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Social Familiarity in Virtual Learning Environments - An Empirical Approach on Engineering Students' Interaction in Collaborative Minecraft Scenarios

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Social Familiarity in Virtual Learning Environments

An Empirical Approach on Engineering Students' Interaction in Collaborative Minecraft Scenarios

(Research Paper)

1. Introduction

Industry 4.0 is approaching. It refers to contemporary automation, Big Data exchange and manufacturing technologies [1]. A crucial part of it is furthermore cyber-physical systems, supported by the Internet of Things as well as the Internet of Services: In short: it implies a lot of remote and/or virtual collaboration. At the same time, an increase of virtual or remote work in a globalized world for the sake of training the Engineer 4.0 presents a special challenge to engineering education itself. It demands a self-evident usage of effective e-collaboration tools in order to interact with often unfamiliar colleagues around the world. Scenarios, in which all facets of collaboration may be tested, can for example be built in the indie open-world game *Minecraft*.

The full understanding of advanced e-collaboration, whether anonymous or not by the help of exemplary software-tools like Minecraft, will be of major importance for the optimization of learning in an Industry 4.0 context. The nature of collaboration itself must be undermined by evaluating gamy collaborative tools in order to then find out, how these should be designed to be used in business. This is crucial because it is expected that within the next few decades, more than half of all office-related tasks will be completed remotely [2]. Thus, the usage of Virtual Learning Environments (VLEs) – at best in an education state – should be facilitated whenever the content allows so.

Moreover, VLEs must present scenarios which allow to go beyond oral or written (a)synchronous communication. This fact underlines on the one hand the importance of an appropriate VLE design. On the other hand, before designing these proximities, it must be researched how well engineers can interact and be creative by utilizing the respective tools and which conditions their employment requires. It must be science's main goal to properly prepare engineering students for an Industry 4.0 context. Only after careful consideration of all these (educational) conditions and requirements, one can think about which content to credibly implement into VLEs like Minecraft.

This research paper seeks to contribute to the answer of the question of how well young engineers can and want collaborate in Minecraft-VLEs already now. This shall be done by answering the following key questions:

- With regards to the functioning of a collaborative planning tool like a blackboard, how must VLEs be designed in order to foster virtual problem-solving?
- How are real life problem-solving processes different from those in VLEs?
- Deriving from the results, what are the advantages, challenges of and cooperating in VLEs?

To answer the research questions, it will be preceded as follows: First, the key assumptions and definitions shall be presented. In addition, it will be clarified which limitations this work faces with regards to completeness, explanatory power and psychological insights. Section 3 summarizes related works, the state of the art in relevant research as well as the academic voids, which develop hereof. Hereafter, the theoretical framework, on which this work is based, meaning the Blackboard Modell for organizing and conducting tasks and in how far VLEs can function as such, will be presented. After that, the experimental set-up of the virtual reality study will be described. Section 6 summarizes significant results which are crucial in order to answer the key questions. Section 7 will discuss and interpret the results to thus make tentative inference concerning their denotation. The conclusion will finally contain an outlook concerning further research, which must be undertaken in order to embed remote virtual engineering education in an Industry 4.0 context.

2. Assumptions, Definitions & Limitations of the Study

This section seeks to elaborate the funding assumptions and definitions, on which this work is based as well as the limitations with regards to the results of the study.

First of all, the term collaborative learning, in this paper also referenced to as e-collaboration, must be illuminated. Collaborative learning describes a scenario in which two or more people try to solve a given problem together. The main advantage is that they profit from each other's knowledge and skills (asymmetric roles) [8]. This way, learning capital in the form of common knowledge is being created. It includes the asking of questions, sharing information, evaluating the others' ideas and monitoring each other's work. Thus, collaborative learning combines methodologies and scenarios/environments, where the learning individuals depend on each other [9]. This scenario might be placed in real life (face-to-face), in online chats/forums or VLEs. The classical tools to evaluate e-collaboration are conversation and statistical discourse analysis [10]. Collaboration and cooperation must be differentiated here since cooperation targets the working together towards shared goals. In contrast, collaboration refers to working in a group of two or more in order to achieve a common goal while respecting each individual's abilities and contribution to achieve it [24].

