Sociability in Virtual Reality: Two Evaluations along a Design Science Research Process

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Abstract

This study investigates sociability in the context of immersive virtual reality (VR). A Design Science Research process was applied and three iterative development versions of a VR application were studied. Sociability around the technology was investigated with two theoretical perspectives: social interactions and social presence. First, the importance of social interaction elements (shared knowledge, mutual trust and influence) were evaluated in a qualitative analysis. Secondly, the impact of social presence was evaluated in an experiment. The findings indicate that users highly prefer personal social interaction as a part of a VR experience. The key contributions to the field of social computing are i) Introducing the four design principles that can be empirically linked to beneficial sociability, ii) identifying the theoretical logic of linking design features through behaviors/emotions to cognitive outcomes in the case of virtual reality, iii) exemplifying the use of Design Science Research in the field of social computing.

1. Introduction

Immersive virtual reality (VR) technology enables multi-sensorial experiences that have potential to empower users through increased perceptual fidelity [1]. Recent technological advancements have, again, created a buzz in popular media [e.g., 2,3,4] and academic research has started to increase in volume and breadth. The current VR-related customer experience literature has mainly concentrated on the user's individual interactions with the system for example by studying their interactions with virtual objects [5], storylines and narratives [6] and sensory effects including visuals, sounds, movability and haptics [7,8,9].

However, it has been noticed that social factors related to the use context may significantly affect the user experience. It has been found that VR may provide improved social interactions between the user and other users and fellow customers as well as with salespersons and business representatives by creating new types of encounters [10,11,12]. It has also been found that VR can generate positive word-of-mouth in users' own social networks [13] and that advertisements using immersive technologies can create increased engagement between the user and the brand [11]. According to research, these interactions can have a positive effect on sales by helping the customer to better understand the benefits of the sold service [12]. These notions warrant a deeper investigation of the effects that social interactions have on the way VR technology is being used, and to what extent personal guidance is needed when using VR applications – a key question regarding scalability of the technology.

In this research, we focus on interactions around VR technology in the following social contexts: i) user as a part of peer-group, ii) user interacting with a service employee in person, and iii) user interacting with a service employee remotely. In addition, we account for the way the user interacts with the system and investigate whether it is dependent on the social context. We focus on three key interaction characteristics: shared knowledge, mutual trust and influence in line with Nelson and Cooprider [14]. These variables have not previously been studied in VR technology use. Our focus is particularly on how to facilitate social interactions between customers and their front-line service employees [15], and we study ways of increasing meaningful interactions. The research question is the following: How does the use situation affect social interactions between customers and front-line employees when using a VR application and how to enhance them?

Design science research (DSR) methodology [16,17] was used to describe the development process of a VR application consisting of three iteratively developed versions of the application. In DSR literature, the versions are called artifacts. Artifact 1 enabled both peer-group use and use together with a service employee, artifact 2 was designed to be used together with a service employee, and artifact 3 remotely with a service employee. The application versions were developed by a forest industry company and it aims at digitalizing labor-intensive customer service in a use context that is challenged by long physical distances. The qualitative evaluations of the development versions focus on social interactions when using the VR application. The empirical data was collected during demonstration phases of the artifacts as the customers were using them and it consists of transcribed video recordings of the customers testing the application and transcribed audio recordings of customer interviews. The investigation was deepened with a between-subject experiment to test the effect of a service employee helping the customer in person vs. remotely when using the application.

The key contributions to the field of social computing are i) Introducing the four design principles that can be empirically linked to beneficial sociability, ii) identifying the theoretical logic of linking design features through behaviors/emotions to cognitive outcomes in the case of virtual reality, iii) exemplifying the use of DSR in the field of social computing.

The paper is structured as follows: First, we introduce our theoretical perspectives to sociability that we use to study VR technology use. Second, we present the DSR methodology including artifact design, development, demonstration and evaluation as well as the experimental design. The results are presented according to the study framework followed by summary and implications.

2. Social construction approach

According to the service-dominant logic, the service is the fundamental basis of exchange and value is co-created with customers [18]. Both the service exchange and the value co-creation are influenced by social forces [19]. Edvardsson et al. [19] present four propositions for the social construction of the service exchange and the value co-creation. According to their propositions, the value is interactive, relativistic, and meaning-laden in a given context. In addition, different customers do not by all means use and value resources in the same way. Both service exchange and value co-creation can also be asymmetric as the benefits are not always shared equally between the actors. Finally, the roles of the service exchanges and actors are dynamic in constantly evolving and adapting service systems.

These social construction propositions have been widely applied in business and system studies in designing e.g. social interactions and social presence. The next sub-chapters introduce these concepts and how we use them in this DSR study to increase the beneficial sociability of the VR systems.

2.1. Social interaction and virtual reality

Social interaction elements such as trust and influence between system users can lead to shared knowledge and have a significant impact on the system performance in terms of e.g. value co-creation and co-innovation processes as well as customers' brand attitude [20,21,22].

Following the social interactions theory [14], trust is "a set of expectations shared by all those in exchange" [23] and is usually created through repeated communications [14]. Besides being a feature of interpersonal relationships, trust can also occur towards an information system. Personal experience, familiarity, affiliation, belonging, transparency, factual signals and heuristic cues may create trust in information systems [24]. While face-to-face interactions are often considered fundamental in creation of good-quality relationships and trust [25,26], also computer-mediated trust can evolve to the same level over a time [27]. Similarly, also VR applications induce reciprocal behaviors [10] suggesting potential in trust-creation.

