Collaborative Learning in Action at UT

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ABSTRACT

During the COVID-19 pandemic, the way of teaching and education has been changed extremely, and these changes are likely to (whether partially) continue after the pandemic as well. Most education has moved to an online environment, but this has caused several problems. This research uses a systematic literature review in order to see which e-learning methods and techniques are available right now, what are their strengths and shortcomings, and how to apply (possibly after adapting) these methods and techniques in bachelor courses at the UT (University of Twente), in such a way that it will benefit the students. It mainly focuses on collaborative learning principles and existing e-learning technology, and the combination of those, where the research zooms in on Virtual Worlds (VWs). Findings suggest that the use of customized avatars supporting non-verbal communication and easily accessible collaborative tools in one shared environment are suitable for online collaborative learning. The conclusion can be used for further research and for the development of a VW supporting collaborative learning in higher education.

Keywords

Collaborative learning, e-learning, technology, higher education, online education, Virtual World, VW

1. INTRODUCTION

During a global disease outbreak like the COVID-19 pandemic currently, it is very important to limit the number of infections in order to save lives. Many preventive measures are recommended to achieve this goal, of which avoiding attending public places (including universities) and observing social distance [18]. Due to these measures, physical education on universities was strictly limited, and therefore, most education moved to an online environment. Moreover, it is very likely that even after the pandemic, education will still partly take place in an online environment. Educational institutions will probably move to blended models, where "remote and digital platforms support in-person classroom teaching" [10]. However, this online education came with some problems and shortcomings. One issue is the lack of technical support: it turned out that the success of e-learning projects was often dependent on the skills and quality of technical support provided to end-users [18]. Furthermore, working together in a group in an online setting also causes different problems. One problem is the fear of teachers to deviate from the well-established "sage on stage" mentality (characterized by the traditional classroom setting) to the increasingly popular "guide on side" mentality (characterized by various forms of group and peer learning) [22]. Furthermore, online teaching and learning has been considered as one of the necessary components of education, but this does not automatically mean that if all the facilities are available, students will take advantage of them. Instead, what some students got were replications of traditional teaching materials rather than suitable ways to present, and attractive classes delivered in an e-learning context [12].

On the other hand, a lot of research has already been done in improving the quality of online education. As an example, VR (Virtual Reality) could be a suitable type of technology. VR can be seen as a "computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment" [16]. This makes VR suitable for creating an online (virtual) environment, which looks like a physical class room. Many educators have already said that they will incorporate aspects of this technology in their approach to teaching [8]. Nevertheless, only 10% of the VR applications are used in collaborative learning principles [21]. Furthermore, most of these VR technologies remained only in an experimental state, and it turned out that there were some gaps in these applications that serve to provide insights for future improvements [21].

Another quite new technique used in collaborative learning is gamification. Research has shown that "the use of gamification in the online environment has a positive impact on student engagement", and therefore supports their learning process. "Adopting gamification in an online environment improves students' reactions and enjoyment" [11]. Hence, gamification also sounds as a good online learning principle, especially because lack of motivation is a common problem among students in distance education [3]. However, just like many other e-learning principles, many teachers often lack computer knowledge in this area. There is a gap in computer competency and a shortage of technical support from universities [18].

This research focuses on the existing e-learning technologies and proposes collaborative methods and techniques that can be directly applied at UT bachelor courses, to benefit the students. These methods and techniques are clarified by a list of requirements. A systematic literature review is conducted to investigate which available technologies are the most suitable for collaborative learning, where the focus is on Virtual Worlds (VWs). A VW is "a computer-simulated environment which may be populated by many users who can create a personal avatar, and simultaneously and independently explore the virtual world, participate in its activities and communicate with others" [9].

The remaining of this paper is structured as follows: section 1 further describes the goal of this research, as well as the research questions. Section 2 presents some related work, whereafter section 3 describes the methodology. Section 4 describes the extraction process of the primary studies, section 5 presents the obtained results, including the requirements list, followed by a discussion and conclusion, which are sections 6 and 7, respectively.

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1.1 Problem Statement

As the above-mentioned research [11][18][21] has shown, there are several techniques available which serve to improve the quality of e-learning, in combination with collaborative learning. Nevertheless, every technique or method has its own advantages, such as a higher student engagement, but also disadvantages, such as the lack of knowledge and insufficient technical support. This makes it very hard to come up with a suitable system which makes use of e-learning technologies to offer collaborative learning principles to benefit students.

1.2 Goal

This research aims to address the advantages and disadvantages or shortcomings of the currently used e-learning techniques, and to check which of these techniques or methods are the most suitable for collaborative learning, with the focus on VWs. Based on this, a list of requirements are delivered in order to come up with a proposal consisting of methods and techniques which can be used to benefit students. The goal is to propose these methods and techniques in such a way that they can be directly applied at the UT bachelor courses. The results of this research can be used for further research on collaborative learning in VWs, and the application of this on universities and higher education in general.

