Investigation of Collaborative Virtual Environments in the Automotive B2B Sector with Mozilla Hubs

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The transition from traditional meetings to online meetings has accelerated dramatically in recent years. This poses some challenges, especially for people working remotely. Even though most of the work in the Business-to-Business (B2B) sector of the automotive industry is done online, many situations arise where products have to be reviewed in person. In this paper, the transmedia tool *Mozilla Hubs* is used to investigate requirements for collaborative virtual environments and evaluate whether the tool could be suitable for digital product reviews in the B2B sector. The results show an overall positive and enjoyable user experience. While the transmedia approach gives the user the freedom to choose their preferred device, it also means that the the experience is less consistent and varies in graphical fidelity and immersion. This can result in a presentation of the 3D models which is not representative of the actual asset. For the purpose of reviewing a design, this can be detrimental. However, *Mozilla Hubs* can be utilized for meetings that do not require complex 3D visualizations.

CCS Concepts: • **Human-centered computing → User studies**.

Additional Key Words and Phrases: User Experience, Transmedia Experience, Online Meetings, 3D Collaboration, Collaborative Virtual Environments, Mozilla Hubs

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1 INTRODUCTION

During the global lockdown, small online meetings and bigger digital conferences have taken on a whole new meaning. They enable digital face-to-face communication when direct interpersonal contact is not possible. The worldwide spread of the Corona virus has posed unprecedented challenges to the globalized world and had a significant impact on it [31]. Tools like *Mozilla Hubs* transfer elements of conventional online meetings into a three-dimensional virtual world [23]. The web-based technology that is used has the advantage that many different devices are able to attend the meeting. In addition, each device used provides other benefits, resulting in a transmedia experience [17, 18]. The advantage of designing a transmedia experience is that users are more involved in the experience instead of passively observing a meeting [13].

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The purpose of this work is to identify requirements for collaborative virtual environments that are important to review digital products in the automotive B2B sector. The suitability of *Mozilla Hubs* for such meetings will be evaluated. For this, experts with a background in the automotive industry and experience in the creation of 3D visualizations will be interviewed. Based on the assumptions and expertise, a prototype will be created using *Mozilla Hubs* and later evaluated by a focus group. A product review meeting will be simulated in order to identify problems and strengths of *Mozilla Hubs*.

2 RELATED WORK

This paper investigates requirements for virtual three-dimensional collaboration and how to create a positive user experience for meeting participants. In this chapter, the fundamentals of user experience are explained. Additionally, related work about conventional online meetings as well as about already existing collaborative virtual environments is presented.

2.1 User Experience

UX is the holistic experience with a product [16]. Not only interactions are taken into account, but also subjective impressions that arise before, during and after use [6]. Consequently, UX also includes expectations for a product and reflections after using it. The focus is not on the individual product but also on everything related to it. Experiences are perceived differently. For example, the use of avatars in virtual meetings might create a positive experience for users who want more interaction with their colleagues, while a negative experience could be created for users who are only in the role of an observer. It becomes clear that the UX depends on the subjectively perceived quality, which determines whether a product will be used in the future or not [16].

2.1.1 Hedonic Quality. UX is about creating short-term positive experiences, pursuing long-term meaningful objectives and developing capabilities [5]. Using the example of an online meeting with avatars, a short-term positive experience could be seeing colleagues as animated characters. A long-term meaningful objective could be a better and more direct communication over time when a team has to work online. Positive experiences are driven by positive emotions and occur when psychological needs are fulfilled. Psychological needs are present in varying intensities in every person, regardless of culture. They express requirements and desires [14]. When needs are fulfilled by a product, the potential to create positive experiences arises [15]. This ability of a product is referred as hedonic quality.

2.1.2 Pragmatic Quality. Usability is the part of UX that focuses on interacting with a product. It describes the effective and efficient achievement of quantified objectives [1]. For good usability, interactions should be practical, predictable and clear [16]. The ability of a product to achieve quantified goals intuitively is referred as pragmatic quality.

2.1.3 Human Centered Design Process. The human-centered design (HCD) process is an approach for developing user-friendly and useful interactive systems that focus on user requirements. It is described in the ISO 9241-210 norm [6]. It consists of four phases. In the first phase, the context of use is to be understood. In the second phase, the user requirements are to be specified so that a design solution can be developed in the third phase, based on the user requirements. This design solution is then evaluated in the fourth phase. Each of the phases can go through several iterations. The goal is to develop a product that satisfies the user requirements.