Influencing someone is one type of social interaction [14]. Among the influence methods, motivating, extracting and creating common goals [28], is one. In addition, creating cognitive and emotional influences are distinguished as separate persuasion methods [29].

Shared knowledge between a customer, a salesperson and other groups can be created through information systems in the presence of trust and influence [14]. Shared knowledge goes beyond basic informational interaction by deeper forms of interaction [30,31]. Shared knowledge requires common language, that is, words or symbols that each counterpart understands [32].

Interactions taking place in virtual environments can generate multiple benefits such as semantic visualizations and scalability of the system [20]. The existing literature on interactions in virtual environment and the following benefits has concentrated on product support, relationship management, customer commitment and product development [e.g., 20,33,34], but there is a lack of literature studying the variety of existing interactions enabled by the virtual environment and their effects on the customer service, decision making or conducting business. Moreover, as the virtual environments in the previous studies are environments consumed from the computer screens, the immersive VR consumed with the head-mounted-displays and thus with totally different interfaces have not been studied.

2.2. Social presence and virtual reality

The social presence theory attempts to explain the ability of different communications mediums to transmit social cues, i.e. sociability. The social presence theory [35] recognizes "the salience of the other in a mediated communication and the consequent salience of their interpersonal interactions". Since then, many studies have advocated the importance of social presence in successful communication. However, sometimes the lack of social presence can lead to more pragmatic interchanges, which can in some situations be beneficial [36]. The study suggests that simple communication platforms are efficient for very simple or unequivocal messages, while information that is ambiguous, emphatic, or emotional, a richer platform should be used [36].

The social presence can be measured by both behavioral and emotional social cues and cognitive sociability outcomes (e.g. Tinto [37], Kreijns et al. [38]). Rourke et al. [39] add that in addition to cognitive benefits such as learning, also social and personal integrative benefits as well as hedonic benefits can be promoted by increasing the social presence. This can further lead to involvement of customers in innovation and value co-creation processes and affect customers' attitude towards the firm [20,21,22].

In the information system literature, the social presence is an often used concept when studying e-commerce e.g., Pavlou et al. [40] or social media e.g., Cheung et al. [41]. In the context of the VR, the social presence has been applied to examine team building and playing [42] and virtual training [43], but it has not been examined from the perspective of customer service, decision making or conducting business.

In this study, we apply the framework of social interaction elements [14] in the qualitative evaluation to classify the findings from various VR use cases, while two different social presence situations named in person and remote - system use are applied in the quantitative experiment study. The results combine these two frameworks suggesting the design principles and linking them through social behaviors/emotions to cognitive outcomes in the case of virtual reality.

3. Research methodology

We employ a DSR methodology [17] as our research approach. The DSR has become a popular framework for planning and evaluating the service development especially in the information system research [16,17]. We build three different artifacts of a VR application. The artifact 1 enables the assessment of user's individual interaction together with a service person and as a part of peer-group and it had simple graphics and functionalities. The artifacts 2 and 3 are a developed version of the artifact 1 with better graphics, improved functionalities and more extensive contents. The difference between the artifacts 2 and 3 is in the interface: the artifact 2 is designed to be used in person with a service employee (similarly to the artifact 1) and the artifact 3 allowes user's interaction with a service employee remotely.

In the DSR [17], demonstration phase is a proof-of-concept that the artefact feasibly works to solve one or more instances of the problem. The demonstration is followed by the evaluation, where the purpose is to show utility of the developed artifact [43]. Furthermore, four suggested steps for the DSR artifact evaluation: 1) explicating the goals, 2) choosing strategies for the evaluation, 3) determining the properties to evaluate, and 4) designing the individual evaluation episodes [43].

In our study, three researchers were involved in the application development right from the beginning and empirical data was collected during three development iterations of a VR application developed for a natural resource management company. Consequently, three different VR artifacts were demonstrated representing the three different social contexts: i) user as a part of peer-group, ii) user interacting with a service employee in person, and iii) user interacting with a service employee remotely. The use of the artifacts in these contexts were evaluated based on the sociability perspectives: knowledge sharing, trust creation and influence [14]. In addition, a between-subject experiment was conducted to test the effect of two different social presence situations named in person and remote - system use in more detail and to gain quantitative data. The artifact designs, demonstrations and evaluations are described in the following sections.

3.1. Artifact design, development and demonstration

During the research process, three iteratively developed artifacts were used. During the development process, the general idea of improving the remote decision making remained the same. However, each artifact aimed at solving a more detailed problem defined in the next chapters. A game engine (Unity) was used in the development of all of the artifacts.

