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Supporting Collaborative Creativity with Educational Visualizations in 3D Virtual Worlds

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Abstract. Social media are known for substantial creativity support, as they allow users exploring, creating, and sharing various types of content. Social 3D virtual worlds, such as Second Life, can also be seen as a social media that have wide possibilities for being creative.

In this paper, we explore how 3D virtual worlds can support creativity in educational settings, including creativity of the collaborative process and creativity of the outcome projects. We propose that this technology can support both. In order to test this proposal, we used the data collected in a case study that we conducted within Cooperation Technology course at the Norwegian University of Science and Technology in 2011. The study was supported by the EU research project CoCreat. The data are discussed to present the challenges for supporting collaborative creativity with 3D virtual worlds, approaches to understanding the concept of creativity, and our experience in creativity evaluation.

1 Introduction

Creativity can be applied to every domain of knowledge and must be seen as an important competence. There is evidence in the literature that creativity is an effective method, key component, and valuable outcome of learning [1-4]. However, creativity is not a spontaneous process and it needs to be promoted with novel solutions.

In this paper, we focus specifically on collaborative creativity in educational context. We present and discuss a part of data from an explorative case study on collaborative educational visualizations conducted using our virtual campus in Second Life within the Cooperation Technology course at the Norwegian University of Science and Technology (NTNU) in 2011. There are three reasons behind the selection of a three-dimensional Virtual World (3D VW) as the main technological platform for this course. First – it offers the opportunity to experience different forms of cooperation and mediation. Second – being unfamiliar, it forces discussion on appropriate use of technologies, critical thinking, and reflective learning [5]. Third – Second Life is known for the wide possibilities for self-expression, as it allows users to create and share any content in the world.

Schneiderman sees creativity as a process. He identifies the following main phases in a collaborative *creative process* [6]: collect (searching for material and visualizing it), relate (consulting with peers), create (trying out solutions, creating associations, composing artifacts), and finally donate (disseminating results). These phases can be supported by social media and 3D VW that are known for significant creativity support, as they allow users interacting with each other, exploring, creating and sharing content [7,8].

Creativity can also be thought as a *characteristic of a process outcome*, a product. In a 3D VW, such a product becomes visualization or construction. However, besides the 3D graphics, this technology provides many additional creative ways of communicating ideas, such as dynamic presentations and interaction between avatars.

The objective of this paper is to discuss collaborative creativity of the student project work, including *creativity of the collaborative process* and *creativity of the resultant constructions*. In both cases, we explored the role of a 3D VW as a platform and a mediating tool. We designed the activities of the course using Schneiderman's framework and analyzed how the phases of creative collaborative process were supported. Continuing the research into the use of educational visualizations in 3D VWs, we also explore the creativity of the resultant constructions.

The scope of the concept of creativity was not pre-defined in the course, and therefore, another objective of the paper is to explore how the students understand this concept in application to the project work in a 3D VW. In addition, we present some of the results of creativity evaluation and discuss the challenges of this task.

2 Study settings

The study was conducted with 37 students working on projects in small groups (10 groups of 3–4 students in each), in which they were learning collaboration through experiences. They were forced to communicate intensively, cooperate, and collaborate in a technological environment to complete the task. They were required to create 3D visualizations of major curriculum concepts. The resultant constructions were presented to an international audience at the joint sessions and seminars (Fig. 1).

Each group was required to create and keep a blog for sharing and discussing proposals, reflecting and documenting the progress, and for the final discussion after the constructions were completed and presented. In addition, each student was required to create and keep an individual blog for weekly reflection.

Fig. 1. Visualization project Awareness Lab – student role play

As part of the course, the students participated in the Second International Virtual Summer School on Collaborative Technologies, Serious Games, and Educational Visualizations, organized by two EU projects, TARGET and CoCreat. The goal of the summer school was to demonstrate affordances of the 3D VW technology and let the participants experience different types of collaborative activities.

Two international events were conducted as part of the summer school. One of them was organized as a seminar on EU projects, which included five presentations and a question-and-answer session. The objective of this event was to demonstrate to the students how international cooperation can be established and supported using modern technologies. Another objective was to expose the students to the novel ideas and technologies behind these projects, such as serious games in corporate learning and collaborative creativity. The second event was organized as a virtual tour to the virtual campus of the College of Education (COE) at the University of Hawaii at Manoa (UHM) and augmented with feedback sessions with an invited expert (Fig. 2). Both events of the school and the role-play session attracted international visitors.