Furthermore, it must be defined what mixed-reality is since the conducted Minecraft study consists of a mixed-reality environment (Fig. 1). Mixed-reality is often also referred to as hybrid reality. It describes the interplay between real and virtual worlds for the sake of producing intermediate environments or visualizations, where digital and physical objects interact. Often, it is an interim of reality, virtual reality, augmented reality or augmented virtuality [7].

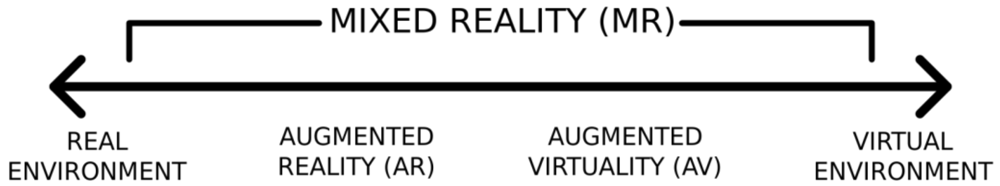

Fig. 1: From real life to virtual environments - a development axis [7]

Mixed-Reality is so new to users that it often involves usage-difficulties. Since the study will show a high level of simulator sickness, this phenomenon must be explained. Simulator sickness, also called motion sickness, is typically experienced while being in simulated environments [19]. The symptoms include discomfort, drowsiness, disorientation, vomiting etc. The individual level of sickness might lead to a semi-optimal usage or even a demolition of the simulation.

As for the potential limitations, it must be stated that the evaluation of the results is still in progress. The herein described study was conducted in July 2015 with 48 participants. The data analysis contains of movement tracking, the evaluation of corresponding in-game videos as well as a speech analysis. This work entails extracts from the in this way gathered results and aims at showing merely trends from which tentative conclusions shall be drawn. Another limit this work faces is the implementation of engineering education learning content into Minecraft. It was not the aim of this study to depict actual content, but to test the collaborative tool per se.

3. State of the Art & Related Research

The upcoming section aims at embedding the herein presented study and its result in an educational, collaborative context. This will be done by naming ground-breaking projects and practices from around the globe as well as a pre-study conducted by the authors.

First of all, previous research on virtual environments showed that personality factors do not play a significant role in terms of performativity. While solving a task in a virtual environment created for the measurement of spatial thinking abilities it turned out that the subjects' performance could not be connected to for example interest in technology in general or pre-gaming experiences. However, in this work, it will be elucidated whether personality has an effect on performativity in collaborative VLEs [26].

As for the used tool Minecraft, it is already widely installed for education purposes. Therefore, it can be considered to (at least partly) be a so-called Serious Game, meaning a game, which was not designed for entertainment purposes alone, although there are gamy elements in it. In addition to these, Serious Games do often serve the purpose to educate or practice certain situations [11]. Education-wise, these might derive from physics, literature, logic, geometry, art, history, chemistry, programming and so on. With regards to personality-development, Minecraft is often used to stimulate leadership-skills, visualization/imagination, self-direction and assessment, decision making, collaboration, communication, ratio and proportion, story-telling and others [25].

The advantages, which Minecraft scenarios entail, are the reproducibility of scenarios and consequently, reduced costs. On a contextual level, the design of Minecraft allows for deliverables which classical learning tools usually cannot offer. An example for students interested in arts would be the in-game texts, which users must read closely in order to progress. For mathematical issues, Minecraft can present various solutions to visualize abstract problems. Since Serious Gaming is a widespread didactical trend, the Minecraft designers even published a special educational version of it, MinecraftEdu. Minecraft as well as MinecraftEdu foster collaborative skills such as negotiating, listening, following directions and accepting criticism [ibid.]. Usually, they are used in primary schools.