The artifact 1 concentrated on the individual user experience and the objective was to recognize and determine the utilities and emotions of using a VR tool to support remote decision making both as a professional planning tool and as a tool to support customer service and service sales. The VR application consisted of a simple forest model that was based on a point cloud of a real forest that was scanned by using a stationary terrestrial laser scanner. The precisely scanned area covered a 25 x 25 meters area and it was surrounded by hills. A simplified version of the point cloud and one 360-degree photo were imported to the game engine. Based on the point cloud data, an interactive environment was generated by adding basic terrain and trees as interactive assets. The application was used with a VR system (HTC Vive) with two hand-held controllers. The system was connected to a PC and it enabled tracking the physical movement of the user in an area covering 2.5 x 2.5 meters. The user was able to teleport herself longer distance in an area, gain money by removing trees simultaneously visualizing how the forest changed. Further, she was able to decide whether she wanted to visit the point cloud and 360-degree photo of the real forest. In addition, a bear was set to wander around the forest. Bystanders, both peers and service employees, were provided with a computer screen showing a 2D-version of the view in VR. This setup enabled simple real-time social interactions, such as commenting, asking questions and giving instructions, between the user and bystanders. The research subjects consisted of 25 persons who used the system as a part of a peer group of one to four bystanders. Another 25 persons used the system together with a service employee. All the system users were invited and the sample population consisted of mainly managers of industrial companies who had interest in utilizing VR in their businesses.

The artifact 2 aimed to evaluate the use with a service employee in person with an application that had more specific set of functionalities. A forest estate covering 10 hectares was captured by using a portable terrestrial laser scanner and 360-degree photographs. In addition, open access terrain data was used to support the production of the interactive forest environment. Otherwise, it was created by following the production process of the artifact 1. Compared to the previous versions, visual quality of the application was improved significantly. The VR application in the artifact 2 included a larger collection of tree assets with more details in them. In addition, small details such as rocks, undergrowth and dead branches were added to make the experience more realistic. Improved usability enabled the user to gain more detailed information about the forest and single trees. By using a map, the user was able to visit tree areas including different types of forests. In addition to removing single trees, the user was able to make decisions about areal forest management operations, such as clear cutting and thinning. The possibility to see the point cloud was removed along with the bear. The devices to use the system were similar to the devices in the artifact 1 (HTC Vive connected to a PC). The company invitations resulted 37 users who tested the application with the personal help of a service. Majority of the users were forest owners and customers of the firm. Therefore, the demonstration of artifact 2 was closer to an authentic use situation compared to the artifact 1.

The artifact 3 included otherwise the same VR application contents as was used in the artifact 2, but the remote features were added. The 2D-version of the view in VR was shared via video connection allowing discussion between the user and the service employee remotely. In addition, the service employee was able to see the user via a web-camera to help in guiding to use the VR-devices. After the company invitation, 27 users came to test the remote service application. The same employee was assigned to do the remote service work via Skype as was helping in person during the demonstration of the artifact 2. Again, the majority of the users were forest owners and customers of the firm.

3.2. Artifact evaluation

We follow the four steps for artifact evaluation [43]. The problem identification leading to the research objective and -question explicate the goals for the evaluation. In terms of evaluation strategy, we choose “Human Risk & Effectiveness” -strategy as our main interest is in various social situations and as in our case, it is possible to conduct the evaluation with real users in their real use-contexts. The applied theories named the social interaction elements [14] determine the properties for the qualitative evaluation and analysis for all the artifacts and altogether 114 users.

Further, artifacts 2 and 3 were compared based on the social presence framework with a quantitative research approach.

For the qualitative part of social interaction, the data consists of answers to open-ended interview questions [44] that were recorded on audio and observations during the use [45] that were recorded on video including both user's comments during the use and how they acted in the physical surroundings, including used dynamics and motions [46, 47]. The material was transcribed resulting in 236 pages of observation notes and transcribed interviews.

In addition to qualitative data, the artifacts 2 and 3 were compared in a controlled experiment employing a 1x2 between-subject design. The artifact 2 represented the experiment condition 1, in-person system use, and the artifact 3 the experiment condition 2, remote system use. The designated variable to represent these two conditions is the treatment factor. The experimental design was used to describe the differences between these groups and the causal relationships of the treatment factor, background variables, and outcomes. This study followed a true experimental research design, in which research subjects were randomly assigned to the treatment groups [48].

The frequency of visits to forest estate, frequency of managing forests themselves and frequency of using forest management services were asked as a part of interview with three questions: 1) How often do you visit your forest estate? (control activity) 2) How often do you manage your forest yourself? (management activity) and 3) How often do you use forest management services? (buying services). The activities were then coded into numbers (estimated number of time annually) and finally, coded into three categories: more than once a month, few times a year, and once a year or less. Similarly, the distance to the estate (accessibility) was asked in kilometers and coded into close access, medium access, and long distance access. In addition, familiarity with VR technology was surveyed and categorized into unfamiliar, somewhat familiar, and very familiar with the VR. Similarly the difficulty-of-use was asked and categorized into difficult and easy to use.

The outcome variables measuring the VR experience were chosen based on the research framework for the social interactions [14] (Table 1). In order to measure the success of knowledge sharing, we followed a scale suggested by Li et al. [49] to measure the knowledge sharing in the form of product knowledge: attention, evaluation, association, questioning and information seeking. Trust creation was measured by the attitudes towards the brand [50]. Influence was measured by the user's intention to interact with others, use the service again or make purchase decisions [51]. All the outcome variables were measured using a 5-point Likert-type scale (1=strongly disagree; 5=strongly agree).

Means and standard deviations were measured for the all variables. K-Means cluster analysis was conducted for the outcome variables. A good cluster analysis is efficient when using as few clusters as possible and effective when capturing all statistically important clusters [52]. In order to determine the number of clusters, we apply an external validation method [53,54] which is based on the interpretability of the clustering results, meaning how straightforward it is to name the different cluster groups. In addition, we used an analysis of variance (ANOVA) to test whether there are significant differences between the clustering factors and removed the non-significant factors from the cluster solution e.g., Bapna et al. [55]. We ended up selecting a two-cluster solution.