1.3 Research Question

The goal of this research leads to the following research question:

How to combine collaborative learning principles and the existing technology of Virtual Worlds to the benefit of the students?

The research question can be answered by the following sub-questions:

1. What are the advantages and disadvantages or shortcomings of the currently used Virtual Worlds technologies?
2. Which components of available Virtual Worlds are the most suitable for collaborative learning principles?
3. What are the requirements for a Virtual World to support collaborative learning?

2. RELATED WORK

In order to obtain related literature to the research domain, mainly Scopus, IEEE Xplore, Web of Science, and Google Scholar have been used. By using search terms such as “collaborative learning”, “e-learning”, “technology”, “higher education”, “university” and “online education”, multiple different documents could be found with research related to these fields.

In the field of collaborative learning and online education, a lot of research has already been done. However, many of these researches are getting more and more outdated compared to the situation in which we live nowadays: many documents are written before the COVID-19 pandemic. Nevertheless, due to this pandemic, online education has grown enormously and this has led to new insights (advantages, disadvantages, shortcomings) of various e-learning methods or techniques. A recent research showed that 41,9% of the respondents (who were teachers) encountered internet connection problems, and 13,6% had technical problems [4]. The important thing here is that this research was based on a survey among teachers or lecturers. However, the students’ perspective is important as well. Existing research often focusses on either the student’s perspective or the teacher’s perspective, or on a more general view. Nevertheless, this research aims to focus on both sides of the problem and tries to distinguish the different problems and enhancements among students as well as among teachers.

The fact that a lot of research about collaborative learning and online education has been done before the start of the COVID-19 pandemic, does not mean that this research is not usable (e.g., [6], [7], and [13]). The existing e-learning technologies discussed in these research papers can be further evaluated based on more recent research papers. The arisen problems of online education during the pandemic have given students and teachers new insights on how online education can be improved. Recent research showed that also health problems play a role in online education, since constantly staring at the screen of a laptop or mobile phone results in having tired eyes and sore eyes, and having back pain due to sitting too much [27].

Combing and comparing new insights with the existing e-learning technologies, concentrating on VWs, should lead to a proposal of collaborative methods and techniques that can directly be applied at the UT bachelor courses.

3. METHODS OF RESEARCH

This research is based on a systematic literature review on the currently available e-learning technologies which support collaborative learning, in order to find the advantages and disadvantages or shortcomings of the different e-learning environments, with the focus on VWs. The goal of this literature review is further elaborated in section 3.1 below.

Secondly, a part of this research consists of requirements elicitation. Based on the literature review, a list of requirements has been set up in order to show of which components a properly functioning VW should consist. The requirements this research performs can be used in the future to actually design and produce a suitable VW. These requirements lead to a proposal that shows which parts of these VWs are the most suitable to benefit students.

3.1 Goal and Need for Literature Review

The main part of the research consists of a systematic literature review to get a clear picture of which existing e-learning technologies are available and can be used in combination with collaborative learning. The reason for undertaking a literature review is to summarize “the existing evidence concerning a treatment or technology”, which is one of the most common reasons for conducting a literature review [15]. To be more specific, this research summarizes the existing e-learning technologies in combination with collaborative learning, where the focus is on VWs. Furthermore, an additional important reason for conducting a literature review is the rapid shift from traditional ways of teaching in classroom to several virtual and distant ways of education, mainly because of the COVID-19 pandemic. Since it is very likely that these kinds of teaching and education will (partly) continue after the pandemic as well [10], the need for a clear proposal of available online learning components which support collaborative learning is high. That makes a systematic literature review quite significant.

3.2 Search Techniques

Initially, the online database Scopus has been used to gather previous scientific research, and based on the relevancy of the papers, a suitable search string (query) has been developed. By maintaining a search log, the search string has been refined

iteratively. This search log can be found here[1], and gives a clear overview of how the search string has been developed and refined over time and eventually, how the final search string has been obtained.

The final search string, which provided a useful result with many relevant papers, is as follows:

```
(
    (
        ("collaborative education" OR
        "collaborative learning")
        AND
        ("e-learning" OR "online learning")
    )
    OR
    (
        "CSCL" OR "Computer-Supported
        Collaborative Learning" OR
        "Computer Supported Collaborative
        Learning"
    )
)
AND
("universit*" OR "higher education*")
AND
("LMS" OR "Learning Management System" OR "Virtual
Learning" OR "Virtual Environment" OR "VLE" OR "CMS"
OR "Course Management System" OR "VR" OR "Virtual
Reality")
```

The reason for this query is based on the key concepts (core concepts) of this research. Truncation has been applied, such that also research papers in which a diverse form (e.g., the plural form) of a key word occurs, are included.

