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Collaboration and Dialogue in Virtual Reality

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ABSTRACT

"Virtual reality" adds a new dimension to problem-based learning (PBL) environments in the architecture and building construction educations, where a realistic and lifelike presence in a building enables students to assess and discuss how the various solutions interact with each other. Combined with "Building Information Models" (BIM), "Virtual Reality" provides an entirely new opportunity to innovate and optimize architecture and construction in its early stages, which creates an iterative learning process. The analysis identifies several clear opportunities regarding extended use and involvement of the gamification mechanisms known from, e.g., video games software – like the principles behind quest, levels, dungeons, etc. – to support web 2.0 features in the future development of VR systems. The study clarifies the challenges of creating web 2.0 solutions with the complexity and robustness that supports a sketching, design-oriented, exploratory and investigative learning process, which is at the core of problem-based learning.

Keywords: Gamification, PBL, Innovation, Dialogue, Collaboration, Virtual Reality, web 2.0

INTRODUCTION

New social trends and technology contribute to increasingly complex collaborative interactional processes, where the concept of knowledge is transformed through the use of virtual and digital forms of communication (Selander, 2008). These new technological advances within web 2.0 offer the potential to create various interactional processes through virtual forms of communication, where users are linked together in collaborative communities

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(Lane, Osborne, & Crowther, 2015; Selander, 2008). The web 2.0 technologies are therefore increasingly used in computer games to give the narrative history of a greater degree of social interaction. Particularly video games in the genre of Massive Multi Online Role Playing (MMORP) games are built around the use of avatars that are linked with chat systems through a virtual environment in real time (Golub, 2010; Chang & Lin 2014; McGonigal, 2011; Gee, 2003). In doing so, this particular kind of video game has managed to use the social communication tools that define web 2.0 to support the game's narrative challenges and problem solving. Video games, as a learning context, therefore, represent a new way of thinking within the educational system, as it allows educators to create teaching approaches that support the development of competences related to collaboration and problem-solving on virtual communication platforms through dialogue and interaction (Yeh, 2010; Selander, 2008; Gee, 2003).

Education that focuses on architecture and building construction is traditionally characterized by having a practical and professions-oriented approach, in which students in addition to a theoretical curriculum are also taught skills such as "learning to design" in order to develop practical designing skills (Schön, 2000; Knudstrup, 2003; Knudstrup, 2005). The use of Virtual Reality and "Game Based Learning" adds to the web 2.0 technologies an embodied and explorative dimension, so that the Problem Based Learning (PBL) pedagogic experimental approach can be supported, particularly within higher education in architecture and building design.

PROBLEM AREA AND RESEARCH QUESTION

This study aims to examine problem-oriented learning situations in a blended learning context where the academic focal points are architectural and technical topics when designing a building. Whereas a large number of studies have focused on different forms of virtual simulation tools based on predefined tutorials about collaborative processes, this study is addressing the problem from a new angle, as the virtual universe is created through the use of the students' own iterative design of a building (Knudstrup, 2003; Knudstrup 2005). The study design aims to identify the factors that are necessary for a "Virtual Reality" system that can guide its users through complex and collaborative processes in a virtual context generated by themselves.

> *What effect will the use of gamification principles have on collaborative and problem-based learning processes in user-created virtual reality environments?*

The next section describes the theoretical framework, which focuses on "Activity Theory" (AT) as a structure for analysing what effect gamification principles have on a Virtual reality system's ability to mediate collaboration and dialogue. In section three, Design-Based Research is introduced as the larger, overarching framework, and AT would then count as the structuring, analytical tool within that framework. The argument for this choice is that it would be possible to let the perspective and aspects of gamification inspire and inform the design activities through an iteratively process known from Design-Based Research methodology. Section four contains an analysis of the collected data and sections five and six conclude with a description of the paper's findings and contribution.

PROBLEM BASED LEARNING AND GAMIFICATION

Within Problem Based Learning (De Graaf & Kolmos, 2003; Kolmos, 2004), John Dewey's theory (Dewey, 1986) about experience as something connected to experimenting and exploration, has been a great source of inspiration. Experience, as a concept in Dewey's thinking, is something more, and something different than just knowledge obtained through the acquisition of knowledge and past actions. Experience is about the relationship between thought and action and the relationship between humans and the environment. Dewey argued that we participate in a world where action and thinking are related, and experience is the concept that both describes our interconnectedness with the environment, and the relationship between action and thought – this is the transaction that is the experience (Dewey, 1986). Dewey's ontological understanding of experience is therefore based on an idea of humans as always being situated, and that the individual and the environment is transactionally related in a mutually constitutive and integrated whole (Buch & Elkjær, 2015; Elkjær & Wiberg, 2013). The learning process with respect to architecture and building construction is thus characterized as being situated through a practice-oriented project where social participation is essential for creating an iterative design and learning process.

Existing research (see e.g. Dau, 2015; Matzat, 2013) discuss pedagogical models for blended learning, which is used in a profession- and practice-learning context. However, these studies do not deal with educations where product- and design development is the focal point of the learning process. There is a big difference whether the educational learning goal is centred around professional training, literacy and dialogue instead of collaborative design processes where a concrete product is developed through methods such as sketching, design-oriented activities, modelling, prototyping, etc. (Schön, 2000; Knudstrup, 2003; Knudstrup 2005). An Australian study has investigated architecture students' perception of online learning (Lane, Osborne, & Crowther, 2015). The study showed that a negative perception of online learning is prevalent, due to the used technologies' inability to facilitate situated learning synchronously. If a virtual reality system should support a PBL environment within an architectural design process is, it is essential that the systems technological solutions contain the necessary educational tools. In particular, the degree of interaction, tactile experiences, and synchronous participation have been absent in the previous E-learning models (Ng, Bridges, Law, & Whitehill, 2014). New opportunities in IT hardware and software are now opening up for interactive synchronous tools supporting PBL pedagogy and collaborative methodologies (Savin-Baden, 2014).

In recent years, gamification has emerged as a new concept (Gee, 2003). Unlike business and educational institutions, the computer game industry has found a model to get people to work together in a virtual universe. Across national borders, computer players can innovate and solve problems on specific issues while the activities are performed with a high level of motivation and energy. The high degree of socialization through the use of avatars and dialogue-based collaboration entails a high level of telepresence – the experience of being present in a virtual environment through communication. Combining web 2.0 with games creates a form of practice that draws on more than one modality with regard to communicating different types of meaning (Golub, 2010). Dewey's definition of “Aesthetic experience” can be used to explain the relationship between the virtual environment and the students’ learning process. “Aesthetic experience” is about active participation towards a final goal, which at the same time is also experienced as a satisfaction through the interaction with the environment (Dewey, 2005).