The cluster membership was regarded as a dependent variable in the binary logistic regression analysis where all the background variables with main and interaction effects were measured. Backward Wald was used as an estimation method. The Backward Wald stepwise selection removes automatically insignificant ($p > .05$) variables from the model using the probability of the Wald statistics. In our case, three variables including both main and interaction effects were significant explaining the the binary logistic regression of two cluster groups.

Table 1. The initial scale.

Background variables
Treatment factor: in person / remote (Experiment, Nominal)
Control activity (Nominal scale 1-3)
Management activity (Nominal scale 1-3)
Use of services (Nominal scale 1-3)
Accessibility (Nominal scale 1-3)
VR familiarity (Nominal scale 1-3)
Difficulty-of-use of the technology (Nominal scale 1-2)
Evaluation variables (Likert-scale 1-5)
Product knowledge:
This kind of system would help in managing forest estate (Attention)
In my opinion, the modelled forest seemed real (Association)
In my opinion, the timber prices were reliable (Evaluation)
I learned new things on forest management (Information seeking)
I could actually apply those things that I learned on forest management (Questioning of product attributes)
Brand attitude:
In my opinion, the digital services of X offer a good user experience (Overall perception)
In my opinion, the digital services of X are better than other similar ones (Comparative perception)
I believe that X will offer the best digital services in the future (Long-term future perception)
Intentions:
I will be in contact with forest specialist after this experience (Interaction)
I can recommend the use of this kind of service to a friend (Interaction)
I am interested in participating in testing a similar service again (Interest)
I am ready to buy a virtual forest management plan on my own forest (Action)
Based on this experience, I am ready to sell wood (Action)

4. Findings

Qualitative findings from the evaluations of the artifacts gained by interviews and observations are classified under the themes: knowledge sharing, trust creation and influence. The quantitative results from the experiment are further scrutinized for the sociability effects by comparing the artifacts 2 and 3 (in person and remote system use). The results show how the social presence (in various forms) can create enhanced trust, influence and shared knowledge and contribute to value communication, co-creation and innovations.

4.1. Knowledge sharing

A service employee being present in the demonstrations guided the users to use the applications in a desired manner, which also helped the employee to better understand usability problems. It also turned out that the more sales-oriented service employees with a basic understanding of the technological features of the application could transmit the required usability information back to the company and application developers by simultaneously concentrating on the customer experience and added-value. Therefore, technical personnel were not required to be present in the demonstrations.

The VR headsets exemplified a unique service situation by blocking visual and audio connections to the real world, which made the users dependent on the service personnel (making sure they did not stumble on a cable or collide with a wall). This unusual social situation made it easy to start a conversation. The users often needed help when using the devices and with the most of their functionalities, and the guided use naturally entailed making a physical connection with the service employee.

The application, especially its first development version, seemed like a computer game. Therefore, knowing that the surroundings were based on a real world seemed to interest the users. That was a feature that was developed during the iterations by for example adding a map of the area. *"I started immediately thinking what this valley is. Every now and them, I visit Nuuksio (a national park) picking mushrooms."* (Peer-group use, artifact 1).

These kinds of comments by users led to a fruitful conversation with the service employee and bystanders. The key for these conversations was that the user could attach the VR experience to a real-life context and share thoughts based on real-life experiences. This contributed to better understanding of user personality, value base and expectations as well as building familiarity and trust between the user and service employee. However, with the remote service employee and without the peer-group in the artifact 3, the users were a bit more anxious and reserved, when these kinds of casual conversations did not occur.

Even though point cloud was considered an interesting and illustrative element connecting the user to the real place, it was removed from the next development versions as it including 360-degree photos of the forest was considered to be enough to connect the user with real-life and thus new conversations and insights could not be extracted.

Service information embedded in the application was considered focal to reach the objectives of the application and it was increased along with the application development iterations. The software development version presented in the artifacts 2 and 3 included more information about single trees and the forest site. By increasing the number of informative elements, it was easier for the users to focus on the content that was guiding them towards the main objectives of the application. However, information and requirements for details varied a lot between the users. Some of the users who clearly regarded themselves as professional foresters criticized "vague" presentation of information. In other words, using special terminology and symbols correctly was important especially when using the system with a service employee in the artifact 2: *"How about seeing how much one has cubic meters? One could see the (cubic) price of the log in that area, the price of birches, that would be way more interesting than the price of a single tree."* (Service employee in person, artifact 2). *"Focal for us is to see the length and the diameter breast height, that is at the height of 1.3 meters, when estimating single tree."* (Service employee remotely, artifact 3). *"The ability to see even the size and the price of a single tree and to compare the revenues from thinning and clear cutting. And to see how the forest looks afterwards."* (Service employee in person, artifact 2).

Accurate and useful information was fundamental for value communication and, if this was not adjusted to the user knowledge level, user innovation and value co-creation processes could not proceed. These kinds of relevant value communications occurred both in person and remotely.

4.2. Trust creation

The peer-group use of the artifact 1 helped users to trust the system. The atmosphere in the demonstration of the artifact 1 was relaxed and the users were able to observe how others used the system before trying out by themselves. This made the social use context safe for those who wanted to observe the use before testing the application by themselves.