In addition to the state of the art usage of the game, the authors conducted a closely related mixed-reality Minecraft study with ten professional trainers and teachers aged between 24 and 60 (M=40.7; SD=13.2; n=2 female) [4]. The purpose was to gather insights on the trainers' perspective on remote learning as well as their willingness and ability to transform. The results showed that especially older participants and those with no gaming experience had problems with the handling of the provided technology as well as with the hereof yielding spatial orientation in the virtual environment ($r_{age}=-.60$, $p<.05$; $r_{gaming}=.78$, $p<.01$). Furthermore, it was encompassed that "[…] participants who reported higher sensations of immersion, got used to the virtual world faster, as seen by their objective behavior within the VLE (e.g. number of gaze fixations ($r_{gaze}=.92$, $p<.01$), spatial coordination ($r_{spatial}=.94$, $p<.01$), general task performance (efficieny) as trainee, respectively trainer ($r_{trainee}=.91$, $p<.01$); ($r_{trainer}=.92$, $p<.01$))" [ibid.]. The work at hand presents the logical continuation and counterpart of this anterior study as it will combine the students' perspective on teaching and learning environments for future demands with the teachers'.

Besides the practical advantages, which e-collaboration in learning contains, there is also a social side to (educational) gaming, which often goes unseen [5]. It refers to research question number one. Nowadays, traditional community structures are falling apart. This means that people prefer to spend time with people they know well instead of participating in civic societies and public activities [6]. Entertainment gaming has found a way to not solve this problem, but re-invent society instead. They are creating virtual social capital, new habits of social bonding by interacting with friends as well as strangers in virtual worlds [3]. It is only logical that as e-collaboration in entertainment games (for example in massive multiplayer online games), becomes a relatively natural, societal habit, which is now being commuted for educational purposes in the form of 3D-VLEs. This entails the addition of gamy, digital or virtual elements to already existing practices. The fact that entertainment games entail their own social practices is important to notice in order to understand the community structures, which derive from educational games or games used in education, such as Minecraft.

4. Theoretical Framework: The Blackboard Model

The so-called Blackboard Model is a virtual or analogue means of organization, which functions as an architectural pattern for problem solving. In this work, it serves as the theoretical framework for the configuration of virtual collaboration. Generally, it consists of the following three components: first, the involved sources of knowledge, which can either be persons or data bases of any kind. Second, it includes a decentralized, blackboard data structure, thus, a physical or virtual/digital blackboard or place of storage, where tasks, results and problems are being depicted. Third, it refers to self-activating, opportunistic interaction between the participating parties without a control mechanism. The rules of interaction and behavior surrounding the blackboard can specifically be determined by all parties involved as well as the preferences of practice these have [27].

The Blackboard Model targets collaborative problem solving, the hybrid transfer of knowledge and "[…] it involves such pragmatic considerations as 'naturalness', availability of a knowledge representation language and the skill of the implementors" [ibid.]. Therefore, it suits the design of the conducted study in terms of researching the nature of virtual, collaborative organization, agile planning and (ideally) task completion. Still, the detailed set-up will be outlined in the next section. Back to the Blackboard Model, this information-system could be described to be a 'multi-agent system' to store, plan, exchange and complete tasks necessary to solve a larger, overall problem and to assign them to the respective expert(s), which is/are then capable of (collaboratively) solving the sub-problem(s).

Since the conducted study seeks to examine the nature of collaboration in VLEs per se, it shall also address the question in how far a VLE can function as a blackboard. It shall be elaborated in how far virtual interaction changes if instructions concerning the given problem are located in a semantically meaningful position (in case of this study, the instruction signs, as it will be shown below). The question is in how far this will affect a structured, yet agile mode of operation. Furthermore, it must be figured out whether a not over-formalized task will lead to a lower level of attachment to it and thus more flexible, spontaneous collaboration. The last question is in how far the uncertainty of what the anonymous co-player can actually add to the given task, meaning what pre-knowledge she has (if any), will influence the interaction. Will it lead to an increased 'try and error' mentality and thus eventually, a more sophisticated reflection on what went right/wrong and finally, in the long run, to a more in-depth learning?