After searching with several different queries, it turned out that focusing on e-learning and collaborative learning only was a far too broad approach: a lot of unnecessary and irrelevant results were obtained. Therefore, there was the need to limit the scope a bit more. It seemed that Virtual Reality (VR) played a big role in higher education e-learning technologies, and that this technology was often combined with so called Learning Management Systems (LMSs). As a result, it was decided to focus more on these online learning environments in combination with VR. This has led to a manageable number of results, of which a relatively high amount was quite relevant for this research. Nevertheless, due to the limited amount of time, it was only possible to focus on one specific domain within these results. Since VWs seemed the most interesting, it was decided to focus on these kinds of e-learning environments.

3.3 Selection Criteria

Consequentially, the above-mentioned query produced 245 results (using the Scopus database). These results are skimmed through to reduce the number of irrelevant results, based on the selection criteria below. These criteria have been set up during the process of developing the search string, based on the relevant papers (including criteria) as well as the irrelevant papers (excluding criteria). The inclusion criteria are as follows:

1. The papers must be written in English.
2. The studies must focus on higher education.
3. The studies must be in a final publication stage.
4. The studies must be of the type conference paper or article.
5. The source type of the study must be a conference proceeding or journal.

Besides, there are the following exclusion criteria:

1. Existing (systematic) literature reviews on e-learning in general are excluded, in order to prevent bias.
2. Studies in which only e-learning technologies occur without any interaction are excluded, since that would contradict the idea of collaborative learning.
3. Theoretical studies or studies without evidence or empirical data are excluded.
4. Papers which are not available, are excluded.
5. Studies in which a proposed system is not evaluated based on students' perceptions or experiences, are excluded.

Next to the results which were obtained from Scopus, the online databases IEEE Xplore and Web of Science have been used with the same search string. In case a paper seemed not available through one of the database websites, search engine Google Scholar has been used trying to still obtain the entire content of that paper.

Possibly, more relevant studies can be obtained by the references in the retrieved studies (the snowballing effect).

3.4 Data Extraction Strategy and Analysis

In order to select the most suitable studies for the literature review, the following procedure has been followed:

1. The first results are obtained by using the search string in the previously-mentioned databases (i.e., Scopus, IEEE Xplore, and Web of Science). The websites of these databases are searching in the title, abstract, and key words of each paper.
2. On each database website, filters are used to automatically reduce the number of irrelevant papers (e.g., papers which are not written in English are already excluded).
3. The remaining results of all databases are put together and duplicates are removed, by using a suitable software (instead of doing this manually).
4. Within this software, filters are applied to reduce the number of irrelevant results even further (e.g., papers which are books or book sections are dropped out).
5. The obtained results are evaluated based on the inclusion and exclusion criteria. This is done in two rounds:
    a. First, the remaining studies are manually selected by the selection criteria based on the following data fields: title, abstract, and key words.
    b. Second, the inclusion and exclusion criteria are manually evaluated more carefully on the remaining papers by reading the introduction and conclusion of the paper.

The described process is also graphically displayed in Figure 1 below.

[1] https://drive.google.com/file/d/1J8Cd_yM94NfzwSRBKBuo3_1IcOlTjeWF/view?usp=sharing

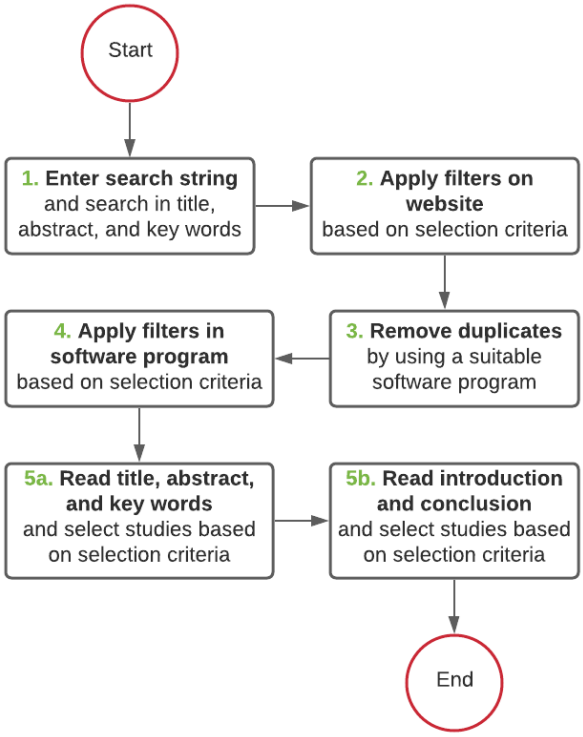

Figure 1. Selection of primary studies

4. EXTRACTION OF PRIMARY STUDIES

This section describes the extraction of the primary studies according to the described plan in the previous chapter. The number of results after each step, for every source and in total, are summarized in Table 1.