In addition, surprising content elements encouraged people to fool around with the system. This lowered the threshold and encouraged people to test the application. Playful elements and relaxed atmosphere also encouraged people to try things that were not obvious: *"Hehehe, (teleported to a tree), I was able to climb up a tree!"* (Peer-group use, artifact 1).

The fact that the surroundings in VR were based on a real-life context made the experience more credible. However, many users also required more realism: *"Let's say that when this is more realistic (...) you would be certain and could rely on that the fact that the forest is like it seems. For remote owners who don't know their forests too well - it would be important."* (Service employee remotely, artifact 3).

Consciousness of visiting a real forest site was elevated by including 360-degree photos of the forest site in the artifact 1 and even higher resolution photos in the artifacts 2 and 3. Photos demonstrated that the application represented a real forest rather than just a generated one. Similarly, users asked whether the value of the trees was based on real-time market prices and tried to evaluate their accuracy: *"Price is what finally makes the difference. Here you could see some kind of an estimation of it. Or you actually got it very easily, that was maybe the most valuable part of this experience."* (Service employee in person, artifact 2).

In the customer face-to-face meetings between the customer and service employee the application content was referred in discussions. This occurred when abstract issues, such as different forest harvest models, were mentioned. The references were made by both customers and service employee nonverbally by pointing the VR gears or/and mentioning "such as in the VR application". In the interviews it occurred that these references worked as risk mitigation factors in terms of understanding the consequences of decisions.

4.3. Influence

Playfulness was significantly increased in a group use and the users invented new ways of utilizing the features of the application. For instance, when a group of people knowing each other were testing the artifact 1, one of them started to removing trees with a laser beam as quickly as possible and encouraged others to behave in the same way. This resulted in a competition of trying to remove all the trees as quickly as possible which was originally not planned as a part of the application: *"Where is the forest? I've destroyed all the trees! You guys want to come and give it a try?!"* (Group use, artifact 1).

Playfulness improved the motivation, and this was emphasized in the peer-group situations. In addition, inventing new features engaged the user, but also motivated peers in the group to test those features.

Peer-group bystanders commented the view e.g. by encouraging the user to ride a bear. Users were also willingness to share the experience during the use and right after removing the headset by commenting the events in VR. However, the system was not designed for sharing the experience in any other ways besides enabling bystanders to watch the use and view in VR from a computer screen. Some of the users realized only after removing the headset that the bystanders were able to see the view in VR from the computer screen. Before realizing that they were actively commenting on what they were seeing in VR to the bystanders.

Overall, dramatic or unusual experiences (such as confronting a bear or high mountains) resulted in a high willingness to share the experience with everyone in the room even while still using the VR device. In terms of drama, especially for first-time users, the turning point was clearly when the headset was put on. Regardless of the users' initial attitude, however, the reactions were positive, as shown in their eagerness to share the experience with the service employee. With the artifact 1 for example, this was the point when users started to innovate their own ideas about using the devices and what might be interesting or beneficial as cases. The experience was strong and difficult to imagine beforehand, even if cues had been given a priori e.g. via seeing the use of peers. According to the observations, the presence of fellow users affected a given person's user experience surprisingly little: the surprise factor remained the same. In terms of experience, there seemed to be no difference from the more social service encounters. However, data on the interactions in terms of the discussions between peer-group bystanders not were collected.

The surprise element always made the user to share the experience with the service employee (in twosome situations) and with the bystanders (in peer-group situations). This was also the case with the users who were more silent and introverted during the overall experience. Also, these users reacted even during the remote system use: *"Wow, all trees are gone, so sad!"* (Service employee remotely, artifact 3).

These kinds of situations gave the service employee a chance to grasp the user personality, value base and expectations to proceed with the value communications. For example, the reaction of the service employee on the previous quote was: *"Well fortunately this is only a virtual forest and in your own forest we can make much lighter treatments."* (Service employee remotely, artifact 3).

There were some results indicating differences in influence between the in person and the remote -system uses. For example, over a half of the users tutored in person gave contact information of their friend or family member which was considerably more than among those who were guided remotely.

Along with the development iterations, the application focus moved from testing single functions and features, even the funny ones, towards supporting the user decision-making. Along with this, the features of the application and the usability design became easier: for example, the comparison of the management outcomes and removing trees. This reduced the need for technical guidance and improved the focus on the main objectives of the application.

4.4. Evaluation of benefits in the experiment

Altogether 64 people participated in the experiment, out of which 37 (58%) were assigned to the in person and 27 (42%) to the remote condition. The background variables were distributed as follows: Control activity (more than once a month 53%, few times a year 35%, once a year or less 12%), Management activity (more than once a month 28%, few times a year 45%, once a year or less 28%), Use of services (more than once a month 4%, few times a year 53%, once a year or less 43%), Accessibility (close access/<50km to forest stand 29%, medium access/50-250km 41%, long distance access/>250km 29%), VR familiarity (unfamiliar with VR 45%, somewhat familiar with VR 41%, very familiar with VR 14%), Difficulty-of-use of the technology (easy to use 70%, difficult to use 30%).