The combination of PBL and Gamification is interesting, as the latter contains an indirect facilitation of processes and partly a playful and explorative aspect. Also, users receive reinforcement in order to promote behavioural persistence, the courage to make mistakes and social acceptance of new ideas (Erenli, 2013; Deterding, 2012; McGonigal, 2012; Morris, Croker, Zimmerman, Gill & Romig, 2013). Video games’ ability to suppress their users fear of failure through a platform or framework that serves as a kind of safe zone is markedly different from the conditions that apply to problem- and process-oriented teaching, where errors often lead to a lack of motivation (Illeris, 2006; Deterding, 2012). In computer games there even is a culture in which a process is repeated until the goal is reached. This culture means that users continuously force the error and after that develop new solutions for building momentum in the game (Deterding, 2012; Erenli, 2013; McGonigal, 2012; Morris, Croker, Zimmerman, Gill, & Romig, 2013).

One of the game models that has been very successful in establishing a sense of collaboration in a virtual space is the genre of Massive Multi Online Role Playing (MMORP) games. This game type is defined through a network-based and virtual universe where people located in different geographical locations interact with each other in real time. MMORP games have built-in troubleshooting features through the quest, realistic scenarios, role play and collaboration mechanisms that stimulate the players' intrinsic motivation, group identity, social acceptance/approval, and "self-efficacy." Studies have indicated that these gaming activities facilitate the development of problem-solving skills of the users (Hou, 2011; Chang & Lin, 2014; Ang, Zaphiris, & Mahmood, 2006) along the way.

The coupling between virtual platforms and PBL processes linked through the use of design principles known from video games is interesting since it offers the possibility of synchronous and real-time participation in a situational context that is based on the students' architectural models.

THEORETICAL FRAMEWORK

This section addresses the study's theoretical framework, through a description of Activity Theory as an understanding of social collaboration in a holistic system. The structure of the study design and hereby a prototype, is based on an operationalization of the theoretical framework combined with a litterature review of existing research within the field of gamification and PBL. This section will close with a description of the drafted prototype of this study.

Gamification represents a significant shift away from the typical teacher-centred approach to a more activity-based approach, where social interactions are emphasized. A litterature review on web 2.0 shows that it is through activities humans transform learning and even embrace the possibility of problem-oriented learning.

Activity theory (AT), formulated by Vygotsky and Engeström respectively is a method that provides an understanding of social collaboration processes by analysing phenomena, finding patterns and making inferences across the interactions.

Activity theory is particularly suitable as a theoretical foundation in web 2.0, particularly due to the descriptive framework, which considers an entire system of collaborative activities (Said, Thair, Ali, Noor, & Abdullah, 2014; Widjaja, 2005; Kaptelinin & Nardi, 2012). The motive for the activity in AT is created through the tensions and contradictions between the elements of the system. This approach is particularly useful for studying a group that exists in a virtual form and its communication and collaboration. The use of activity theory as a theoretical framework, therefore, makes it possible to understand the VR system's complexities, in this context particularly the relationship between the students and the virtual environment as a learning artefact/tool.

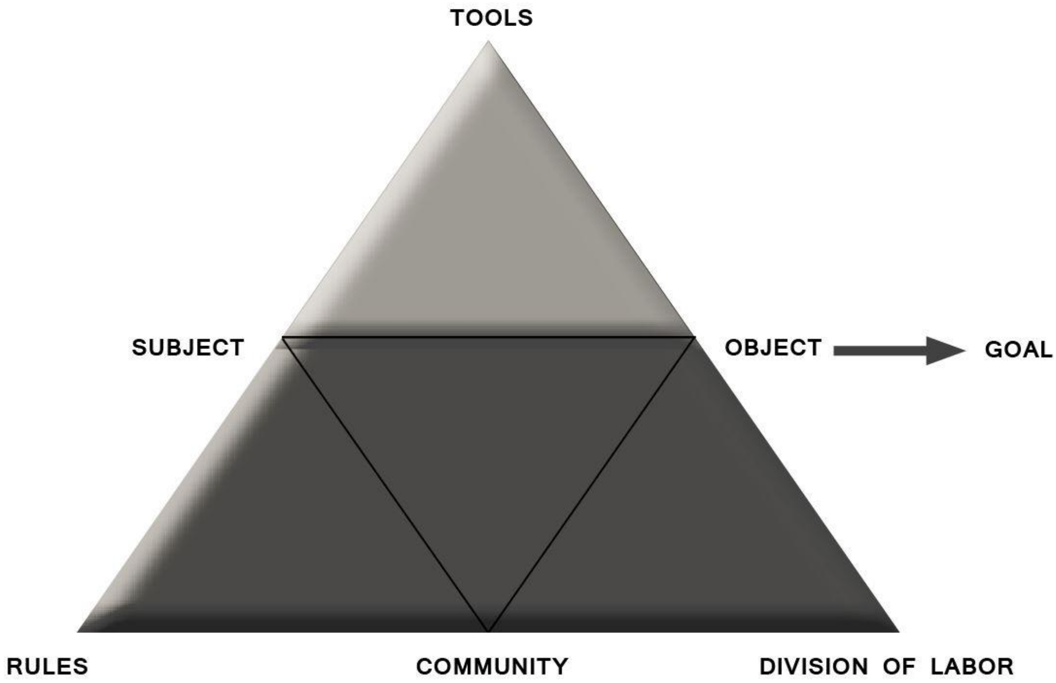

Figure 1: The Activity theory system includes the object, subject, mediating artefacts (signs and tools), rules, community and division of labour.

Wartofsky expands in the text "Models, Representation and the Scientific Understanding" on the way humans understand the perception of artefacts through what he calls a cultural epistemology. He argues that we perceive things in a historically determined way beyond our physical senses (Wartofsky, 2012; McDonald, Le, Higgins & Podmore, 2005).

Wartofsky connects a tool’s user function with the mental models created by human comprehension when they are used. These connections create a movement from the practical and material to the theoretical and imaginary. All kinds of things can thus be considered as tools if their function and their impact are mediating. This mediating nature of an artefact determines the way in which humans transfer and preserve cultural changes, and consequently create new meanings and knowledge. According to Wartofsky, the artefacts contain a cultural function and thereby intentions and cognitive standards that create an agency of the activity (Wartofsky, 2012; McDonald, Le, Higgins, & Podmore, 2005).