4.1 Applying Selection Criteria

In step 5a, the title, abstract, and key words of the 267 obtained studies have been read in order to select studies based on the inclusion and exclusion criteria. After this step, a total number of 70 studies remained, which means that 197 have been excluded, based on several reasons:

- Various papers were not freely available, even with the license of the University of Twente.
- Some studies were far too short, contained insufficient data or a very poor sample.
- Some studies were still in progress, which means that the results of these studies were not available yet.
- A couple of studies did not focus on higher education or universities, but on primary or secondary schools. There were also studies that did not focus on educational e-learning systems at all, but focused on systems for specific companies instead.
- Several studies focused on how teachers or professors should be supported, in order to be able to use a specific e-learning system in the right way. However, these studies did not focus on the functionalities or usability of a system, and therefore, they were not quite relevant for this research.

In the last step of the selection process, step 5b, the introduction and conclusion have been read from each of the 70 remaining papers. Furthermore, the remaining content of these studies may also have been read, such that in case of any doubt, a study could be included or excluded based on a better picture of the study. After step 5b, 21 papers have been excluded, which means that a total number of 49 studies has been left, which are relevant for our research. The main reason for excluding the 21 papers is the lack of evaluation of any system, based on students' experiences. Since the goal of this research is to come up with a list of requirements for a collaborative e-learning environment in order to benefit students, knowing the point of view of students about the currently used e-learning systems is crucial. However, several studies based their evaluation on the number of times a student accessed a certain (part of the) system, or on how engaged a student felt about a system, for example. Nevertheless, these studies do not show anything about why the students are satisfied, or why they are more engaged to use the system rather than getting courses in a traditional setting. The aim of this study is to know which components of existing e-learning systems are useful for collaborative learning among students, but without an elaborated evaluation on and reasoning behind why students are satisfied (or dissatisfied) about a certain system, this is impossible. Therefore, such studies have been excluded in this last selection step.

In some of the excluded papers, the proposed collaborative e-learning environments were not even evaluated at all. The implementation of these systems was mostly based on literature, but after the implementation, an evaluation of or experiment with these systems was lacking. As a result, it is unknown whether such systems will be a suitable collaborative e-learning environment in practice, and therefore, studies with these unevaluated systems are excluded for this research. An overview of the excluded papers after step 5b can be found here[2], such that they can be possibly used for future research.

4.2 Categories of E-Learning Education

Within the 49 obtained studies, there are quite some differences. Due to the relatively high variations between all the e-learning environments in these studies, the need to categorize them, arose. After inspecting all these 49 studies, the following categories of e-learning environments have been obtained:

1. Studies which focus on a specific LMS, e.g. (something like) Blackboard [5], Canvas [14], or Moodle [17]. These studies offer courses which are fully taught online through the e-learning system.
   The total number of retrieved studies within this category is 34.
2. Studies which focus on a VW, in which students and teachers are represented by an avatar, e.g. (something like) Second Life [26]. The courses in these studies are taught through the VW.
   The total number of retrieved studies within this category is 9.

Table 1. Results of extraction primary studies

Step	Scopus	IEEE	WoS	Total
1	245	87	118	450
2	184	87	108	379
3				339
4				267
5a				70
5b				49

[2] https://drive.google.com/file/d/1-BxZ3NNfj4f3c7pOXp4nBrQTsLg1czFc/view?usp=sharing

3. Studies which focus on a blended or hybrid approach. In these studies, traditional classroom meetings are alternated with education through an e-learning system. Hence, the courses in these studies are not fully taught through an e-learning environment, but physical education takes place as well.

   The total number of retrieved studies within this category is 6.

An overview of all the 49 obtained and categorized studies can be found here[3], which can be useful for future research purposes.

Due to the relatively large differences between all the studies and time limitations, there has been decided to focus on one of the three above-mentioned categories. In the next subsection, the reasoning behind the chosen category is elaborated.

4.3 Chosen Category

Most of the 49 retrieved studies are focusing on a LMS, or something similar. Nevertheless, there has been chosen not to concentrate on this category, since after skimming through papers evaluating an LMS, it seemed that most of the times, not all the functionalities of these systems were used, but mostly only the "managing parts" (e.g., taking notes, using calendar functionalities, or watching lectures). However, this research focuses on collaborative learning, and as long as all the functionalities of LMSs are not fully used, the collaborative part is quite marginal.

In most of the studies about a LMS, the discussion forums seemed the only component which supports collaborative learning, since through posting questions and answering on other students' posts, students learn with and from each other. Nevertheless, as already stated above, this is one of the few components of a LMS which has to do with collaborative learning: other parts of the system are often not especially related to collaborative learning or are not even used at all. Therefore, there has been chosen not to further focus on this category of papers.