Table 1 shows the descriptive statistics of the outcome variables. In terms of the items measuring the success of *knowledge sharing*, the majority (82%) of the participants agreed that the virtual forest would be a useful tool for managing forest property (M=4.14, SD=0.859), so the VR in this case definitely worked in *raising the customer attention.* The perceptions about how well the virtual forest represents real forest were almost equally divided among the participants with 56% strongly or somewhat agreeing with the statement "The forest seemed real" (M=3.61, SD=0.986) and 44% strongly or somewhat agreeing that the prices of wood were believable (M=3.45. SD=0.991). Almost half of the participants neither agreed nor disagreed with the prices of wood. These items were measuring the *association* and *evaluation* elements, indicating that these issues could be better addressed in this application in question. Learning about forest management when using the virtual forest (M=2.48, SD=1.380) and utilizing the learned things (M=2.66, SD=1.300) were perceived low by half of the participants. However, these results were strongly deviated, for example, 24% of the participants strongly or somewhat agreed with the statement "I learned something new about forest management. These results show that the *information seeking* and *questioning* are not well addressed by the VR application in this case.

Majority of the participants agreed that the digital services of the firm X provide a good user experience (M=4.02, SD=0.826). Comparing the digital services of the firm X to other similar ones was perceived challenging as 55% did not take a stand on brand question 2 (M=3.56, SD=0.871). Majority of the participants agreed that the firm X will have the best digital services in the future (M=4.05, SD=0.765). These results indicate that the VR in our case had a slightly positive effect on the *trust creation* on the brand.

Influence was measured by the raised intentions including interests, interactions and actions. Majority (89%) of the participants were interested in participating in testing similar service again (M=4.50, SD=0.926) and 83% was willing to recommend service to a friend (M=4.25, SD=1.069). Almost half of the participants were ready to buy virtual forest management plan of their own forest (M=3.27. SD=1.150) and ready to sell wood based on the experience (M=3.33, SD=1.227). Intention to be in contact with forestry specialist after the experience was divided between 34% of participants strongly or somewhat agreeing and 38% strongly or somewhat disagreeing with the statement "I will probably be in contact with the forest specialist after this" (M=2.94, SD=1.363).

The means for the treatment group 1 (in person) and 2 (remote) are presented in the Table 1. The results show that the treatment alone did not have any significant effect on the outcome variables. The only statistically significant outcome variable was the item 12 "interest in participating in testing a similar service again", which was higher for the treatment group 1 i.e. in person system use.

In terms of the cluster analysis, two cluster groups were revealed (Appendix). The cluster 1 represents a positive experience, while the subjects in the cluster 2 had more negative experience. The most striking differences between these groups (i.e. the highest cluster center mean squares) were for the items "perceived learning" (item 10) and "ability to apply the learning" (item 11). This finding shows that the VR has a great potential for some people as a learning platform. While these items were not actually measuring any real learning results, there is still some indication that the VR can enhance the learning motivation in terms of empowerment that was addressed by these two items. In addition, the positive learning experience seems to correlate with the positive overall experience. Other items that contributed significantly to the cluster 1 indicating more positive experience were related to influences manifested by actions and future interactions i.e. progress in the marketing and sales funnels. By implication the cluster group 1 with more positive experience were also the potential customers to seal the deals, while the cluster group 2 with more negative experiences were also more stagnant and reluctant in that regard. While two out of three brand and trust related items were statistically significant clustering items, they were not so important for the clustering than the other aforementioned items. The ANOVA analysis shows that the items 2 and 12 were not statistically significant clustering items thus they were not included in the final clustering used in the binary logistic regression.

Table 2 shows the results for the binary logistic regression where the cluster membership was used as a dependent variable. The nominal variable on the difficulty-of-use of the technology (0=easy to use, 1=difficult to use) was a significant variable explaining the cluster membership, suggesting that difficulties in the technology use drive to more negative user experiences. The negative interaction effect of the treatment factor (0=in person, 1=remote) and VR familiarity (1= unfamiliar with VR, 2=somewhat familiar with VR, 3=very familiar with VR) indicate that the remote treatment for those who were more familiar with the VR technology actually had a positive impact on their experience. On the other hand, the interaction between the treatment factor and the control activity (1=active/more than once a month, 2=medium/few times a year, 3=passive/once a year or less) showed that the remote treatment for those who are not so active in controlling their equity caused an average more negative overall experience. Following the Wald Backward test method, all main and interaction effects for the background variables were tested, however, the in person / remote use, control activity, management activity, use of services, accessibility, VR-familiarity as such alone did not have effect on the cluster membership thus no significance on the customer experience was found. By implication we can say that in order to optimize the user experience, the VR design must be easy to use, the remote services should be provided only to users who are more experienced with the technology and the remote use is not likely successful to activate passive customers.

Table 2. The variables in the binary logistic regression explaining the cluster membership (Cluster 1=positive experience, Cluster 2=negative experience).

	B	S.E.	Wald	Exp(B)	Sig.
Difficulty-of-use of the technology	1,57	0,72	4,76	4,83	0,029
Treatment factor * VR familiarity	-1,90	0,95	4,02	0,15	0,045
Treatment factor * Control activity	1,71	0,81	4,45	5,52	0,035
Constant	-0,70	0,46	2,38	0,50	0,123

5. Discussion

5.1. Summarizing the results as four design principles

Table 4 shows a joint-summary of the qualitative and quantitative research results. Table 4 presents the various design features analyzed in this study followed by the findings organized according to the social presence -framework: behavioral and emotional sociability cues and cognitive sociability outcomes [37,38,39]. The design features and findings are categorized to build proposals for the design principles enhancing the beneficial sociability of the VR systems.