2.2 Transmedia Experience

The term "transmedia" is originally defined in the context of storytelling. It represents a process where elements of a story get dispersed across multiple delivery channels in order to create a unified entertainment experience [19]. That means multiple platforms are integrated that work together for better results [9, 13]. The variety of channels and devices describes a multi-modal approach that makes the experience accessible for a wider audience among the users. In an ideal realization, each medium or platform makes a distinctive contribution to the overall understanding of the experience [17, 18]. Using the example of an online meeting, there could be multi-modal access through different types of devices, such as smartphones and personal computers (PC). The contribution of the smartphone could be mobile access from anywhere, whereas a computer provides a bigger screen size. A responsive transmedia experience enables users to consume content, when, how and where they want [11]. A further characteristic in transmedia experiences is active participation through a variety of touchpoints. This leads to a far more engaging process than just passively consuming content [13].

2.3 Conventional Digital Conferences

Working with various forms of video conferencing systems increased rapidly since the start of 2020. The following year, roughly 50% of corporate meetings in the technology sector were being held digitally [31]. Computer and smartphone-based systems, in particular, are widely spread amongst companies and enable a wide variety of interaction processes (e.g. presentations, discussions, and questioning) that can take place both between internal organizational actors (supervisors, regular employees, etc.) and between actors external to the organization, such as customers, clients, applicants, or patients. Video conferencing (VC) supports more complex forms of interaction compared to traditional communication methods (e.g., letters, telephones, and e-mails). Gathering restrictions due to the SARS-CoV-2 virus have challenged the organization of physical multidisciplinary meetings, requiring innovative remote meeting methods, such as immersive virtual reality (VR) [33].

Although online conferences are being used more and more often and show promise, it is unlikely at this stage that they will be a fully-fledged alternative to face-to-face meetings. The limitations lie primarily in appearance, the expression of emotions, and the control of the participants. The main difficulty is to keep the attention of all participants during the entire course of a conference, especially when they do not have to interact actively. Whereas in on-site conferences, the presenter can directly perceive the feedback of the participants, in the digital world they must specifically approach individual persons and obtain such feedback [4].

2.4 3D Collaboration Tools

In recent years, more and more tools have been created with which people can interact with each other virtually. Due to the pandemic, more people want flexible work options and re-thinking what it means to be in an office [27]. Even before contact restrictions, it is also often difficult to to attend conferences due to travel restrictions, time limitations, or accessibility challenges [24]. Even live events in nightclubs or at festivals cannot take place at the moment, so organizers are creating virtual fallback options [12, 32]. The following tools should provide an overview of the current trends in 3D collaboration.

2.4.1 Horizon Workrooms. Workrooms Horizon is a collaboration experience that lets people come together to work in the same virtual room [27]. The tool is avatar based and offers a huge variety of customization so that users are able to express their own individual style. A main feature is hand tracking, which allows for natural expressions and body

language. It is already shown in other studies that natural interactions [29] and body language cues [2] are important for the quality of the experience. Other features are remote desktop streaming, video conferencing integration and keyboard tracking in order to bring your whole workspace into the virtual office. Users without access to a VR headset can use a desktop application to join video calls but other feature are not supported [27]. This does not, however, create a transmedia experience where every device is part of the experience.

2.4.2 Bootshaus XR. The Bootshaus is a reputable night club in Germany that offers their party-goers a novel XR party experience from their homes. The first event took place in January 2022 where a dj duo played a live set in a precisely replicated virtual environment of the club [12]. The attendees were able to join the experience on any device that has access to a web browser. Users could customize a personal avatar to move and dance in the virtual club area. Some studies found that users have difficulties with setting up their devices for virtual collaboration [7]. The browser-based approach of *Bootshaus XR* mitigates some of these issues and enables a transmedia experience with minimal barriers of entry.

2.4.3 Mozilla Hubs. Mozilla Hubs is another web based collaboration platform with which users can create three-dimensional virtual rooms [23]. Users with mobile devices, PCs and also Virtual Reality Headsets can communicate and interact with each other in one environment. In a study by Le et al., participants valued that they can attend the conference from anywhere and on any device [21]. The *Spoke* feature gives the host the ability to create their own environment for a meeting. For this, they can either use an already existing environment or create their own customized scene by importing from external modeling software. This makes Hubs versatile and suitable for different purposes such as virtual classes, art exhibitions, or a gathering with friends [23]. Features such as spatial audio, screen and document sharing, a 3D model viewer, and a pen tool, are intended to create a richer experience. The results from Le et al. indicate that *Hubs* offers significant potential for future virtual gatherings where experts come together to share innovative ideas [21].