Furthermore, also studies which focus on hybrid and blended learning approaches can be seen as less relevant, within the scope of this study. This is mainly because the e-learning systems which are used in this blended educational setting are LMSs, which come with all the aforementioned issues.

Secondly, the reason to not focus on hybrid or blended learning is because education is still partly physical, which has often as a consequence that the material which is taught in the real classroom, is done in the traditional way (i.e., the teacher as "information distributer", and the students as listeners taking the information and memorizing and reproducing it), which is contrary to the idea of collaborative learning, where the students are working and learning together, and the teacher fulfills a facilitating role.

The last category contains studies which draw attention to VWs, and there has been decided to focus more on the papers within this category. The reason for choosing this category is because of its affinities with collaborative learning: since students and teachers are represented by an avatar, a VW is far more interactive than just an LMS. As a result, from the total number of 49 relevant papers, 9 have been selected for this research to focus on, since these papers have the greatest affinity with collaborative learning. An overview of these papers is listed in Table 2 below.

5. RESULTS

In this section, several findings from the extracted data from the primary studies are described, based on different domains of the concerned VWs. The common advantages and disadvantages of the systems are mentioned, which eventually lead to a requirements list and answering the research questions.

5.1 Avatars

Due to several reasons, many of the reviewed studies considered the appearance of an avatar as a very positive component in the VW. Within a VW, students and teachers were represented by their own avatar, which acts as a character in the environment. Scullion et al. (2012) [25] argued that the representation of yourself as an avatar feels comfortable: you can just say what you want, while you are in a comfortable zone, which is at home. De Lucia et al. (2009) [7] indirectly confirmed this feeling of comfort, because it turned out that thanks to the avatar interaction, "it is important to underline that most students proposed at least a question" [7], whereas in traditional lectures, students did not always ask questions. Feeling comfortable leads to a reduced threshold of starting a conversation, which positively contributes to collaborative education. Besides that, it is actually the avatar who is saying something instead of yourself, which has a consequence that you feel less pressure. Nevertheless, this probably has as a drawback that people get used to the fact that somebody else (i.e., the avatar) is talking for

Table 2. Overview of reviewed studies

Reference	Title
Al-Hatem et al., 2018 [1]	Fostering student nurses' self-regulated learning with the Second Life environment: An empirical study
Ali et al., 2013 [2]	Second Life (SL) in Education: The Intensions to Use at University of Bahrain
Chang et al., 2009 [6]	Evaluation of collaborative learning settings in 3D virtual worlds
de Lucia et al., 2009 [7]	Development and evaluation of a virtual campus on Second Life: The case of SecondDMI
Ho et al., 2009 [13]	Designing and implementing virtual enactive role-play and structured argumentation: promises and pitfalls
Nisiotis & Kleanthous, 2020 [20]	Lessons learned using a virtual world to support collaborative learning in the classroom
Sancho et al., 2008 [23]	Multiplayer role games applied to problem based learning
Sancho et al., 2009 [24]	Do multi-user virtual environments really enhance student's motivation in engineering education?
Scullion et al., 2012 [25]	A pilot implementation of an immersive online 3D environment for collaboration among computing students in a Scottish University

[3] https://drive.google.com/file/d/151ar_jr2wsy6vKKEvgBsGC0NxMtELA_A/view?usp=sharing

them, which can have a negative impact on to ability to give presentations for real persons in real life.

Furthermore, Scullion et al. (2012) [25] also claimed that customization of such an avatar is really important, since it is an expression of yourself. Without personalization of the avatar, the use of it would be boring. Nisiotis and Kleanthous (2020) reported that the students found seeing each other's avatars engaging as well [20]. However, a drawback here is that sometimes, customizing the avatars was a quite distractive feature: "The distraction from customizing their avatars' appearance affected some in terms of the focus they needed for constructing their responses in the process of dialoguing" [13]. Therefore, it would be helpful to limit the number of times an avatar can be customized, in order to reduce this distractive element here.

Nevertheless, some studies reported problems regarding expressing non-verbal communication with the avatars. One reason is that activating gestures was quite problematic: this was "quite troublesome as we need to click for the actions and emotions and (are) not able to just type a simple code" [13]. De Lucia et al. (2009) [7] mentioned that students had some difficulties in communicating by using the avatar gestures as well, and Chang et al. (2009) [6] mentioned the inability to express emotions with avatars. From te teachers' point of view, they also stated that the usage of avatar names was considered as problematic, since you do not always know who you are interacting with [6]. A suitable solution here would be that the avatar names must be the same as the student's real name. Scullion et al. (2012) [25] stated that students and teachers cannot really express themselves since nobody is seeing a real face, which can be problematic if somebody gets out of range, but does not know (e.g., an internet outage). Other participants in the VW may not recognize that a person can be out of range, which can lead to annoying situations, such as miscommunication.