Wartofsky is thus expanding the role and significance of the artefacts’ non-material cultural dimension and opens up a new way of analysing complex activities through the division of the artefacts’ use into three levels as a taxonomy (Wartofsky, 2012; McDonald, Le, Higgins, & Podmore, 2005).

The first level consists of the primary artefacts, which are tools seen as objects, as well as the necessary skills to use them. The second level contains the secondary artefacts, covering representations such as maps or diagrams that can be perceived and that transfer skills and modes of action. The last level deals with ideas or possible worlds. For example, both can exist as a theory, creativity or play. With this separation of the artefact, Wartofsky expands the use of Vygotsky's original triangle by providing the possibility for a wider analysis of complex activities that involve more than one level of an artefact (Wartofsky, 2012; McDonald, Le, Higgins, & Podmore, 2005).

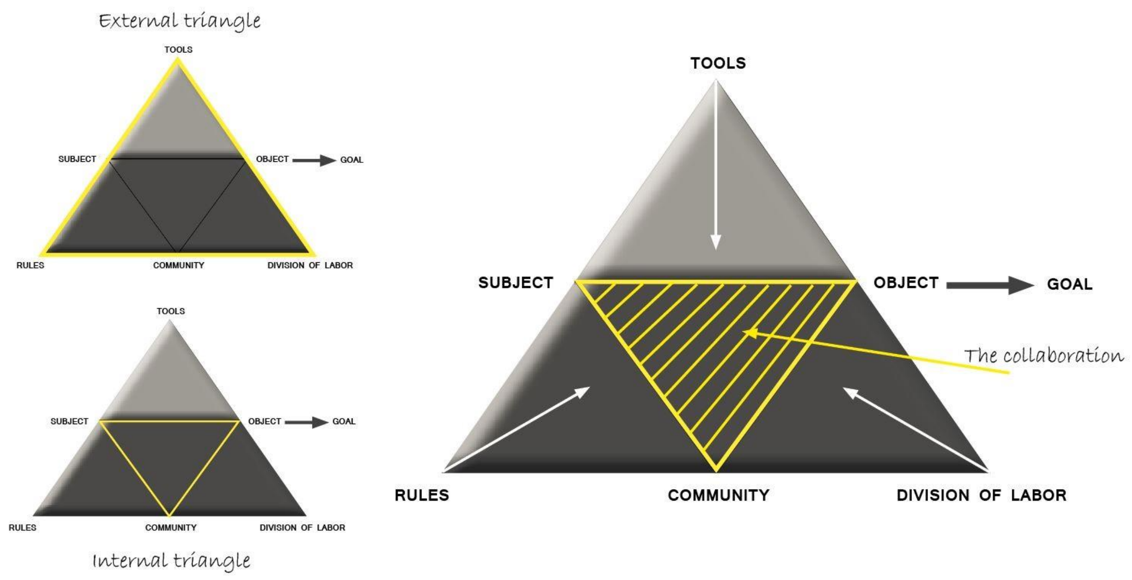

Figure 2: The external and internal triangle of the activity system

This relationship between the students and the virtual environment (VE) makes the Virtual Reality (VR) system an advanced collaboration and learning tool that can be described through terms such as experiencing an imagination, activities, and representations.

DEVELOPING THE PROTOTYPE

Based on the description of the theoretical framework, the following section relates to the operationalization of the "state of the art" into a holistic "Virtual Reality" system by the understanding of "Activity Theory" as the general design principles. The prototype was developed through a series of iterative workshops where participants with different professional building profiles and software developers participated. The prototype has been developed on two levels:

- The framing of software/hardware.
- The creation of the content and its gaming elements – the use of the system.

The inspiration from gamification is primarily focused on the genre of MMORP games. Here, it is particularly the gamifying of the collaborative learning process that is central when it comes to creating a virtual reality software that can mediate the dialogue. The software used has been developed on the “Unity Game Engine” which facilitates working modular. The software simplifies both the implementation process of the Virtual Reality hardware Oculus Rift Development Kit and the future development of the prototype. The “Unity Game Engine” therefore makes it possible to convert a 3D model from the professional building design tool Autodesk Revit into a virtual environment.

The construction of the prototype is based on the following three categories:

- The use of specific software developed by the design principles created by the theoretical framework of Activity theory and with the inspiration from computer games
- The application of hardware that supports Virtual Reality technology
- The use of dynamic 3D models from Autodesk Revit as virtual context

THE CREATION OF THE CONTENT AND ITS GAMING ELEMENTS

The gamification of the collaborative process is created through the outer triangle´s mediation of the inner triangle. This choice makes the notion´s tool, rules and division of labour key elements in the development of the design principles for the prototype’s content and application.