To sum up the findings in Table 1, face-to-face contact is needed to activate passive customers and raise their interest. In the face-to-face encounters it is good to consider the comfortability and ease-of-use as well as showing the personalised value-added. We call this *Activation through comfort -principle.*

Customer empowerment is achieved by making the use easy and familiar for the customers - this is achieved more easily with experienced and already active customers. The empowerment also correlates with improved attention and association all contributing to strengthened activity and interactions i.e. proceedings in the marketing and sales processes. This finding is called *Empowerment through familiarization -principle.*

Trust and value communication can be leveraged by creating customer emancipation. Some building blocks for the customer emancipation is to create connections to the real world and adding surprising contents. These elements were also shown to lead to spontaneous informal discussions, improved motivation and willingness-to-share the experience further contributing to value communications. This finding is called *Value communication through emancipation -principle.* We suggest this principle in design helps in making prompt and accurate value propositions.

Co-creation and co-innovation can be enhanced by adding informative elements and increasing customization. Better focus on the issues important for the customer also streamlines the customer encounter and service process. Combining this with the peer-use further activates people and encourages for playful behavior raising the team spirit and cohesion. We call this finding *Cooperation through shared interests -principle.* The principle shows that development is done in joint cooperation, while the building blocks need to be recognized and created by the designer.

Table 4. Linking design features to sociability outcomes through behaviors, emotions and cognitions.

Proposed design principle	**Tested design features**	**Behavioral and emotional sociability cues (findings)**	**Cognitive sociability outcomes (findings)**
1. Activation through comfort	Face-to-face contact	Activating passive users, feeling comfortable with the social situation	Customer interest, activity, ease-of-use, personalized value-added
2. Empowerment through familiarization	Remote use	Confidence only with more experienced technology users	Empowerment, shared knowledge (i.e. attention and association), and influence (interactions and actions)
	Ease-of-use	Better focus on the content, less need for the social assistance	Empowerment, shared knowledge (i.e. attention and association), and influence (interactions and actions)
	Familiarity with technology	Good working/professional relationship	Empowerment
3. Value communication through emancipation	Connection to the real world	Observed attention and association	Value communications, trust
	Surprising content	Spontaneous informal discussions, motivation, willingness-to-share the experience	Customer emancipation, value communications
4. Cooperation through shared interests	Informative elements	Improved focus and streamlined process towards the objectives	Co-creation and co-innovation
	Peer-use	Activating passive users, playful behaviour	Co-creation and co-innovation

5.2. Theoretical implications

According to our results, accurate and useful information and content was fundamental for the value communications. Also, visualization and explaining abstract issues in VR was found to be beneficial. However, if all this was not adjusted to the customer knowledge level, the customer innovation and value co-creation processes could not proceed. These kinds of relevant value communications occurred both in person and remotely. These findings confirm previous research highlighting personal experience, familiarity, affiliation and belonging, transparency, factual signals as well as heuristic cues as factors creating trust and shared knowledge in information systems [24].

In addition to those findings, dramatic or unusual experiences as well as playfulness resulted in a high willingness to share the experience and initiated casual conversations and further to deeper value communications. This effect was weaker with the remote use contexts. All in all, in person use contexts improved trust compared to remote system use confirming with the previous studies [25,26,27] and showing that the VR does not differ from other computer-mediated information systems in this regard.

Playfulness also seemingly improved the motivation, and this was emphasized in the peer-group situations, where the bystanders encouraged to play, compete and test new features. However, accurate and useful information and features supporting the customer decision-making required reducing technical guidance, which was in our research case done at the cost of also reducing playfulness. In addition, inventing new features engaged the user, but also motivated peers in the group to test those features. These findings suggest and confirm with the previous research that creating cognitive and emotional influences are distinguished as separate persuasion methods [29] and that they can emphasized in the peer-group situations [28].

The social interaction theory [14] suggest that elements such as trust and influence between system users can lead to shared knowledge. Similarly our results suggest that deeper level value communication, co-creation and innovation is happening after customer activation and empowerment i.e. in deeper forms of interaction [30,31,32]. To achieve this level we suggest four sociability design principles for the VR environments.

These suggested design principles have implications also to the social presence -theory. First of all, different levels of social presence can be created through the VR-mediated information systems providing opportunities for e.g. customer services, decision making and conducting business. The social presence and derived benefits, however, are perceived differently by various actors and there also seem to be asymmetric benefits. For example, our results showed that more active customers and experienced technology users are not that dependent on the social presence than passive customers with no technology experience. The first mentioned group also benefits more from the system use than the other group. The system provider, on the other hand, can have different benefits in terms of customer activation, proceedings in the marketing and sales processes, improved customer motivation and willingness-to-share, value communications, co-creation and co-innovation - all depending on the individual customer. In addition, also this DSR study and process showed that the service systems are dynamic, constantly evolving and adapting to the customer needs. These findings link the social presence to the social construct approach as introduced by Edvardsson et al. [19].

The proposed design principles seemed to have multiple benefits in terms of scalability which can be presented as follows.

The fun factor. Users' willingness to share fun experiences makes VR a good content for group events. Using VR as a part of an event helps in sharing the experience, even with the applications that are originally designed only for individual use. It is also easy to share the group experiences in more scalable medias by sharing photos and videos of the usage. However, only new and noteworthy experiences are suitable for these purposes.