On the other hand, another positive concept of the avatar is their role-playing character. Ho et al. (2009) [13] investigated the use of a VW for discussing a certain topic and thereby provide structured argumentations, based on different roles. In this study, the students were discussing on scenarios "based on contexts dealing with life and death issues revolving around euthanasia", and they had to "think in role as particular individuals", such as a doctor, pastor, or husband [13]. Ho et al. (2009) showed that the avatars are pretty useful in this role-playing scenario: "students indicated they were allowed to 'role-play to understand the characters more and hence provided better points of view'" [13]. These better provided points of view have a positive influence on collaborative learning, since if within a group, students are able to substantiate their argumentations better, this will eventually lead to better considered decisions and hence, to better performed group work. Besides that, Sancho et al. (2009) stated that "95.45% of the students thought that the role game dynamics has made the course more motivational and fun" [24], and (Sancho et al., 2008) stated that "social pressure, time limits and the positive mood created by the role playing scenario make students ask and reply questions themselves, instead of listening to the teacher's explanations for issues that they don't feel they need" [23], which also shows that the role-playing character positively contributes to collaborative learning. Hence, a role-playing character with avatars in a VW seems to be helpful.

Another positive consequence of the presence of avatars is the following: "through conversations with other characters, we could actually see how others think and also why I think in this particular way" [13]. Therefore, the avatars contributed to better a better understanding of other students, which is a great benefit for collaborative learning.

After all, there can be concluded that avatars in general seem to be really helpful in VWs. Students feel comfortable by using them and like the customization of it. The use of avatars contributes to collaborative learning, as they have a role-playing character, which supports a better substantiation of arguments. However, avatars can sometimes be problematic regarding the expression of non-verbal communication.

5.2 Available Tools

The different VWs in the studies offered a variety of tools, each with its own benefits and shortcomings. These are discussed in this section.

A big advantage is the number of different tools students and teachers can use. Participants are no longer limited to a whiteboard and PowerPoint presentation only (as in most of the traditional classrooms), but they can just write or draw whatever they want, as much as they want: "There are a lot more assets you can use" [25]. One of these assets is the screen sharing feature [25], which makes collaborative learning far easier. Also, the fact that "the environment provides media to leave messages or ideas for other group members" [6] has a positive influence on collaborative learning.

Another additional benefit is that all the available tools and information are in one place. Materials are near to each other and easily accessible, rather than switching between browser tabs and software applications [20]. The fact that everything is in one environment (world), contributes to the usability of any VW.

Regarding the communicational tools, like voice and text chats, the opinions are divided. Scullion et al. (2012) [25] emphasized the value of having a choice between a text-based chat or a voice-based chat: the text-based chat keeps a log, so you know what others have said, whereas the voice-based chat is usually faster and meanwhile, you can do other things (like typing) simultaneously. However, Scullion et al. (2012) [25] also mentioned difficulties in connecting multiple users in a voice chat, and problems with echo and users moving out of range. A great additional feature of the text chat would be to have the possibility to add colored text and emoticons [25], but overall, Scullion et al. (2012) seemed quite positive regarding the voice and text chats.

The textual chat was also considered as positive in Nisiotis and Kleanthous (2020) [20], because it was very useful for facilitating and better managing coordination within the groups, "as it allowed establishing communication for information sharing, and socialization" [20], which has a positive impact on collaborative learning. One more advantage of the textual chat is that minutes of a meeting can be taken through chat [6].

Nevertheless, Sancho et al. (2009) [24] stated the finding that students consider the voice and text chat the less useful tool, which was surprising, since these tools were used most frequently. Evaluators of this study think that "this could be due to the reason that the students used the chat mostly for non-educational socializing purposes" [24]. In the study of Chang et al. (2009) [6], the VW Second Life was used, and they mentioned that participants found the usability of the text chat inconvenient.

Overall, there can be concluded that the VWs offer tools which make the users not restricted to "traditional tools" only, and that it is handy that everything is in one place. Nevertheless, some tools have their shortcomings and therefore need some refinement.

5.3 Training and Previous Experience

Most of the studies showed that participants who were experienced with the use of VWs, often encountered less difficulties while using them. In order to prevent problems with

non-experienced users, Ho et al. (2009) offered orientation sessions before the start of the course, which were considered as helpful [13]. Chang et al. (2009) provided valuable support during the course as well, and several online tutorials, wikis and forums were available [6]. These training and support facilities are necessary, especially for unexperienced users, since: participants who have never used a virtual world before, can be a bit apprehensive [25], there is the fear of not being experienced enough in the virtual environment [6], students felt under pressure to complete an assignment in an environment that they were not fully familiar with [6], and unfamiliar students can get distracted from the use of tools for non-verbal communication and can encounter difficulty in focusing on given tasks [13]. De Lucia et al. (2009) noticed that "users with lower experience expressed the worst judgements" [7]. Nevertheless, students who feel more comfortable and less fearful of using technology perceive the use of the VW to be easier [2], which together with the other studies shows the importance of an introduction session or training before the course in a VW starts. A disadvantage is that this will cost time, as also was pointed out by Chang et al. (2009): it took about 2.25 hours on average to get familiar with the environment [6]. Teachers stated that an introduction training only was not enough, but a more extensive training is required for students and staff, including ongoing technical support (e.g., a help desk) [6].