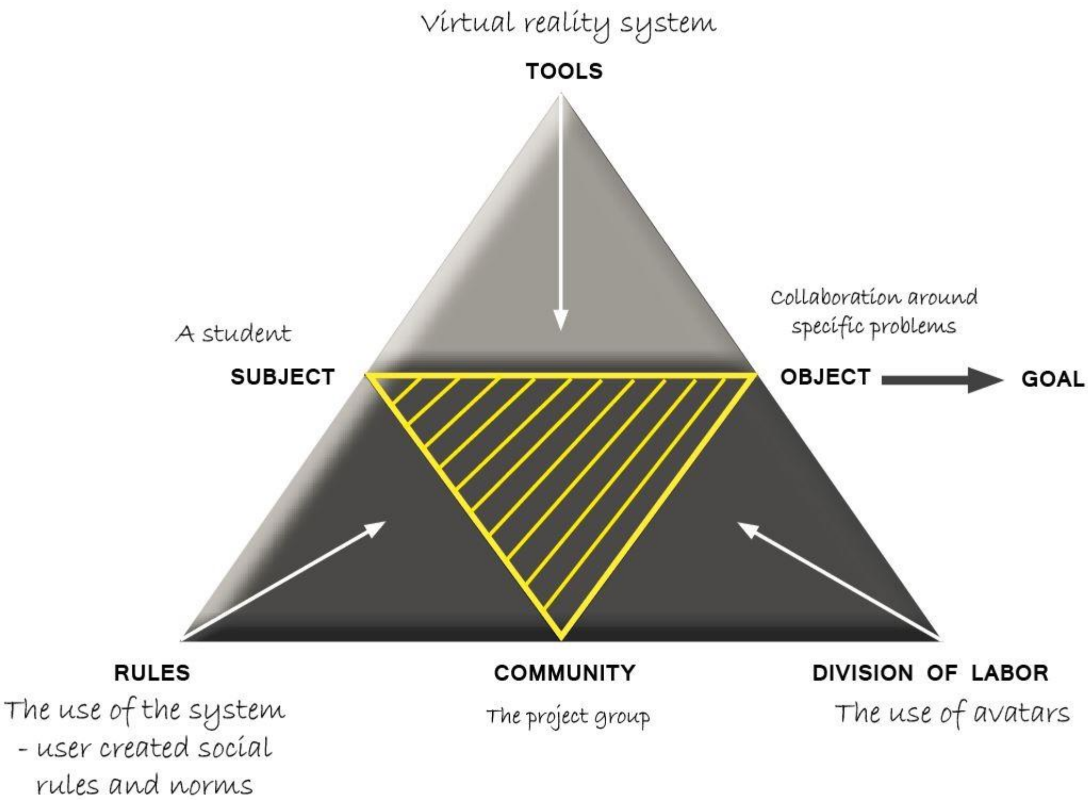

Figure 3: *The internal triangles three axes are mediated through the external triangle.*

The concept of **"tools"** represents the virtual system (software) as a digital tool that mediates the participant's collaboration in a virtual environment. MMORP games inspire the VR tool through the use of a network-based universe that allows its participants to interact with each other in real time. The concept of **"division of labour"** represents the roles of the participant through the use of avatars, while **"rules"** covers the system limitations and barriers and also their acceptance by common standards. The focus is the formation of group identity and social acceptance/approval of rules, as known from computer games.

DESIGN PRINCIPLES FOR THE OUTER TRIANGLE

The outer triangle's three points (tools, rules and division of labour) are the core design principles of the prototype. Combined, they describe the activity system's outer triangle, which mediates the gamification of the collaborative process.

The Artefact/Tool

The virtual system, as a mediating artefact, contains some elements that define the possible use and content of the system. These are divided by Wartofsky's taxonomy consisting of three levels:

First level of artefacts The objective use of the program, and the "know how" to do it	**Second level of artefacts** The system as a mental tool	**Third level of artefacts** Creativity, play, and imagination
Use of the individual user controlled Avatars. Individual adaptation is possible with respect to the choice of professional role, based on the field.	The student builds the VR environment through their work on the project – the 3D environment is changing continuously because of the students' iterative workflows.	Visible roles with respect to the task.
Avatar has to "spawn" for each new user created so that it is possible to be more users online at the same time. (Fig. 5)	Discussions about issues arising out of the virtual model.	Playing with the model and the creative use of the virtual environment
The model has to be partially transparent so that it is possible to see the building constructions.	The limitation of the system leads to rules about its application, as well as a shared understanding of the rules that apply.	
The Ability to "click" a laser pointer on and off that creates a laser beam extending from the avatar's viewing direction at head height. The laser also marks the area where the user is in focus.		
The use of dynamic 3D models from Autodesk Revit as virtual context.		
Overview of how individual users are located in the building, shown by the 3D plan details for the various floors.		

Figure 4: Displays the content of the virtual system.

Figure 5: Screenshot from within the Virtual Environment

The Division of Labour

Participants have the opportunity to choose between seven different roles visualized through the different colour categories. The Role descriptions are based on real life functions in the professional architectural building industry.

- Users and client advisor (white)
- The architect (yellow)
- The executive (Green)
- Engineering group, technical installations (orange)
- Construction Engineer (red)
- Group of "Building information model" (black)
- The Project Manager (blue)

Each role contains an accurate description of the primary functions and also provides an indication of the interdisciplinary collaboration.

The Rules

The rules of the system are primarily user-driven, without any procedure for using the virtual system. It is the participants themselves who create the framework around the task through their spontaneous dialogue and collaboration. Thus, the development of user-created social rules and norms becomes essential for the use of the system and thereby mediates the objective of the collaboration.

METHODOLOGY

Studying collaboration and dialogue in a virtual environment calls for developing designs to be tested and refined through several iterations in an attempt to understand the complexity of collaboration processes mediated by virtual reality. Design-Based Research is therefore chosen as the study methodology, as it is characterized by being a theoretically founded method to study learning and teaching in its reality through the testing of iterative designs (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006).

Interventions with practice play an active role in Design-Based Research projects, and new design principles are developed and subsequently implemented in a practical setting. A fundamental assumption in Design-Based Research is that only through the use of new design principles for intervention can better theories about practice be developed while attempts to improve practices are made. The Design-Based Research method is based on theoretical positions (design theories), and also, the implementation of a given design contributes to the further development of theory (The Design-Based Research Collective, 2003).

The purpose is to develop new theories that do not solely aim to improve practice but also attempt to develop further the theories behind the design principles. The process is iterative, and it is not only evaluating the intervention, but it also seeks to implement systematic improvements to the design. Data is gathered continually in order to redefine problems and principles (Akker, Gravemeijer, McKenney, & Nieveen, 2006; diSessa & Cobb, 2004). This study is based on the test of the first iteration of the prototype. See the description of the process in figure 6.