The group factor. Users and bystanders tend to easily create a group where one is using the devices and others attend by proposing what to do in the virtual environment. The setup also attracts groups to stop by and try. This can be used in cases when various users are needed to discuss about large or complex entities. However, hosting of group use events requires active organizers, a resource that is required to enable the experiences also for the more passive participators. The current requirement for participation of multiple users is factor that currently hinders the scalability of many VR services. Considering the way that current VR systems are designed for individual use purposes only, it is surprising how important the social aspect seems to be for the experience - whether it is about using a system in a group or sharing the experience with others. However, a polished design of the total customer experience including the social aspects is not yet industry standard in VR.

Curator-user interaction and dialogue. In majority of the use cases, the use of VR currently requires help of a service personnel. In many cases, this seemed to make users devoted to return the favor by discussing with the service personnel or putting effort in trying to create ideas how to improve the experience. Users were also willing to discuss while wearing the headsets. From the social point of view, if the design does not allow any kind of social interaction, all the potential the users have to discuss and share the ideas is wasted. Instead of trying to automate the use of the systems, the focus should be put on generating value from the social factors that are currently a natural part of design of a successful interaction. However, scalability potential of the value generated from the social features of VR is yet to come. Along with the multiplayer features that are becoming a more natural part of the VR experience designs, interaction with others can be implemented naturally also remotely.

Increased time spent with customer. Especially in sales, VR provides a good excuse for increasing customer engagement and spend time with customers. From a service design point of view, a focal question is how to organize the time efficiently. Companies can also help their customers to continue value creation after the meeting by e.g. designing ways to easily share the experience, that is - at the current state of the technology development - an undervalued concept.

5.3. Limitations and future research

This paper is limited to analyzing a design process of only one application. Due to the iterative application development process, the social interaction was not the only factor that was changed, but also the system development features such usability, user-interface, graphics, instructions etc. were also develop between the design artifacts. Further, the application was developed for a specific purpose in the context of forestry. Therefore, some of the features of the application may be limited to the studied use case only.

Further, the research was conducted in the country of origin of the application, which may influence the behavior of the users participating the research. Because of the novelty of the technology, also the social settings in which the application was studied were new to many. The research setups for testing the artifacts varied from public pop-up events to more controlled laboratory experiments. Similarly, this caused diversity in the research population varying from general managers and business practitioners to the more focused group of forest-owners as existing customers and potential end-users of the service. Therefore, the results could be different when both the technology as well as the way it is utilized socially are institutionalized among the end-user or customer groups.

Finally, measuring the interaction elements including trust, influence and shared knowledge in the sociological research context set the typical limitations of measurements in the social sciences [56].

Nevertheless, the results underline the significance of social factors in designing any new digital services that challenge traditional social interaction. They also point out the need to further study the linkages between sociability and scalability of emerging digital services, for example, with more controlled experiments.

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Appendix. Descriptive and cluster statistics.

		Descriptives		Treatment factor means					Cluster center means				
		Mean	**Std. Dev.**	**In person**	**Remote**	**Mean Square**	**F**	**Sig.**	**Cluster 1**	**Cluster 2**	**Mean Square**	**F**	**Sig.**
1	In my opinion, the digital services of X offer a good user experience (Overall perception)	4,02	0,83	4,08	3,93	0,38	0,55	0,462	4,27	3,74	4,50	7,26	0,009
2	In my opinion, the digital services of X are better than other similar ones (Comparative perception)	3,56	0,87	3,70	3,37	1,72	2,32	0,133	3,76	3,35	2,59	3,56	0,064
3	I believe that X will offer the best digital services in the future (Long-term future perception)	4,05	0,76	4,19	3,85	1,78	3,14	0,081	4,27	3,81	3,48	6,45	0,014
4	In my opinion, the modelled forest seemed real (Association)	3,61	0,99	3,65	3,56	0,14	0,14	0,712	4,15	3,03	20,02	30,13	0,000
5	In my opinion, the timber prices were reliable (Evaluation)	3,45	0,99	3,43	3,48	0,04	0,04	0,847	3,73	3,16	5,12	5,60	0,021
6	This kind of system would help in managing forest estate (Attention)	4,14	0,86	4,14	4,15	0,00	0,00	0,967	4,66	3,61	17,14	36,59	0,000
7	I am ready to buy a virtual forest management plan on my own forest (Action)	3,27	1,15	3,21	3,36	0,31	0,23	0,635	4,00	2,39	32,68	47,83	0,000
8	Based on this experience, I am ready to sell wood (Action)	3,33	1,23	3,34	3,32	0,01	0,01	0,940	4,11	2,39	37,18	47,74	0,000
9	I will be in contact with forest specialist after this experience (Interaction)	2,94	1,36	2,90	3,00	0,13	0,07	0,791	3,68	2,04	33,76	28,01	0,000
10	I learned new things on forest management (Information seeking)	2,48	1,38	2,24	2,81	5,10	2,75	0,102	3,36	1,55	52,67	48,51	0,000
11	I could actually apply those things that I learned on forest management (Questioning of product attributes)	2,66	1,30	2,51	2,85	1,79	1,06	0,308	3,45	1,81	43,42	42,71	0,000
12	I am interested in participating in testing a similar service again (Interest)	4,50	0,93	4,76	4,15	5,78	7,43	0,008	4,58	4,42	0,39	0,45	0,504
13	I can recommend the use of this kind of service to a friend (Interaction)	4,25	1,07	4,38	4,07	1,45	1,27	0,264	4,70	3,77	13,61	14,45	0,000