2.5 Hypothesis

The advent of VR workplace tools can be explained by a set of hypotheses which are investigated in this paper:

H1: Collaborative virtual environments have the ability to create a richer experience than conventional online meetings.

Virtual meetings with 3D avatars and spatial audio in *Mozilla Hubs* [23] could have the ability to create a more interactive experience that engages users. Difficulties like keeping the attention of all participants or getting more feedback from the audience [4] could be mitigated.

It is also assumed that:

H2: The main advantage of *Mozilla Hubs* is the integration of different devices and the minimal entry barrier.

Mozilla Hubs and XR Bootshaus adopt the transmedia approach of integrating several devices into the experience. With the variety of channels and devices, a wider audience among the users is accessible [13]. The participants of other studies value the option to attend meetings from anywhere, on any device [21]. At the same time, the web-based design of *Mozilla Hubs* makes it relatively easy to join collaborative virtual environments [8].

3 EXPERT INTERVIEWS TO UNDERSTAND THE CONTEXT OF USE

In this paper, we investigate whether *Mozilla Hubs* is a suitable replacement for in-person design review meetings. Our research is guided by the HCD process and develops a prototype based on insights gained from expert interviews. These interviews were conducted to gain a better understanding of the context of use. A focus group was later tasked with assessing, whether the prototype satisfies the users' needs.

3.1 Method

Expert interviews are a common method to understand the context of use and get insights as they can be used to ask about users' expectations and requirements of a system and to evaluate ideas [26].

Experts from the B2B sector who have experience with large online meetings and design shows, were surveyed and divided into two groups. The first group consists of three employees from a large automotive company who are involved in design shows and the second group comprises two experts in the field of VR and 3D visualization. The age of the experts ranged from 26 to 32 years (M=29.4, SD=2.4). Four of the five participants are male, the other is female. No distinction was made between genders.

First, the expert was given an introduction to the topic and an explanation of how a design show is defined and what transmedia means. For the next 30 minutes, open questions were asked about digital meetings and 3D visualizations. Depending on the subject's background, the topic of 3D visualizations was addressed to a greater or lesser extent. After that, *Mozilla Hubs* was briefly introduced and the expert was allowed to explore the room. In the *Mozilla Hubs* room, a 3D model of a vehicle was already visible. Afterwards, the expert reflected upon their experience and was asked about their requirements for such a room.

3.2 Results

The results of the expert interviews from the B2B sector and the field of VR and 3D visualizations are summarized below.

3.2.1 Problems with Conventional Online Meeting Tools. The experts from the B2B sector have multiple online meetings a day and work mainly from home. They are provided with a business laptop and a smartphone. Common meeting tools are Microsoft Teams and Zoom. The experts noted that interacting with their colleagues is significantly more difficult in an online setting. Colleagues are less inclined to provide feedback, the mood and atmosphere can be interpreted more poorly, and facial expressions and gestures are missing when attendees are only participating via voice. Another problem is that one-on-one conversations are less likely to occur. Talking to a coworker in a more casual setting about related projects happens naturally before and after an in-person meeting. When working from home, they have to specifically arrange an appointment. Meetings take on a more functional purpose and interactions are less personal, resulting in a greater perceived distance between one another.

3.2.2 Design Review Meeting for Products. When it comes to design reviews by a team or department, the experts meet their colleagues in person. For larger events, hybrid meetings are held where a few colleagues present physical product hands-on via live stream while the other participants attend virtually. The experts are of the opinion that three-dimensional visualizations show a significant potential for product presentations. However, they remark that visualizations are only suitable up to a certain stage in prototyping for physical products. Touch and feel plays an important role in the later parts of their development process. Accurate scaling and geometric ratios, as well as errors

and imperfections, only become visible, if a physical representation is used. Moreover, designers and engineers are interested in details such as lighting, surface textures and materials. This requires a high fidelity rendering of computer generated images.

3.2.3 Business Value Requirements. The requirements for a tool like *Mozilla Hubs* would be spatial audio for one-on-one conversations, an easy interaction and navigation across all devices, and realistic scales and ratios. In addition, tools for surveys, feedback and reactions are desired. The experts see the unique selling point for Hubs in the transmedia approach. It is very useful in order of a variety of devices within the company or at suppliers or customers. They also mentioned that the access via web browser is easy.