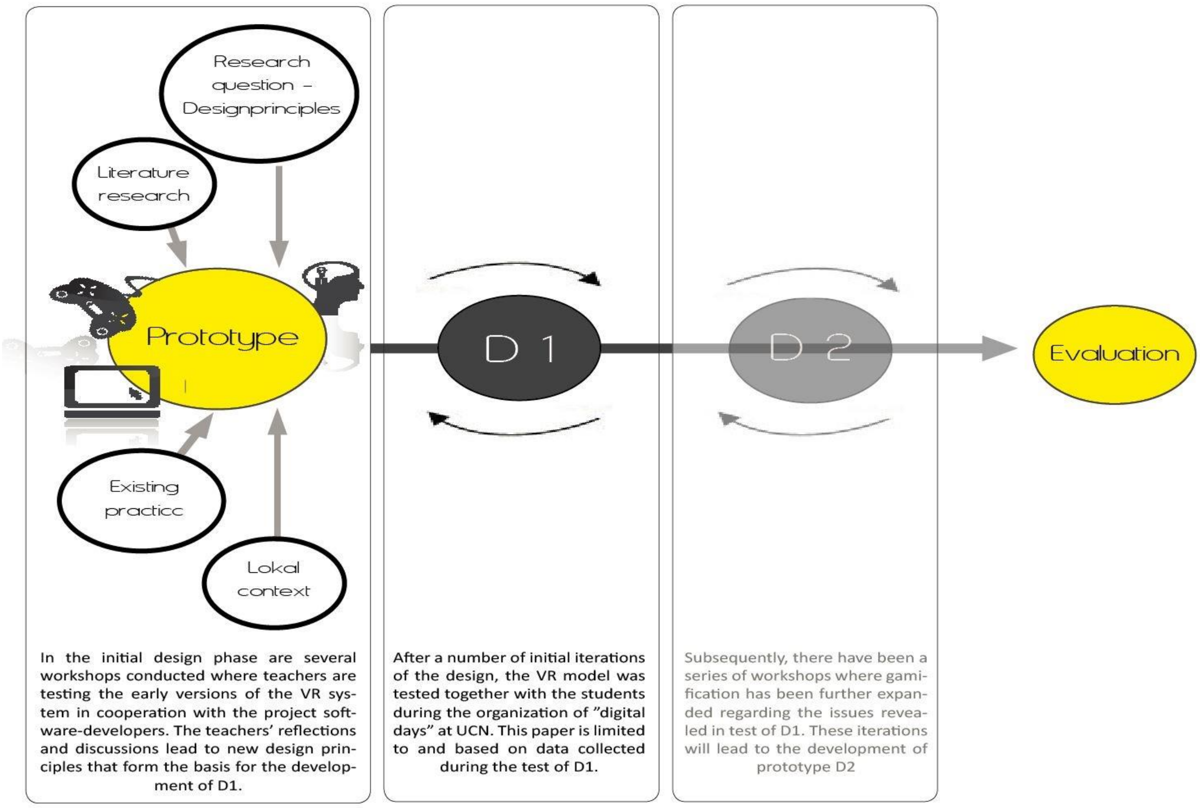

Figure 6: Displays the project structure through the method Design based research

DATA COLLECTION

The prototype was tested on the occasion of "The Digital Days" at the University College of Northern Denmark, Department of Architectural Technology and Construction Management, where two different project teams worked on a renovation of a real-life project. The project, which forms the basis for Digital Days 2014 is a revitalization and restoration of the museum Kunsten in Aalborg, Denmark. The restoration of the existing building, which was designed by Alvar Alto, must be implemented in a way that respects its architecture and cultural heritage. The participants from 16 different educational programs of five educational institutions each represented different professions. During three days, the students explored and tested digital methods and processes in a practice-related experiment. The developed prototype was an integrated part of the workflow. The system was tested on the problems that arose spontaneously within the three-day design process. Through the creation of a virtual meeting room, students from the two project teams where regularly collaborating in a virtual simulation of the construction project around specific issues. The students were present in the same physical rooms during the experiment.

The data collection primarily consisted of field notes, participant observation, and video observation. During the experiment, two physical screens reproducing an overview map of the building's different floors was set up. Thus, it was possible to see how the students acted in the virtual environment and follow their patterns of movement. Based on the collected data, relevant persons were selected for subsequent qualitative focus group interviews.

Generel information about the case		
Number of cases	2 cases with Danish students and international students respectively. Each case consists of 20–25 students with different roles	
Participating educational programs	16 educational programs from 5 educational institutions	
Information about the participants		
The relevant role of the participants in relation to the VR simulations	Architectural Technology and Construction Management	Responsible for coordination, planning, project management and construction management.
	Energy Technology	Planning of plumbing and design of electricity
	Hospitality and Experience Management	Represents the developer role with tourism as the approach
	Engineer in Indoor Environment and Energy	The design of indoor climate and energy
	Cand. cient.techn. in Building Informatics	Specification, design, implementation and evaluation of ICT solutions in the construction industry.
	Engineer in Structural and Civil Engineering	The design of supporting structures
	Engineer in Architecture & Design	The design of the architectural design solutions
Information about the datacollecting		
Field observation	4 people from the development group of the prototype were observing the VR simulations	
Video cameras	2 cameras - 15 hours of recording	
Voice recorders	2 dictaphones - 15 hours of recording	
Number of simulations per case	12 simulations - Each group participated in two simulations of their project per day	
physical screens	Two physical screens that viewers participants activity inside the virtual environment	

Figure 7: Displays information about how the data is collected and the study-setup

RESULTS AND ANALYSIS

The testing of the prototype is designed to describe and document the collaboration processes, of virtual reality in a construction project. The experiment of learning activities around complex problems in virtual reality, is about how the environment mediates the participant's collaboration. The collected data shows some tensions in the activity system of the experiment. The following part of the analysis address some of these tensions in the collected data, and the described prototype.

THE USE OF THE SYSTEM AND ITS NARRATIVE STORY

The dominant form of the dialogue consists primarily of a simple transfer of knowledge, including orientations and clarifying questions. A large proportion of the students are passivly listening and only when asked directly; they take an active part in the discussions. Situations where the students just stand passively inside the model while they are talking are prevalent. The following example shows a conversation about the project's file management, as well as a delegation of tasks. This situation is independent of the presence within the virtual model.

Dennis: But I think it is the way we should do it because Michael is stressed right now. They're just announcing… so if you focus on the file analysis now, then Michael does the drawings you need. Moreover, you have to contact the architect group with your questions. Alice, you can contact Martin, and he will contact me.

The example shows that the students' use of the system on a mental level (Wartofsky´s artefact level two) are largely dependent on some form of facilitation. The students find it hard to create a systematic approach due to a lack of systemic restrictions and rules about the system is used. These lack of restrictions makes it difficult to grasp the opportunities and thus the selection of problem areas. The analysis of the data, therefore, indicates that the conditions for the use of virtual reality imply a collaborative learning process that is dependent on the system's ability to facilitate processes, including an initial framing of the task.

The analysis shows that if the utilization of the virtual environment should contribute and mediate a problem-based process, it is crucial to create a preselected route that provides some predefined "nodes" as the basis for learning – the narrative story. The students' use of the virtual model was often characterized by a spontaneous trip through the building, which forms the foundation of a discussion based on a series of coincidences, which never actually provided the students with a grasp of the problematic areas of concern.

Dennis: The wall we just went through is going to be demolished and this wall is also okay? Yes, and this one? Moreover, the thing you have here is very strange. We are going to demolish that corner, and extend the wall, so it goes all the way down to the end wall. We just delete this corner here, and then we extend the corner to the end okay? Are you with me still?