5. Experimental Set-Up & Methods

The following section describes the experimental set-up of the virtual reality study. As for the spatial conditions, it took place in three rooms. One room was used for technological coordination, and the other two contained the technical equipment needed for the task, each with one test person in it in order to keep them separated from their team mate.

5.1 Participants

Forty-eight engineering students (15 female, 33 male) aged between 19 and 36 years (*M*=23.9; *SD*=4.5) participated. They were randomly recruited through flyers and via e-mails, and then also randomly assigned into pairs. Thus, there were 24 teams, 11 of which comprised of mixed gender participants. One team of the 24 had to be excluded due to a member of the team suffering from severe simulator sickness. Before the study began, it was ensured that the participants did not know each other or meet before the study started. Furthermore, each participant was placed in a separate room while waiting for the study to begin.

5.2 Procedure

The VLE for the test was based on Minecraft. The participants were provided with a large digital house, a hall and a technological laboratory in the VLE. They were asked to restore the lights in the partially blacked out hall with the help of an unknown partner. Signs in the VLE adviced the participants to do so. The research plan consisted of two groups, an experimental and a control group. In both groups, the students worked on laptops. All used a simplified keyboard, where all keys except the arrows had been removed. The arrow keys allowed the participants to control horizontal movements and the mouse allowed the participants to interact with the VLE. By clicking the mouse, they could select the different kinds of items they needed to solve the problem. The experimental group carried out the task wearing a head mounted display (Oculus Rift, Fig. 2). All participants were given a tutorial/test scenario before the actual test to ensure that inexperienced gamers were able to handle all the items needed in the VLE and also to teach the experimental group how to control the head mounted displays properly. During the tutorial/test scenario, all participants worked on their own, though both groups could communicate through the microphones attached to the headphones throughout the actual scenario.

Fig. 2: Technical Set-Up of the experiment

The test scenario introduced the subjects to crucial controls and all the items required to turn the lights in the scenario back on. Each participant was given small exercises to complete without time limits so that they could practice (Fig. 3) using the equipment. Instruction signs with text guided them through the scenario.

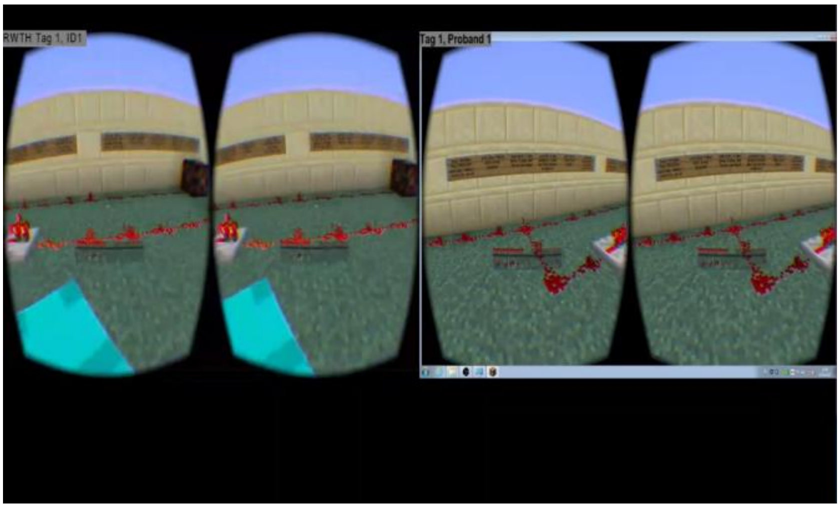

Fig. 3: Screenshot displaying the test scenario seen through the Oculus Rift

The subsequent task was structured in such a manner that each of the team partners held one of the items crucial for solving the task at hand. The subjects were not informed about this in advance. Therefore, communication about resources and division of labor between the team members via their headsets and microphones was an essential prerequisite for solving the task. Using communication skills the equipment in each participant's inventory was discovered during the solution process. In order to capture the complexity of collaborative interactions, the test was conducted using multiple analyzation tools that use a mixed-method approach. This will be explained in more detail below.