3.2.4 Technical Requirements. The experts from the field of VR and 3D visualization gave insights on the typical requirements of customers. Business Partners in the automotive industry prefer visualizations with a high fidelity. Crafting detailed assets can take several days to weeks due to the need for high geometric detail and realistic materials. Many of the experts' customers use VR for a more immersive experience and a more life-like inspection of the product. The experts believe that *Mozilla Hubs* is a great tool for meetings in general but not suitable for design reviews. If the application is intended to run both on PCs and mobile devices, a wide range of computational performance needs to be considered. A browser based delivery further limits, how complex a scene can be.
In light of these technical restrictions, the following hypothesis needs to be verified:

H3: *Mozilla Hubs* is not suitable for design reviews due to insufficient visualizations caused by the limited performance of devices and browsers.

4 MOZILLA HUBS PROTOTYPE

In order to evaluate the hypotheses stated above, a virtual 3D environment using *Mozilla Hubs* was created through which people with different devices participate in a design review meeting. The range of possible devices includes computers, smartphones, and VR headsets from any manufacturer. When first joining the virtual experience, participants are presented with 3D models of automotive parts, gather information about them, and discuss them in small groups (Fig. 2). Spatial audio enables such discussions without causing interference. Afterwards, each participant has the opportunity to give a vote to the automotive part that they personally liked best.

The prototype was build using *Mozilla Hubs'* Spoke feature to create an individual room for the automotive meeting. For the car and wheel assets, various templates from Sketchfab [30] were used and then completely reworked in Blender [10]. The final models were exported as `.glTF` files and imported into *Mozilla Hubs*.

5 EVALUATION OF THE PROTOTYPE

To follow Nielsen's recommendation to have participants go through real tasks in a user test [25], a virtual design show was simulated. To make the design show as authentic as possible, the users were not invited individually but rather in a group. Due to the limited number of participants and the wide range of supported platforms (VR, PC, and mobile), the same focus group went through the experience twice using different devices.

5.1 Focus Group Method

For the focus group, four participants were selected who have a professional background in online design shows and 3D visualization. In each case, at least two of the participants knew each other. As noted in the expert interviews, the

Fig. 1. Welcome area of the *Mozilla Hubs* room.

Fig. 2. *Showroom 1* area where participants can view and discuss car rim designs.

Fig. 3. *Showroom 2* area where participants can view and discuss exterior colorways.

Fig. 4. Wall onto which participants can cast their votes using *Mozilla Hubs'* pen tool.

participants were also divided into two user groups. One group consisted of two employees from a large automotive company and the other one are experts in 3D visualization. Even though the participants were divided into two user groups, they all had the same level of education and work in a similar field. This ensures that the members of the focus group can all partake in the discussion and provide meaningful insights based on their area of expertise [20]. The participants were on average 31.3 years old (SD=4.1).

After they were introduced to one another, the participants were given a *Mozilla Hubs* link and told who should participate with which device. In the first round, three participants took part on a laptop and one participant used a VR headset. The participants were guided through the design show prototype. In the end, they were asked to split into

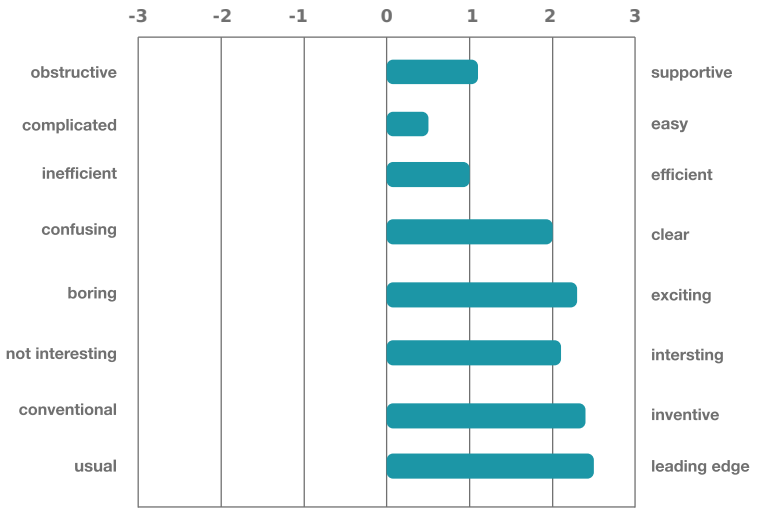

Fig. 5. Mean of the UEQ-S questionnaire results. Each item is given a score between -3 and 3, corresponding to the negatively and positively worded properties respectively

two groups to talk about the design and make use of the spatial audio feature. Each of the participants then filled out the UEQ-S questionnaire [28]. It consists of eight opposing properties, which a product can have. The first four items measure the pragmatic qualities and therefore the usability of the product. The last four items measure the hedonic quality.