Fig. 2. Feedback sessions with an invited expert – virtual event

3 Method and data collection

Our approach to using educational visualizations in 3D VW for learning has been developed in several previous studies [9]. The methodology is based on constructionism – an educational philosophy which implies that learning is more effective through the design and building of personally meaningful artifacts than consuming information alone [10]. Constructionism is related to the social constructivist approach, which proposes that learners co-construct their environment and understanding together with their peers [11]. In addition, we applied role-playing, which is a widely used and effective learning and teaching method. It implies an active behavior in accordance with a specific role [12].

We consider a student group a subject within a learning community. The results of activities performed by students is an artifact, a reification of experience [13] that is shared with other community members, e.g. future generations of students.

The data were collected from the direct observation of students' activities online, pre- and post-questionnaires, virtual artifacts, such as chat log and 3D constructions, and users' feedback in the form of group blogs. For data analysis, we use the constant comparative method [14] that was originally developed for use in grounded theory methodology and is now applied as a method of analysis in qualitative research.

4 Data and results

All 10 groups managed to complete the task. As a result, we got 10 constructions visualizing different topics. Students applied different metaphors and design approaches that can be sorted into three main categories.

Groups 6, 7, and 11have made constructions to be mostly the *scenes for their role-plays*. Even though these constructions were very different and had different level of detail, their purposes were too unclear without the presentations. Three other groups (1, 5, and 9) made their constructions as *facilities*; workplaces, which visitors could use, games, where they could play, or tools, where a single user could learn. Groups 3 and 10 have made their visualizations as *museums* or exhibitions. These groups offered a guided tour through their constructions instead of the role-play. Finally, groups 4 and 8 combined the exhibition/museum metaphor as introductions to the topic and facilities as a fun and practical experience.

In order to assess creativity, we applied different approaches. The question on creativity support in 3D virtual worlds was asked in the individual pre- and post-questionnaires. The feedback was negative, especially against the background of other similar questions, in which 3D VW were evaluated as moderately suitable for collaboration and visualization. Nevertheless, we looked into detail and analyzed the data from discussions in the group blogs, where the students reflected on their experience after completing constructions in Second Life. The discussions included the analysis of their own constructions and peer-evaluations. In addition, a group of post-graduate students from the COE UHM was invited to explore and evaluate the constructions.

We provided similar guidelines for these evaluations in the form of a set of questions to discuss and aspects to consider.

In the following, we present how the students discussed creativity in the collaborative process and creativity in the resultant constructions.

4.1 Creativity in the collaborative process

Within the final task, the students reflected generally on their collaborative process during the exercise, including a reflection on how creative it was.

Creative process versus planning. Six groups explicitly stated that the process of their project work was creative. Moreover, four groups (including some of already mentioned) noted that they had a creative and productive idea generation process. One group stated that it was hard to assess their own creativity.

– Generally, we are of the opinion that our construction process was somewhat more creative than in real life since.

– So, in regards to the process we are quite happy with our level of creativity.

Two other groups stated that their construction process was not creative. These students also stressed that they had a plan from the very beginning and just worked towards the goal.

– Our construction process has been fairly straightforward and perhaps not overly creative. We decided on a suitable topic to elaborate, and worked together […] to make a construction that could illustrate this topic in an acceptable way.

In addition, it should be noted that two of the groups recognized the possibilities creativity expression in 3D VW and that they could be much more creative, however without experience, the technology is rather difficult to use.

3D environment affects creativity. Half of the groups stated that 3D VW positively affects creativity and supports generation of new ideas.

– New ideas were often generated by "playing around" with objects without a concrete plan of what we wanted to achieve but by combining elements (prims) which we liked into a greater construct.

At the same time the other groups argued that the technology, being unknown, hinders creativity.

– It affected our creativity in that manner that neither of us had any experience working in 3D CVEs. So when we were supposed to start building, we did not know what was possible, and how to do the things that were possible.

Three of the groups noted that their creativity was not affected by the technology as they were brainstorming the constructions before starting to work in Second Life and designing on paper.

– In the beginning, we spent time brainstorming about our project, at this point we ignored any technical limitations and decided that we would adapt our idea to these limitations when we started to build.

Resources affect creativity. The students discussed how resources and examples of similar projects available in the Virtual Campus affected their creativity.

Only one student group stated that their creativity was positively affected by the resources and other constructions in the Virtual Campus. The other groups were to

different degrees certain that their creativity was not affected. However, five groups stated that they were inspired by the available resources and examples of constructions. In addition, three groups argued that resources in the campus ease the constructing process.

