier findings indicating that 3D visualizations remain present online without being overly ubiquitous. The lowest-rated category, though still satisfactory, was dependability, which relates to users' sense of control over the product. Some respondents attributed this result to occasional performance slowdowns within the prototype caused by the high volume of graphical elements. Overall usability was rated as excellent. Respondents also confirmed that the 3D graphics were visually consistent with other interface components—such as colours, buttons, and typography—while simultaneously providing added functional value. On the basis of these findings, all hypotheses H1–H5 were confirmed.

H1: We confirmed the hypothesis through research on 3D web animations and our previous experience producing 3D animations with computer graphics tools, compared to programming with three.js. Given the background in 3D modelling, computer graphics, and web programming – which is time-consuming and production-intensive, especially when developing new 3D web content – we designed the 3D animation and elements using the free, open-source programme Blender, in a relatively manageable period of time.

H2: The hypothesis was confirmed through testing our website and analysing the survey results. In the research phase, we conducted a survey with questions relating to both the 3D visualisations on our website and the overall impression of the website's image. The vast majority of respondents gave a very positive response to the use of 3D visualisations. We also included an official user experience questionnaire in the research, which yielded positive results. On a scale from -3 to +3, the scores for individual categories were as follows: attractiveness 2.01; perspicuity 1.96; efficiency 1.71; dependability 1.49; stimulation 1.65; novelty 1.85. In two categories (attractiveness and novelty), the website was rated "excellent" (in the top 10% of the benchmark), while in the other four categories (perspicuity, efficiency, dependability, and stimulation), it received a "good" rating (our prototype's score was below the top 10% of products but above 75% of inferior products).

H3: We confirmed the hypothesis by testing our website and analysing the survey results. In the research section, we asked respondents about the impact of 3D animation and 3D elements on their experience. A total of 69.52% of respondents stated that 3D visualisations captured their attention and interest. More than half (54.29%) browsed entire pages due to the use of 3D visualisations, and almost half (44.76%) reported that 3D visualisations helped redirect their gaze to other elements, such as text and buttons. The use of 3D visualisations also indicated that most visitors would like to return to this type of website multiple times.

H4: In the research part, we asked respondents about the impact of 3D visualisations on the recognisability of the content presented on the website. The vast majority of respondents identified the type of content and attributed its recognisability largely to the combination of 3D visualisations and text. In a more detailed question, we found that 3D animation and elements had a greater impact on recognisability than text.

H5: Based on the respondents' answers, we concluded that 3D visualisations align very well with the rest of the visual elements, such as illustrations, colours, fonts, and the content itself.

The results also highlight opportunities for further development and research. Although dependability received the lowest score, it remained within a positive range, suggesting room for technical improvements rather than conceptual shortcomings. Some respondents linked this score to occasional prototype slowdowns, implying the need to optimize 3D assets, reduce file sizes, or streamline rendering processes. Future work could focus on increasing interactivity, provided that additional resources, expertise, or budget are available. Further research might also compare different

styles of 3D elements, contributions from various designers, and alternative layouts or functionalities to determine how distinct design approaches influence user perception and experience.

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