Afterwards, a second round of the design show was conducted where each participant used a device different device from the first round. Two participants took part on a mobile device, one participant on a laptop and one used a VR headset. The first round was conducted in the same way as the second round and the participants were then asked to fill in the UEQ-S questionnaire.

After the user study was concluded, the participants held an open discussion guided by a set of leading questions. The conversation focused on usability issues, the sense of presence, the difference between the end devices, and the benefit of *Mozilla Hubs*.

5.2 Results

5.2.1 User Experience. The UEQ-S was quantitively evaluated using a standardized *Excel* spreadsheet [22]. The items which correspond to the pragmatic qualities, were given a mean score of 1.2 ($\overline{SD} = 1.1$) (Fig. 5). The *complicated-easy* item received the lowest score, while still trending towards the positively worded property ($M = 0.5$, $SD = 1.9$). The *confusing-clear* item received the highest score of the pragmatic qualities ($M = 2.0$, $SD = 0.8$).

The items which correspond to the hedonic qualities, were given a mean score of 2.3 ($\overline{SD} = 0.6$) (Fig. 5). All hedonic items show a similar trend towards the positively worded properties.

As shown in Fig. 6, the pragmatic quality is *average* compared to other products which were also evaluated using the UEQ-S questionnaire. The hedonic quality, however, can be categorized as *excellent*. Hypothesis 1 (*Collaborative virtual environments have the ability to create a richer experience than conventional online meetings.*) can be partially confirmed because our prototype's *excellent* hedonic quality indicates a rich experience.

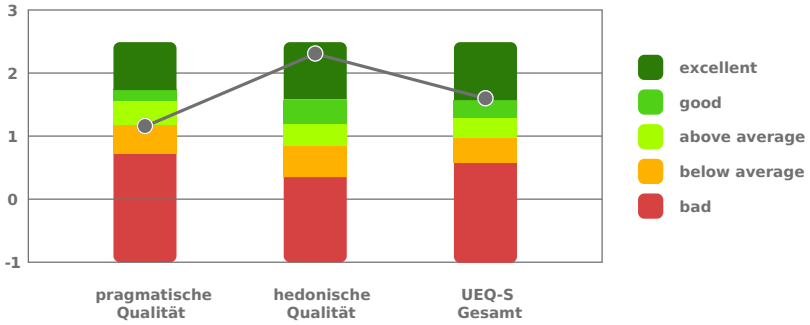

Fig. 6. The result of the UEQ-S in relation to benchmark values.

5.2.2 3D Collaboration Experience. The qualitative data of the focus group were analyzed according to Mayring's *inductive category formation of the qualitative content analysis* [3] and divided into the following categories: *Sense of presence; Problems with Mozilla Hubs; Requirements for Mozilla Hubs; Idea of use; Advantages of Mozilla Hubs; Comments on the end device.* The results are structured based on the hypotheses and linked to the individual categories.

All four participants said that they had felt more present in the *Mozilla Hubs* room than in a traditional online meeting. Three out of four mentioned that the avatars who indicate when you are speaking also made them feel more physically present. In addition to this, two out of four mentioned that the 3D sound provided one a greater sense of belonging. Hypothesis 1 (*Collaborative virtual environments have the ability to create a richer experience than conventional online meetings.*) can be confirmed based on the statements.

5.2.3 Transmedia Approach and Entry Barrier. All participants mentioned that joining the design review meeting through a link in a web browser was particularly user-friendly. However, the individuals who used a standalone VR headset had technical difficulties when first entering the virtual room. The graphical fidelity was also worse compared to a VR headset that is connected to a dedicated computer. This resulted in a presentation of the 3D models which was not representative of the actual asset. For the purpose of reviewing a design, this can be detrimental. Three out of the four participants noted that the quality difference between the devices posed a risk to their experience. Hypothesis 3 (Mozilla Hubs *is not suitable for design reviews due to insufficient visualizations caused by the limited performance of devices and browsers*) can thus be confirmed.