– We looked at the earlier projects to get a feeling of what is possible of achieving in the given time for the project. Of course, our building was a bit inspired of the style of building with multiple floors and walls surrounding the building.

Sharing 3D constructions also received a positive feedback, as the students get additional motivation from exhibiting their construction for other people.

– Sharing and exhibiting constructions in the Virtual Gallery is good because it can help newcomers introduce what 3D CVEs are capable of, what is possible to do, what types of collaboration are possible.

4.2 Creativity in the resultant constructions

The *resultant constructions* were analyzed by the students from NTNU, including self- and peer-evaluations, and by the post-graduate students from COE UHM. Students from both universities had similar guidance that included the question on creativity. In addition, the Norwegian students discussed how resources and examples of similar projects available in the Virtual Campus affected their creativity.

Self-evaluations. Five groups explicitly called their constructions creative. Explaining this statement, the students mentioned a number of factors. Elaborated aesthetics was the most popular indicator of creativity, but in addition, visual symbols, variety of visualization means, and the difference from other constructions were mentioned.

– We think our construction is pretty creative, because we are the only one of the groups who chose to create a round, and pretty colourful, house.

– Based on the end result we would consider the construction as very creative, as we had to use all of our creative skills to make it as good working in both design [and] conveying a message.

– We have used several means of communication, 3D objects, signs, a browser and sound. We were the only group applying "talking objects".

Three groups expressed against creativity in such constructions. They all argued that clearly presented information and intuitive functionality are more important should be elaborated before the creative elements.

– We chose to focus on displaying how it could be used through actually using it in a CVE. Functionality prior to creativity.

– The creation of the building itself was however not that creative, and we rather haphazardly joined together pieces into creating what in the end resembles a house. Here we wanted an exhibition that displayed some text about the topic as well as instructions for the game.

Peer-evaluations. Each group evaluated projects of two other groups, following the same scheme that was used for the self-evaluations. In peer-evaluations, the students discussed the ideas behind the projects more often than the constructions or the role-plays. There were two times more positive evaluations than there were negative.

– […] to meet up with a company through this job portal, to get to know the company and an introduction to how they work and what they work with, is in fact a great idea.

In half of the peer-evaluations, the students discussed the relations between creativity and functionality, though they were not asked about that. Two common trends were most visible. First, the students often argued that elaborated functionality (including reality resemblance) of the constructions hinders creativity.

– The construction was very detailed (it really looked like a lab)! The idea of the construction was creative, but since the construction should look like a real lab, it's difficult to discuss the creativeness of it.

Second, creative ideas were recognized as hindering functionality and adding ambiguity into the constructions. In addition, in two cases creative ideas were connected with incomplete implementation of the constructions, as they would require more effort.

– In spite of bold attempt, it is not quite wise choice that combine maze with information. When one explores the maze, useful information is easily to overlook in some extent.

External evaluations. The resultant constructions were also evaluated by a group of post-graduate students from COE UHM. They were asked to evaluate constructions without seeing the role-plays and provide feedback for the students from NTNU.

In their feedback, all the students from COE UHM stated that constructions are creative to some degree. They appreciated that such visualizations have potential to be used in educational settings as an exciting, fun, and motivating/creative activity.

– Very creative. They used a lot of visual tools. […] I think they could use a URL loader. They did represent the different types of social media well, but could have used other types of tools such as video or URLs to display them better.

However, without attending the role-plays, it was difficult to understand fully the purpose of the constructions. Therefore, many students expressed doubts about whole constructions or particular elements and suggested ways of clarifying their meaning.

– It seemed like there needed a professor available to utilize each site as it was unclear what the objectives are without someone to guide you.

In the second part, the students discussed how working in a 3D environment affected their creativity, how it supported generating new ideas or caused problems.

5 Discussion

5.1 Approaches to understanding creativity

Creativity turned out to be a complex phenomenon, especially for assessment and evaluation. The feedback shows that students have different understanding of what should be called creativity and creative. However, we were able to discover certain trends and regularities, which will be discussed in the following.

The first approach for identifying creativity was found in selecting certain *creative elements* in the constructions: elaborated aesthetics, visual symbols, variety of visualization means, and the difference from other constructions. The latter category implies

that creativity might be seen not as an absolute value, but it is related to the community. Most of these indicators were discussed by students in self-evaluations.