With respect to the cases where the students could not move optimally around the virtual environment because of outright errors in the model, it is striking that the project group did not considered it as a problem. One explanation may be that the students' lacked an understanding of their role, or it may be explained by the students' immersion through the use of avatars. The roles proved to be unclear, which mean that no one was taking action with regard to the issues that appeared along the way.

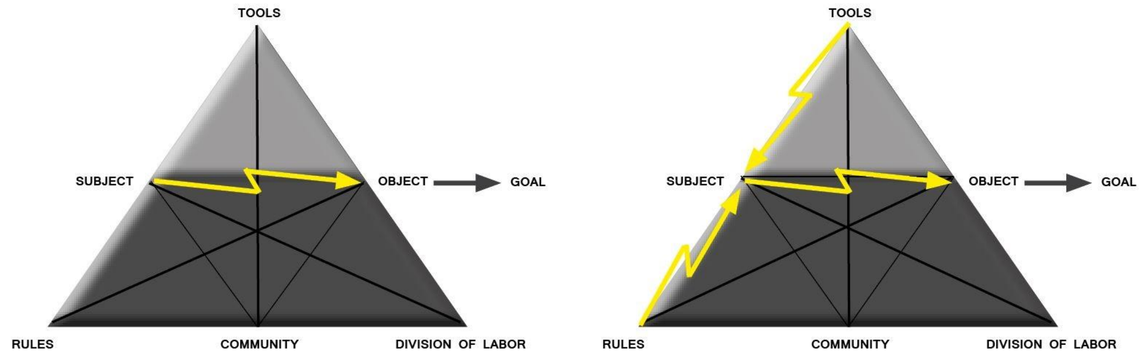

Figure 8: The participants were not able to use the VR system in an appropriate manner due to the system's inability to facilitate its user.

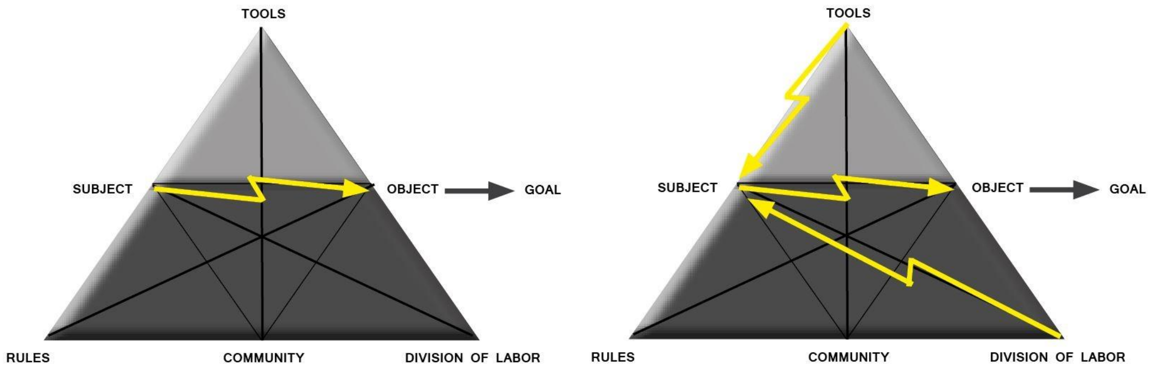

*Figure 9: T*he participants' lack of understanding of their role, or the immersion through the use of avatars, makes it difficult to use the system to establish collaboration and dialogue.

Here it may be crucial that the students do not on a very basic level have the necessary skills to use the system, corresponding to Wartofsky´s level one of an artefact. Another explanation for the observations may be that most of the students' mental energy were being used to be present in the virtual space, which leaves very little time to be reflective and engage in a debate regarding a specific issue.

THE USERS' OWN ITERATIVE AND UNFINISHED DESIGNS

The observations show, particularly, that the 3D model's level of detail affects the students' ability to navigate the virtual environment as it was greatly dependent on whether the building had a logical structure – no blocked areas, ghost walls, missing light/textures, holes, for example. The students disappear from each other several times due to the model of the building.

Interviewer: Well, there was the opportunity to go through?

Peter: Yes somewhere, suddenly I went through a wall, so I was a bit like: "Where am I now?" Moreover, then you go back again, and then all the others, they are gone, and then you cannot find the others.

Interviewer: Well, very funny. Then the space experience with each other disappeared.

Dennis: It was the same at the stairs down to the depot downstairs, there was apparently some surface which made it so that once you went through it, then your fellow players disappeared, if one can say so. So you also lose a little thing with; okay he is down there, I do not know because I cannot see him, but I know that because he says he is down there.

Unlike computer games, “Virtual Reality” used in an architectural and construction professional context, leads to situations in the early design phases where the uploaded 3D model is prepared at a level of information where it appears unfinished. Video observations show some cases where the VR system's realistic representation of the building was a problem. The fact that the participants in the system are only aware of the current room on the specific floor they are on makes it difficult to understand and imagine the building as a geometric spatial model – also called the third level of the artefact. Particularly the student’s discussions concerning issues about the static system and piping of the building are challenged. The students here chose to use the two overview screens for consistency, which could be seen as a creative alternative to the system’s intention.

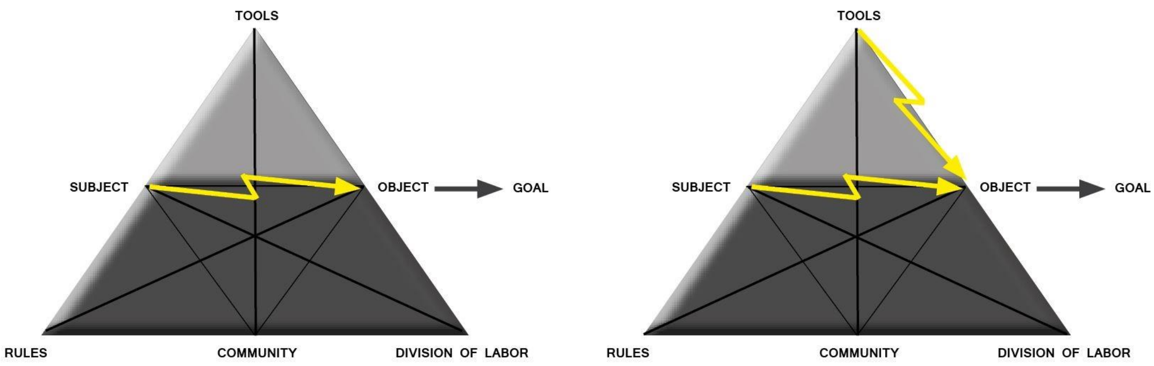

Figure 10: Because the 3D model is created by the users' iterative and unfinished designs, it was difficult to navigate inside the virtual model.