Fig. 4: Screenshot displaying the assigned Minecraft task of closing an electrical circuit

5.3 Methods & Materials

Upon arrival at the experiment, the test persons were given a questionnaire asking for their demographic data, physical impairments relevant to the study (e.g. impaired vision) and their gaming experience. The subjects' personality was then assessed using the BIG 5 questionnaire [12]. The BIG 5 measures five crucial personality factors, namely extraversion, neuroticism, openness to experience, consciousness and neuroticism. The ten items are scored on a five-point Likert scale ranging from 1 (applicable) to 5 (inapplicable). The participants' attitude towards teamwork was assessed using the questionnaire for the Acquisition of Personal Attitude (FEE), which comprises of questions like "Within groups I gladly take responsibility" or "I prefer working in teams rather than alone" [13]. The eight items were also scored on a five-point Likert scale ranging from 1 (applicable) to 5 (inapplicable). The participants' acceptance of technology was also assessed using the Technology Usage Inventory questionnaire (TUI) [14]. The eight questions on this questionnaire are also scored on a five-point Likert scale ranging from 1 (applicable) to 5 (inapplicable) in order to get an impression of the participants' comfortability with new technologies (inter alia "I keep myself informed about new technologies").

During the test scenario and the actual task, a screen capture tool recorded the participants' behavior within the VLE in order to track their performance. The analysis of both objective performance (the scientific evaluation of quantitative and qualitative data retrieved from audio and video recordings) and the participants' subjective perception of their performance, may diverge. Therefore, both elements need to carefully be looked at. The subjects' collaborative behavior and communication within the VLE was assessed and extracted using the Minecraft Research Observation tool [18]. The participants were unaware of these assessments, but informed about the anonymized observation in general. This multi-method approach was applied to uncover the differences between subjective and identified attitude using a quantitative assessment.

After the test, subjects were given questionnaires asking about physical problems during the task, their degree of acceptance of the technology and their social experiences during the test. Observations made by participants on the social presence scale (SPS) [16] included items like "When I have real-time conversations in this VLE, I feel like I am dealing with a very real person, not a stranger". Furthermore, participants' sociability was assessed taking into account observations from the Sociability Scale [ibid.], comprising of phrases like "This VLE enabled us to develop into a well-functioning team".

Finally, an evaluation of the subjects' team-communication was carried out in six sections of the Kommino, a questionnaire about general communication and organization behavior [17]. The questionnaire comprises of questions like "I'm quite content with the communication I had with my team partner" or "Without good communication with my team partner, I would not have been able to perform my job in the VLE". As it was the case in the first questionnaire, all questions on the post-questionnaire were scored on a five-point Likert scale ranging from 1 (applicable) to 5 (inapplicable). After that, the participants had the chance to outline the extent to which they accept the technology used, the in-game flow of the experience, the social aspect and the collaboration with their partner in guided interviews. These interviews give, next to the quantitative questionnaires and the objective data, more of an insight into the participants' impressions after the experiment.

6. Results

The quantitative data collected during the test was analyzed using IBM SPSS. Independent sample *t*-tests confirmed that there were no significant differences between participants in the control group and the experimental group with regards to the answers they gave to the questionnaires. Therefore, the data of the two groups were analyzed together. The analysis of the quantitative data indicated that most of the participants felt that the VLE allowed informal, spontaneous conversations (M=4.42; SD=.54), which enabled them to develop into a well-functioning team (M=3.91; SD=.75) and feel comfortable working together (M=4.09; SD=.94). Even participants who indicated that they were rather shy (checking 4 or higher on the 5 point scale) stated, among other things, that this VLE allowed them to easier have informal, spontaneous conversations with their partner (M=4.33; SD=.65, n=13). Additionally, test participants who claimed to have a fear of rejection (4 or higher on a 5 point Likert scale) highlighted the positive aspects of the VLE in terms of team-work and team development opportunities (M=4.08; SD=.95). In contrast to the quantitative analysis, the video-analysis shows otherwise, with only 4 teams actually chatting about informal topics during the task. Furthermore, over half of the participants stated that they experienced simulator sickness and/or difficulties concerning the handling of the given technologies, besides being able to fulfill the Minecraft task.