However, when evaluating projects of other groups, the second approach appeared. The students stated that the *ideas* behind certain projects were creative, while the constructions themselves were called either simple or incomplete. This implies that creativity can lie also in a way of conveying the message.

Moreover, some of the projects were evaluated as creative by the reason of *creative presentations* performed live by the students. Most of such projects had simple constructions and the main message was conveyed by the role-play. Therefore, the main problem with such constructions was to understand their purpose and the idea behind for the visitors who could not see the role-play.

For example, group 1 made a tool for training aphasia patients. The construction has the design different from the others. They used interactive 3D symbolic elements, audio and textual media content. The metaphor type used is facility – learning tool, which can be used without role-play. The construction is clearly explained by text and a graphic poster, so the message is clear. However, the overall design (big blue cylinder house) of the construction has no connection either with the topic they visualized (communication), or with aphasia/medical theme.

Another example can be group 6 that made a visualization of awareness as two chemical/biological labs, working in cooperation. The construction has a more realistic design, replicating the appearance of real labs. The groups also used various media content, interactive elements, graphics, and text. They used the construction as an environment for the role-play, so without the play, it was very unclear what was the purpose of the construction. However, even those who were present at the role-play did not rate the construction very high as the play was very dynamic and some of the audience did not manage to follow. Overall, the construction visualized an example of applying the concept of awareness.

5.2 Challenges for supporting collaborative creativity in 3D virtual worlds

Creative collaborative process. The design of the study and the design of the 3D environment for this course were based on Schneiderman's framework of creative collaborative process. Student self-, peer-, and external evaluation indicate that all four phases of creative collaborative process were supported. As presented in the Data and results section, the students explicitly mentioned that activities of all four phases affected the creativity of the process.

However, we identified two major challenges in applying 3D VWs for supporting creative collaborative process in educational settings. First, the technology is difficult to use or at least it appears to be. In total, more than half of the groups stated that it hinders creativity. Some were using other technologies to support idea generation process. Some others reported that they could be more creative if they knew how to use the 3D VW efficiently. Second, the community level of communication and collaboration is limited. Even though the students recognized the positive effect of interacting with the visitors and sharing of the constructions, they also noted that the community is too small and the time span is too short to be beneficial.

Creativity of the constructions. The analysis of the data indicates that most of the groups consider the resultant constructions creative or, in some cases, potentially creative.

However, we discovered a number of challenges for creativity of educational visualizations in 3D VWs, the most important of which are presented below. First, creativity is often in conflict with functionality. Creativity goes together with new interesting ideas and unusual experience. However, too much focus on creativity makes the purpose of the constructions unclear and hinders their functionality. Consequently, it requires more effort on a clear explanation or a presentation. On the other hand, too much focus on functionality and clear presentation of the information makes construction boring and less engaging. Second, there is a difference between a creative construction and a creative way of presenting information. In other words, creativity can be found in the structure of the construction and its content (in our case, how the construction is built) or in the presentation form (how the concept is visualized).

5.3 Creativity evaluation

The evaluation of creativity support is rather complicated by objective and qualitative measures. In the study design, we proposed how creativity can be measured [15]. We were planning to study "symmetry of ignorance" and creativity. In this perspective, we put particular attention in studying interaction among participants with different backgrounds to observe the impact on creativity. Our hypothesis was that groups with students with varied background would be more creative than homogeneous groups. However, the results present no significant difference.

At the community level, we hypothesized that sessions with the presence of external experts and students from other universities would trigger high level of creativity. The feedback indicates that the students acknowledged the possibilities of 3D VWs for international collaboration, virtual visits, and knowledge sharing as it was done during the virtual events. Some of the groups also noted that virtual events helped generating new ideas. Sharing 3D constructions and exploring the projects of other students also received positive feedback.

Different resources were provided to make construction process easier. Though this is essential to promote usage of the system, it might also hinder creativity. We evaluated the final constructions and identified that they all can be considered as original and not as a re-use of the provided resources. Self- and peer-evaluations also confirm that resources ease construction process, but do not affect creativity.

Breakdowns in construction process were studied since they might actually have led to creative problem solving. Though the 3D technology was generally found unfamiliar and challenging, it made the groups collaborate more closely as they needed to consult each other and rely on each other's support to achieve their goals.

Finally, we attempted to explore the relation between learning and creativity. Though the constructions might be very creative from an aesthetic or experiential perspective, this does not necessarily lead to learning. Most of the groups reflected that the visualization process deepened their understanding of the course concepts. However, we could not identify a strong enough connection to creativity.

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