They point out, however, that the VR system visualizations of the building components contributed positively to a deeper understanding of the context and thus allowed for development processes and new answers to detected problems. The students' statements thus indicate that the virtual universe was what mediated the development of a problem-based learning process. They emphasize an example where the building's ventilation system, with a graphical selection in a grey tone, triggered a discussion about the construction of the pipeline.

Dennis: I can certainly do ... we had a case at the last meeting about ventilation in the model, and it worked well. You see the tubes; they are a greyer shade so we could see where the ventilation should be, well, the pipes runs here and there. So that it worked well.

If virtual reality is to contribute to a conversational reflection it is crucial that the consequences, arising in connection with the dialogue, can be incorporated into the VR system so as to maintain the iterative transformation of the building. This reflective process is just an example of Dewey's thoughts about the link between thought and action, which the traditional web 2.0 technologies have difficulties facilitating. The virtual environment helps to maintain and mediate the iterative process while the students are acting through their avatars actively in response to the challenges they encounter.

ESTABLISHING RULES OF ACCEPTABLE BEHAVIOUR

The tension generated by the human interaction with the system is especially evident. The technical difficulties with the use of the system were filled with so many problems that it was beyond the ability of the participants to maintain a dialogue within the group, and it pushed the student's spontaneous use of the system in a new direction, which would shift the focus from the original topic.

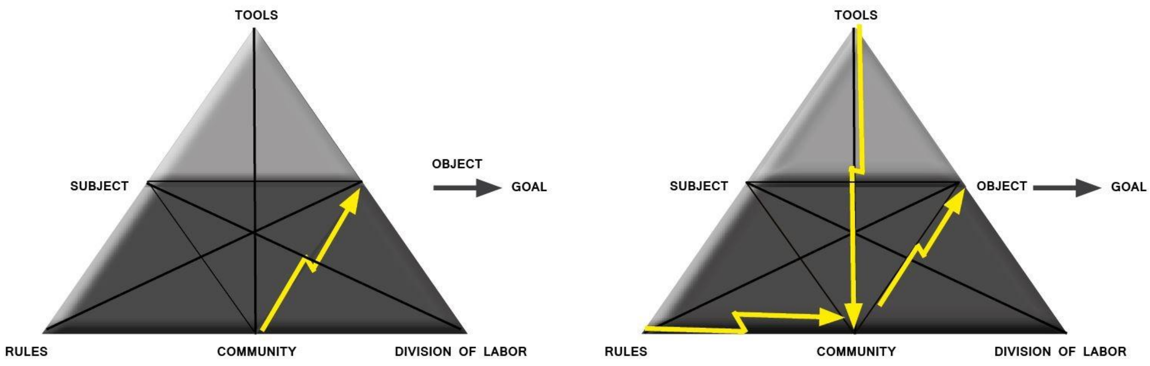

Figure 11: Unclear rules of acceptable behaviour inside the virtual universe gave the participants problems in terms of concentrating on using the system.

The clearest example of Wartofsky´s third level of an artefact appeared in the direct parallel to the MMORP game, which resulted in the students playing with their avatars on several occasions. The example below shows how the laser pointer suddenly became a light sword, and the student started to run around inside the virtual environment trying to catch each other.

Student 1: I think it will be fun, I believe he has gone hunting. I will see if I can find Michael quickly.

Student 2: Try to go in there

Student 1: I cannot go any further

Student 3: Hell, that is the Aalborg Tower!

Student 2: Does it look like that?

Student 1: There he was. There is too much play in this. I think we have got it working.

Student 2: Shut up, you are a kid.

Student 1: I may be 23, but that does not change anything

Student 2: Why is he running faster than you?

Student 3: It is a sprint.

Student 1: I will shoot you…

The spontaneous play within the system occurred primarily during start-up periods where the students were waiting for each other to join the world. Playing with the system is an example of how VR can support exploring and curious behaviour, which according to Dewey is what initiates and supports reflection processes. The surroundings thus offer the chance to play, which creates affordances when it comes to investigative behaviour. The students explained that they were able to find a serious focus on the task as soon as the project leaders announced that the meeting was ready to start.

Peter: I think our first trip there, it was like; now I shoot you, and now I will shoot you. It was the very such first time. Ah, well, I had to see how it worked, which was great, and now you are dead and stuff. However, when we started to take it seriously, it was an excellent tool, I think.

Another important aspect that proved crucial to the establishment of the student's collaboration inside the system is the fact that it is hard to follow each other inside the virtual building. Looking more closely at MMORP games, this situation is not an issue. There are three main reasons for this: (1) The virtual universe has a natural frame that leads the computer players in the right direction. (2) Computer players have built a strong discipline to prevent people going their way, as it often leads to the game punishing the participants with new, unforeseen challenges – it is not effective. (3) Gamers have a predetermined target they all pursue and have an interest in reaching.

Using VR for the visualization of a building has been challenged on the following three grounds. The building is not a linear structure where there is a starting point and an end point.

Also, a building does not contain clear and unambiguous logistics. The unclear logistics means that without a predefined route that all students know of, or an agreement saying that everybody should follow the supervisor, there is a significant risk that the users will get away from each other. The observations repeatedly show that the participants chose to pursue their curiosity of wanting to "discover" the virtual model. This behaviour consistently lead to the students getting lost and away from each other.

The students in this experiment had no previous experience with the use of virtual reality in their studies, and they had not had the opportunity to build a set of standards for how to act. The observations, therefore, revealed several examples of the students spontaneously rebuking each other to maintain focus on the task and also preventing getting away from each other inside the model.

Peter:	You should not go too far away!
Morten:	No no, it was because we were upstairs. You rebuke me constantly Peter (blue avatar)
Peter:	Yes, it is because you are running around like that.
Morten:	Yes, I don’t just want to stand there and stare.