In addition to that, they were confused by the fact that only one hand can be used to interact with the environment. While they did find fault with the quality and controls, they both stated that they would prefer the experience with the VR headset because judging geometric proportions is more difficult when viewing a 2D projection on a computer screen. They also indicated they did not get motion sickness. The experience lasted about 10 minutes. The two participants who tested the controls both on a smartphone and on a laptop indicated that they preferred the phone's simple and intuitive controls. Additionally, one of the two individuals stated that the control on the laptop was mentally exhausting and the other individual stated that the controls were less precise and accidental inputs were more common. Hypothesis 2 (*The main advantage of* Mozilla Hubs *is the integration of different devices and the minimal entry barrier.*) can be partially confirmed. On the one hand, the transmedia approach allows for a wide range of devices to easily access the meeting through a link, which was valued by the participants. On the other hand, the devices don't offer the same experiences in terms of their graphical fidelity, the representational accuracy of the design, and their controls.

5.2.4 Suitability for B2B Customers. All participants stated that the graphical design of *Mozilla Hubs* is too playful for a professional environment. One of the four participants indicated that none of the avatars would be suitable for a member of the management board. One participant stated that they were not aware of which end devices the other participants were in the *Mozilla Hubs* room with. The other participants gave him nods of approval. Two people stated that the hardware would require further development, and one participant stated that they were missing specific features such as distinct user roles with restrictions, more productivity related features, and a collaborative 3D modeling tool.

In addition to the problems that *Mozilla Hubs* presents, the participants also provided ideas for using Mozilla Hubs. The ideas were provided by one participant each: *Team meetings where there is a lot of talking; Meetings in which intermediate states of prototypes are shown; Rough mapping of geometric shapes; Internal exhibitions where products or ideas are presented.* Another participant predicted that the processing performance of future devices will eventually be a non-issue and could then see the benefit of using *Mozilla Hubs* for presenting 3D models.

6 DISCUSSION

The results of the UEQ-S questionnaire show that a positive user experience is achieved using *Mozilla Hubs*. The excellent hedonic quality can be explained by the fact that it is a novel tool that users are interested in. The focus group subjects had fun exploring the interaction methods and collaborating with other avatars. The comparatively lower pragmatic quality scores are consistent with the technical difficulties experienced by the participants, resulting in a low score for the item *complicated-easy*. Nevertheless, technologies like *Mozilla Hubs* offer advantages for digital meetings, especially as users feel more present [2, 24]. This is consistent with the findings from Le et al. on how collaborative virtual environments offer significant potential for future virtual gatherings and can potentially replace face-to-face meetups [21].

The transmedia approach enabled users to experience the meeting with various devices, contributing to a better overall experience [18]. Subjects remarked that certain devices offer certain advantages. While VR created the greatest sense of presence, interaction on the smartphone was the most intuitive and the desktop had the best graphical presentation. A major downside also becomes obvious here. Each technical device used for the evaluation displayed the products in a different way. This makes it difficult to use *Mozilla Hubs* for product reviews in companies which have very high demands on visualizations, according to the experts. In addition, *Mozilla Hubs* lacks some features for the corporate context, such as avatars with characteristics of real users and representations of facial expressions and gestures.

At the moment, technical constraints of browsers and devices prevent *Mozilla Hubs* from being used in the automotive B2B sector for product reviews. However, the focus group has shown that typical problems of conventional online meetings such as the lack of engagement of the participants or the lack of directly presented feedback can be overcome in virtual meeting spaces by giving each participant their own virtual character and offering many new interaction possibilities.

7 SUMMARY AND OUTLOOK

In this paper, requirements for collaborative virtual environments were collected with the help of expert interviews. It became clear that virtual environments have the potential to solve existing problems of conventional online meetings, such as the lack of interaction and feedback due to the digital distance between participants. There is also a need for 3D visualizations in the B2B sector of the automotive industry. It enables companies to evaluate and provide feedback on

new and upcoming products. However, the experts assumed that a transmedia tool like *Mozilla Hubs* cannot provide the level of detail required for the representation for such product models.

A prototype was then created and evaluated with a focus group to validate the results from the interviews. The prototype confirmed that users generally have a positive user experience and enjoy using the tool. The transmedia approach has the advantage that users can use their preferred device but also the disadvantage that the representations and interactions differ between devices. The focus group confirmed the experts' assumption that the visualization of products is not sufficient detailed for digital design reviews. However, *Mozilla Hubs* can be used for other meetings that don't require complex 3D visualizations.

To further examine the results of this paper, tools utilizing game engines could be compared with browser-based tools to identify the advantages and disadvantages of transmedia web-based approaches in comparison to performance-based approaches.

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