5.4 Comparison With Traditional Learning Approach

The main disadvantage of the usage of a VW compared to traditional learning or lectures, is the fact that it is more time consuming [6], which probably also has to with the lack of technical support and training beforehand. This again emphasizes the importance of an extensive training before and ongoing help during the course, also because "when faced with difficulties and challenges, the students seem to fall back to the traditional mode of learning" [6].

Nevertheless, the VWs were often considered as a positive experience compared to traditional classes: "It is a lot more interesting and interactive rather than just looking at a boring screen, and doing individual research" [20]. Nisiotis and Kleanthous (2020) also indicated that the majority of the participants said that "the quality of the learning experience in the VW is better than in face-to-face classes" [20] and that the virtual environment takes away the formality of the traditional classroom, which was also announced in de Lucia et al. (2009), by saying that "the distance between student and teacher is reduced: it is more natural, spontaneous and easy to communicate" [7]. De Lucia et al. (2009) also stated that "the student perception to be in a usual didactic setting increases the realism and presence sensation because the student's perception of moving in the DMI [Mathematics and Informatics Department] building, where they are accustomed to interact with their course colleges" [7]. Scullion et al. (2012) concluded that the VW is perfect for lectures and that it can be used to complement more traditional teaching methods [25]. Furthermore, Al-Hatem et al. (2018) showed that the increase of the interactivity in the environment also increases the user's confidence, and had a positive effect on the user's motivation [1], which is positive. After all, there can be concluded that compared to traditional learning methods, VWs are more interesting, interactive and engaging to work in.

5.5 Environment in General

In general, the VWs are mostly considered as interesting and engaging. Another positive point is that it enables communication to be done both synchronously and asynchronously, and that the number of available rooms is not limited, which is mostly the case in real life [25]. Since there is always a room available, students can always meet together and discuss things, which positive contributes to the idea of collaborative learning. Also, the privacy in these virtual rooms is appreciated [6]. Besides that, the VWs enhanced students' autonomy in learning [13], whereby the teachers are facilitating instead of giving instruction, which is a positive deviation from the traditional way of teaching.

Furthermore, the virtual environment "facilitates the perception of social spaces with attributes as trust and belonging" [7], which has again a positive effect on collaborative learning, since a feeling of trust and belonging is very important. Also, the coordination between group members was considered as quite effective and productive in the VW, and that students corrected each other in case an issue or mistake was identified, which contributed to the level of trust and togetherness even more [20]. Ali et al. (2013) stated that Second Life, the VW this study used, was easy in use [2]. Chang et al. (2009) and Nisiotis and Kleanthous (2020) stated some practical benefits: working in a VW saves traveling time and solves the problem of transportation issues, working at home was considered to be an advantage [6][20]. Besides that, the VW helped in organizing the group [6], which has a positive impact on collaborative learning.

5.6 Other Disadvantages and Shortcomings

Besides the already mentioned disadvantages or shortcomings of the several VWs, there are some more. Most of the shortcomings were related to technical issues. The server on which the VW was running, was not always available or stable enough to handle all the users [25] or the router was unstable and the number of students was limited [13]. Also, problems regarding internet connectivity and time lags arose, as well as the need to frequently update the system [13].

Sometimes, the usage of the VW by multiple groups was problematic [6], and assigning rights or permissions to users did not always work [6] or was not even available, which had as a consequence that students were able to delete somebody else's work [25]. Avatars were able to look into close buildings or rooms [6], which violates the privacy of other groups. Some studies reported room for improvement regarding the interface usability [6], because specificity in information for user navigation was poor [13]. One more feature that was missing, was an undo button [25] and a map of the VW the participants were in [6][13], to make clearer where they exactly are in the world.

5.7 Requirements for a Virtual World

Based on the obtained results from the reviewed papers, the following functional requirements are needed for a VW to support collaborative learning:

- The VW should have an avatar which could be customized, but customization cannot be done more than two times during a course.
- Users should be able to easily use non-verbal communication (like gestures) within the VW.
- The avatar's name should be exactly the same as the user's own name.
- All the available tools should be easily accessible in one place.
- A text-based chat should be included, which keeps a log and offers the possibility to add colored text and emoticons.
- A voice-based chat should be included, which should make it able to easily connect multiple users.