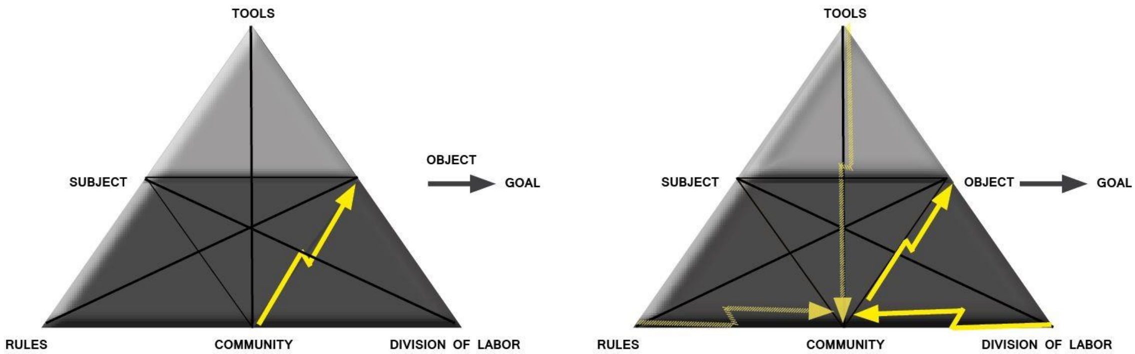

Figure 12: *The definitions of roles and who has the right to decide.*

The example shows that there was no clear standard for how they should act inside the model and this led to a spontaneous dialogue about behaviour and an argument about who had the right to decide. Here, it is especially the definitions of roles that initiated the spontaneous creating of social rules, where the leader of the meeting, represented by a blue avatar, was trying to take control. In the cases where the students were able to navigate inside the three-dimensional universe, as well as keep all the participants online, some observations showed incipient tendencies to a focused dialogue. Marked differences could be observed during the three days. The processes on day 3 were clearly more organized and focused.

FINDINGS

The project's aim has been to describe and document the processes that the involvement of virtual reality, as a collaboration and communication tool, leads to in terms of problem-oriented work. The objective was also to get localized relevant focus areas to optimize the current design principles towards the development of the next prototype.

The physical experience of being present in the building provided students with a greater understanding of the complex issues their projects deal with and the ability to create inquiry. The group's own investigations of the building design are what creates the right conditions for problem-based learning processes in a virtual environment. Particularly the students' spontaneous and personal "tour" inside the building supports Dewey's concept of exploration, which is essential when it comes to creating processes of reflection that contribute to learning. The students experienced first hand when the building was designed in inappropriate ways, such as having closed areas and holes, or areas that have not been acted on or discussed. These experiences created meta-reflections during the VR experience and in the follow up group discussions.

The strength of VR combined with web 2.0 is mainly related to teamwork, as VR provides an opportunity for the students to be synchronously present in the same room. When this "room" is based on the students' own iterative design, a much more experimental, physical and lively dialogue is supported, something the traditional web 2.0 technologies have difficulties facilitating.

The analysis shows, however, that the use of the three gaming elements – "Avatars," "Real-time environment" and "Social acceptance/approval of rules" – in the study are not enough to facilitate a problem-based learning process. Increasing the use of gamification principles is therefore essential if VR shall add some seriously new opportunities to web 2.0 technologies. Especially design thinking and sketching methods will require much more active and interacting opportunities in the virtual environment. The analysis showed several examples of passive dialogues, only slightly mediated by the VR system. Therefore, an increased use of gamification principles could be yield results with respect to creating active actions that are more situated, experimental and collaborative.

The following four points are examples of gaming principles that may support Dewey's concept of **exploration,** as a way to create emotional tensions that lead to changes in the direction and content of the students' experiences through processes of reflection.

- **Quest:** A defined task or activity that triggers a reward.
- **Level:** The way an MMORP game categorizes their player's overall effectiveness and possibilities.

- **Dungeon:** An adventuring area where the players carry out scenarios or missions that have its own history in the game.
- **Wipe:** A Wipe is a situation where the entire group is killed. Wipes may occur for many reasons; the team is failing to do their job or unexpected issues when challenging content have to be "learned."

In addition, the learning potential in the application of virtual reality can be strengthened by improving the system's ability to support the avatar's role through specific tools and options for action.

The use of Wartofsky's taxonomy shows that it is crucial that the participants in the virtual system, have the necessary skills to let the system mediate their collaborative process. Through the use of Wartofsky's definition of the tool at level 1 in the analysis, there are indications that the lack of a knowledge base and competence led to challenges with respect to level 2 (the mental level) and 3 (imagination) of the artefact. One example involved the participants having a hard time fulfil their role descriptions, as their primary energy was focused on getting the virtual tool working in the most core areas.

One thing is the participants' qualifications and competence; something else is the system's limitations in facilitating the collaborative process. Wartofsky's definition of level 2 as the mental level showed that without a systematic approach to the model, it is difficult for participants to start up a dialogue. The analysis demonstrated that the use of virtual reality requires a very precise framing regarding the participants' tasks and activities within the system. Improving the system's ability to facilitate this increases the possibility of the establishment of a collaborative dialogue.

New design principles should, therefore, address the facilitation of the participants' navigation in the environment and frame the relevant activities through various graphic effects and user interfaces. Here it would be natural to look at existing navigation solutions known from, for example, computer games software.

It is estimated, however, that participants with a longer habituation period will be able to take far greater advantage of virtual reality because of the expected improvement in the agreement upon the rules. This expected improvement requires constant access to the software to develop new cultures, norms and methodologies for the use of the system.

Furthermore, the potential of a graphical upgrade of the participants' avatars with respect to different forms of expression, allows the system's visual side to support a deeper understanding and collaboration with respect to the building's problem areas through dialogue. The analysis, therefore, points to the advantage of adding some features to the system that can support the participants' opportunities to see who is talking, and partly upgrade the avatars' ability to visualize simple body language.

The conclusion of this study, therefore, suggest that the described development opportunities in the software can strengthen the collaboration process to a much greater extent and thereby strengthen the collaborative and problem-oriented learning process.

CONTRIBUTION

The project contributes to the existing knowledge by examining the challenges and opportunities that the use of VR offers blended learning in professional and practice-oriented educational programs – particularly the possibility of incorporating physical and explorative learning processes on the distance in future web 2.0 technologies. The project represents an idea of a VR design that can subsequently inspire further developments, especially regarding the use and inclusion of gamification as a way to facilitate blended learning.

The project contributes to showing how new technologies, such as VR and video games, can provide both a new vision and also new opportunities for strengthening the involvement of a practice related dimension in problem-based learning environments. The study clarifies the complexity and robustness that web 2.0 solutions must contain to support a sketching, design-oriented, exploratory and investigative learning process, which is at the core of problem-based learning in architecture and design education.

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