Despite the items being divided unequally amongst the team members, in 3 of 23 teams (17,4%), one of the team members did most of the work on their own. Even though these teams were also able to accomplish the task, they did not show any evidence of a collaborative practice. In 10 of the 23 teams, team partners orally shared their level of experience, describing what they saw and supposed, taking into account the assignment solution. This affected their division of labor. The participant with the superior experience was also shown to be the one to seize the instructing position. All 23 teams accomplished the task assigned to them. 18 of the 23 teams explicitly aimed to coordinate as part of a team-after verbally agreeing the division of sub-tasks.

The study showed that participants considered it less important to get to know their team partners. Most teams only greeted each other generically by a short “Hi!”, before jumping into the assignment. Six of the teams started the task right away without any greeting at all. They just checked whether they were connected to the person on the other side (“Are you there?”). In fact, only 4 of the teams formally introduced themselves with their names. During the quantitative survey, 88,9 % of the subjects checked “fully applicable” or “fairly applicable” when asked about having had spontaneous, informal conversations.

7. Discussion

In sum, the results allow for five tentative main conclusions.

- First, they show that VLEs allow for informal conversations, from which the process of team-building and classical socializing might profit, if this opportunity is indeed used.

- Second, it can be conducted that VLEs do also allow for shy/reserved students to play a major part in a creative, collaborative learning process (since the division of Minecraft items made it necessary for both parties to perform).

- Third, it can be seen that students feel only a minor fear of rejection due to the anonymity that VLEs provide (it is up to the users whether they prefer to introduce each other or not).

- Fourth, there seem to be issues with the handling of the used technology.

- Fifth, VLEs can function as an entirely new form of blackboards without having tasks formally written down or pre-planning. They foster agile ‘try and error’ by lowering the subjective attachment to the given task.

Relating to the first two research questions (*With regards to the functioning of a collaborative planning tool like a blackboard, how must VLEs be designed in order to foster virtual problem-solving?* and *How are real life problem-solving processes different from those in VLEs?*) and conclusion number one, one may therefore infer the following: Since only 4 teams did formally introduce each other, it appears that VLEs do not stimulate the social practices that create the kind of amicable bonds in entertainment gaming. Thus, subjects have the opportunity to informally, not-task-related communicate and realize so, but do not make much use of it. The reason might be that VLEs are not as open as those provided in classical games. Often, VLEs are reduced to a very specific number of actions the user can perform. In the used Minecraft scenario, e.g., she was only provided with the items she needs to successfully complete the given task, nothing more. Thus, a reduced, task-oriented design might lead to an increased goal-orientation, which might take place at the cost of cordial interaction. Apparently, this is a disadvantage of VLEs and is thus also part of the answer to research question two (*How are real life problem-solving processes different from those in VLEs?*)

Another disadvantage, which might explain the low level of non-task related communication, might be the full anonymity. One the one hand, it provides the necessary protection/shelter, which especially shy/reserved students might prefer. On the other hand, this anonymity leads to a loss of formal interaction, like the pitching of individual skills, weaknesses and preferences, which they considered common in real-life learning groups consisting of people they know. If the students had clarified questions like whether they had any pre-experiences with Minecraft (like some of the subjects indeed had), the task might have been easier to fulfill because of a better organized work-share. This relates to research question one.

At the same time, also adding to question one, it has been shown that VLEs may serve as an even more informalized blackboard through which an overall task (in this case fixing the electrical circuit by using the unequally separated items) may be completed by informal, agile and flexible planning. The unknown variables, meaning an unknown co-player, her unknown abilities/pre-knowledge as well as the unknown subtasks necessary to succeed inserted a lot of freedom of interaction into the scenario (refers to conclusion number five). Although the main task to fix the circuit came in a written instruction sign, all following steps did not need any refurbishment in order to function. This shows that besides new social practices, virtual collaboration will likely enable less structured working habits, to which formal, written elements (in this case for example a chat) can, but do not have to be added. VLEs seem to be ‘safe’ enough for ‘try and error’ although more complex tasks in a professional context will certainly demand written protocolling and agreements. Nonetheless, it has been shown that VLEs can serve as an interactive, extremely open, collaborative organizational tool: a blackboard to immerse and virtually interact inside instead of solely more or less formal planning.