- Before the course within the VW starts, an extensive training about (the use of) the VW should be given.
- During the usage of the VW, there should always be technical support available.
- It should be able to give users rights or permissions within the VW.
- An undo button should be available in the VW to undo a certain action.
- A map of the VW should be included.

Furthermore, consider the second bullet list below, which consists of non-functional requirements for a VW to support collaborative learning:

- Updates of the system should not be required too frequently, but at most two times during a course.
- The maximum number of users in a VW should never be less than the number of students and teachers within a certain course program.

6. DISCUSSION AND LIMITATIONS

All the above-mentioned studies in the results section focused on the application of a VW in an educational course on higher education or university. Nevertheless, it must be acknowledged there are some limitations of this research to be discussed in this section, based on the reviewed papers.

The first point is the differences between the samples (participants) of the reviewed studies: these differed from fourth year university students [25] to pre-university students [13]. These differences can have an impact on the results. Besides that, the number of participants in the experiments was not always quite high. Furthermore, the experiments in the reviewed papers were conducted in different countries, which means that the culture in which the research is conducted is different in each study. Cultural differences may affect the results as well.

Second, most of the studies evaluated the VW only during one course, which mostly has a time span of ten weeks. This is a relatively short time, so research over a longer period or a longitudinal study will be needed in order to come up with more reliable results. This research should then also be conducted with more participants of various study programs around the world, in order to make the research more usable for other countries and higher educational institutes as well.

Third, some papers are already more than ten years old [6][7][13], which means that the VWs which have been evaluated in these studies, are nowadays possibly a bit outdated. Nevertheless, this does not mean that these papers were not usable, since the beliefs and opinions from students can still be considered as valuable, because they indicate what students think is important, and what is missing.

Furthermore, the way in which the reviewed papers were obtained, could have been easier. At the very beginning, the focus of this research was more on e-learning technologies in general, rather than specified on VWs. Nevertheless, due to time limitations, there has been decided to limit the scope more and therefore focus on VWs only. However, if this research has been focusing on VWs from the very beginning, possibly more relevant papers regarding this topic could have been obtained, instead of only the number of reviewed papers right now.

7. CONCLUSION

This research investigated currently available VWs, based on a systematic literature review, and examined the advantages and disadvantages of these environments, and which components are the most suitable for collaborative learning.

The first research question can be answered as follows: the usage of avatars seems to be an advantage in a VW, because it makes the students feel more comfortable. Customization of the avatar was considered as positive, whereas the number of times a user can change his or her avatar should be limited, since otherwise it will be a distractive feature. Furthermore, the role-playing character of an avatar was positive. A disadvantage is the problems in expressing non-verbal communication. It should be able to make gestures easier than by clicking a button. Another disadvantage is the use of avatar names, instead of real names. Besides that, an advantage is having the choice between both a voice-based chat as well as a text-based chat. However, the chat functionalities were not always easy in use, which is problematic. Nevertheless, an advantage is the fact that all the available tools are easily accessible in one place. Another advantage are the offered trainings or information sessions and technical support during the use of the VW. Besides that, the biggest benefit of the VW compared to the traditional learning methods is its engaging and interactive character. Some other disadvantages were technical issues regarding the internet accessibility and connectivity, and the need to frequently update the system.

The answer to the second research question is: the appearance of an avatar contributes to collaborative learning, as well as the usage of the cat functionality and a screen sharing feature. Also, the fact that students were always able to meet in a virtual room, has a positive impact on collaborative learning. Besides that, the VW helped in organizing the group, which is also positive regarding collaborative learning.

To answer the third research question, several requirements are needed for a VW in order to support collaborative learning, of which the most important requirements are the usage of customized avatars supporting non-verbal communication, easily accessible tools in one place, and an extensive training beforehand and technical support during the usage of the VW. The entire list of requirements can be found in subsection 5.7.

To answer the main research question: the best way to combine collaborative learning principles and technology of VWs is to provide VWs where the users are represented by customized avatars with their own name, should be able to easily express non-verbal communication, should have easily access to all the available tools in one place, and should be able to use a chat functionality.

Future research is needed in order to come up with more reliable requirements, based on a longitudinal study with more participants from several studies and countries. Currently, this research can be used as a base for higher educational institutes and universities (including the UT) to develop a VW in which the mentioned requirements are implemented. On the other hand, the requirements derived from this research can be used as a check to evaluate the suitableness of existing VWs for collaborative learning.

Besides the focus on higher education and universities, future research can also focus on pupils in high school or even on primary school, to make lessons more engaging and interactive and thereby support collaborative learning. On the other hand, future research on VWs can also focus on other domains than education. The use of VWs in business, meetings, or non-formal socializing purposes can be investigated.

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