Apart from this, VLEs have shown to be very beneficial for shy/reserved students or those in fear of social refusal. This refers to conclusions two and three. Due to VLEs, coy and/or excluded students might find the courage and self-confidence to play an active or even leading position in a learning group. They might then transfer this positive experience to real-life.

Concerning the handling of technology, simulator sickness was a very common issue (conclusion four). This phenomenon might be due to the fact that the used technology, especially the Oculus Rift, is rather not commonly accessible. It might be too expensive or only be used for scientific/research purposes. For example, the virtual reality glasses used in this paper will enter the publicly available markets in March 2016 the earliest [22]. Thus, one cannot expect a routinized exposure to it yet. Nonetheless, simulator sickness is a major issue in collaborative learning, especially if done in pairs. If one party gets sick and the subjects depend on each other in order to fulfill the task, the assignment must be stopped at the cost of both. Until users get used the Oculus Rift, users should be free to choose whether they prefer to work with a laptop, like the control group did, or with virtual reality glasses. Moreover, a mix of students wearing the Oculus Rift interacting with students working on their laptop should be implemented until the mentioned technologies become common.

As for the Oculus scenarios themselves, these can only be credibly realized if the content allows so. This means that its usage preferably makes sense in 360° environments, for example in walk-in virtual production and/or factories. Ideally, it should then be connected with for example an omni-directional floor in order to create a close-to-reality scenario. However, the latest Oculus Rift is still triggered by visual bucks such as haziness or fixed-images. Moreover, there is not much content available, which would foster a perfect symbiosis between technology and the seen picture. It also disturbs the perception of content. There are only a few 360° test movies available so the full Oculus user experience cannot be researched yet. Consequently, virtual collaboration inside potential VLEs experienced by the Rift is more a vision rather than a concrete near-future plan [ibid.].

8. Conclusion & Outlook

In conclusion of this paper, it can be said that generally, VLEs offer a lot of chances for decentralized, commonly accessible and fun learning, agile planning, but also entail several pitfalls. At the same time, users needed time to get used to them. It is beyond doubt appealing to test the didactic and educational potential of new technology, but one must not overstretch the gap between technology, which is commonly available/used and the technology that might be used in the next few months or years. To explicitly test the commonality of new technology, it might be useful to include the full and detailed Simulator Sickness Questionnaire (SSQ) for the acquisition of simulation sickness into future research designs [20].

Besides the current issues with technology usage, the question remains, which kind of engineering education curriculum content can be credibly realized in Minecraft. The building bricks system might be useful for architecture students, but it might need more refinement, tools and physical laws in order to depict elements of electronic engineering, physics and mechanics. A more useful tool could be a remote lab or a virtual lab. It has the advantage that content can credibly be depicted, but is on the other hand extremely laborious and expensive to service. Henceforth, one must first understand the nature and possibilities of virtual collaboration in order to design (educational as well as business) environments around these.

What is certain is that e-collaboration will be a crucial part of educating engineers in an Industry 4.0 context. Moreover, collaborative e-learning will become a major part of educational research itself since it allows for Big Data analysis and therefore individualized, goal-oriented teaching and learning. So besides the freedom of action that VLEs offer with regards to blackboard-like planning, a certain degree of formalization and/or recording is required in order to give advice on learning progress and potential improvement. Only by monitoring students in the long run due to modern technology, their understanding of content and personal habits and desires can be found out about and consequently included into future curricula.

As soon as these obstacles have been taken and students (as well as teachers) got used to remote, augmented and virtual teaching and learning, VLEs might become more social. The reason is that they would not have to focus on the usage of new technologies so much anymore, which could foster (in-) formal communication and thus the establishment of new (or old) social and work-related practices. Only then, there can be a clear answer to the question whether students are indeed ready for collaborative education by using the latest technical tools: yes, they are.

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