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Chapter 16

CREATIVE COLLABORATION IN A 3D VIRTUAL WORLD

Conducting educational activities, designing environments, and preserving results

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Abstract: Supporting social creativity across different domains and disciplines in learning communities is an important part of collaborative process in university education, workplace, and in the context of large-scale international projects. In this paper, we present the experiences from the Virtual Summer School in Second Life as an attempt to support creative communities in a systematic manner and preserve their knowledge in a shared repository. The Virtual Summer School acted as a forum for the presentation of innovative approaches, developments, and outcomes of research projects in the areas of technology-enhanced learning, serious games, and collaborative technologies, facilitating the exchange of ideas between students, researchers, and practitioners. Based on our experience and data collected, we present lessons learned and implications for supporting creative communities by conducting collaborative activities and by preserving their results.

Key words: 3D Virtual Worlds, creative communities, educational visualizations, social creativity, collaboration, community memory, Second Life

1. INTRODUCTION

Establishing and nurturing vibrant and creative learning communities is a complex process (Wenger, McDermott, & Snyder, 2002). Such communities are seen as highly important in developing and spreading new skills, insight, and innovation (Johnson, 2010). The notion of a Community of Interest (CoI) incorporates the variety and dynamism that are typical features of a modern workplace (Fischer, Rohde, & Wulf, 2007). According to (Fischer, 2005; Fischer, et al., 2007), CoIs have potential to be more innovative and transforming than a single Community of Practice if they can exploit "the symmetry of ignorance" for social creativity. Supporting social creativity across different domains and disciplines in learning communities is an important part of collaborative process in both university education and in the context of large-scale international projects.

We argue that three-dimensional Virtual Worlds (3D VWs) can benefit creating and supporting learning communities. However, it requires a careful design that incorporates various activities and exploits advantages of the technology. 3D VW are often seen as a type of social media which are known for community support (Jina, Wenb, & Goughc, 2010) and they have some unique features in addition (Molka-Danielsen, 2011). They support synchronous interaction, providing a sense of presence, which is important for the development of online communities (Bronack et al., 2008). Many 3D VWs support user-generated content, allowing to leave traces of activities, which may become part of the shared repertoire of the community through reification (Wenger, 1998). Wide opportunities for interaction and simulating environments make 3D VWs suitable for conducting a range of virtual events, including meetings, performances, and role playing (Sant, 2009).

The above features of 3D VWs extend the possibilities of using boundary objects (Star, 1989) and shared artifacts as catalysts of collaboration (Thompson, 2005; Wenger, 1998). Boundary objects are externalizations that have meaning across the boundaries of the individual knowledge systems or sub-communities and are necessary for overcoming distances in social creativity (Bruner, 1996; Papert & Harel, 1991b). Examples of such objects include 'monuments' (symbols strengthening identity within the community); 'instruments' (an infrastructure supporting interactive communication), and 'points of focus' around which the collaboration is structured (Thompson, 2005). In addition, online communities can benefit from such VW environments being dedicated community spaces (Wenger, et al., 2002).

However, a collection of static or even interactive objects and environments do not provide a solid enough representation of community

memory. Learning communities may carry and communicate part of their knowledge, both tacit and explicit, through collaborative activities, practices, relations, and experiences. Such fluid 'knowledge containers' are difficult to capture and store in traditional repositories, but the knowledge they carry is essential for many high-skill professions. Drawing upon the work in activity theory (Engeström, 1999; Leont'ev, 1981), we may see *activity* as a primary source of knowledge development and distribution. Therefore, we focus on visualizing and crystallizing learning community activities.

We have earlier discussed and realized the idea to store community memory as a repository of virtual places that act as crystallization of memories of users and groups, their trajectories, culture and ecology within an organization/community, activities and cooperation patterns, constituting the shared repertoire (Prasolova-Førland, 2004). A typical example is a seminar room, with traces reflecting the presentations held there (e.g., agendas, slides, logos). Another example is a visualization of a student science project, containing traces of the students' collaborative constructive activities and elaborations of the ideas behind.

In this paper, we explore alternative approaches to technology-enhanced learning, community building, and creativity support. We have chosen the Virtual Summer School as an innovative education form exploiting the strengths of 3D VW in both conducting collaborative activities and crystallizing their traces in a shared repository.. The Second International Summer School on Collaborative Technologies, Serious Games, and Educational Visualizations was held in the Virtual Campus of the Norwegian University of Science and Technology (NTNU) in Second Life. The school was conducted in conjunction with the Cooperation Technology course at NTNU and organized by two research projects supported by the European Union (EU) – TARGET (http://www.reachyourtarget.org/) and CoCreat (http://www.cocreat.eu/).

2. STUDY SETTINGS

In order to evaluate the effect of the Summer School on learning communities involved, we have conducted an exploratory case study. Educational activities of the study were systematically designed using a theoretical framework of collaborative creative process (Schneiderman, 2002), as presented below (Table 1).

Table 1. Creativity phases and Summer School activities

Creativity phase	**Course activities**
Collect (searching for material and visualizing it)	• brainstorming the topic to be visualized

	• describing the design in group blogs
Relate (consulting with peers)	• participating in virtual events • exploring other constructions
Create (trying out solutions, creating associations, composing artifacts)	• collaborative construction • accessing building resources
Donate (disseminating results)	• role-play presentations • preserving constructions in the Virtual Gallery

2.1 Collaborative educational visualizations and role-plays

Collaborative educational visualizations and role-plays were conducted as part of the Summer School with 37 students working in 10 groups, 3–4 students in each. The students were required to build an educational module representing a major curriculum topic and present it at a joint session by role-playing (Fig. 1).

Figure 1. Student visualization project Awareness Lab

We used pre- and post-questionnaires to identify the previous experience of the participants, their expectations of the forthcoming activities, and how the activities conducted matched their expectations. Each group was required to keep a blog for sharing and discussing proposals, reflecting and documenting the progress, and for the final discussion. In addition, each student was required to keep an individual blog for weekly reflection. The final

presentations were attended, apart from the students, by representatives from EU projects and the general public. The resultant constructions have also been evaluated by students from the College of Education (COE), the University of Hawaii at Manoa (UHM). After the role-play session, each group saved its construction in a repository and evaluated the work of two other groups.

2.2 Supporting and preserving educational visualizations

In order to assist students with constructing, presenting, and storing student 3D visualization projects, we designed a set of tools and places that we called Virtual Gallery (VG). It is designed based on the results of a case study we conducted earlier and serves mainly as a shared repository (Prasolova-Førland, Fominykh, & Wyeld, 2010).

The VG prototype was implemented, including a realistically reconstructed building (modeled after an existing student activity house on campus), a gallery for storing and presenting 3D constructions, and a library of pre-made 3D objects, scripts, textures, and links to other resources and virtual places (Fig. 2). The library of pre-made 3D objects, scripts, and textures could allow concentrating more on the creativity instead of technical details. In addition, student 3D visualizations occupied considerable amount of space in our virtual campus in Second Life and there was a need for better storage solutions.

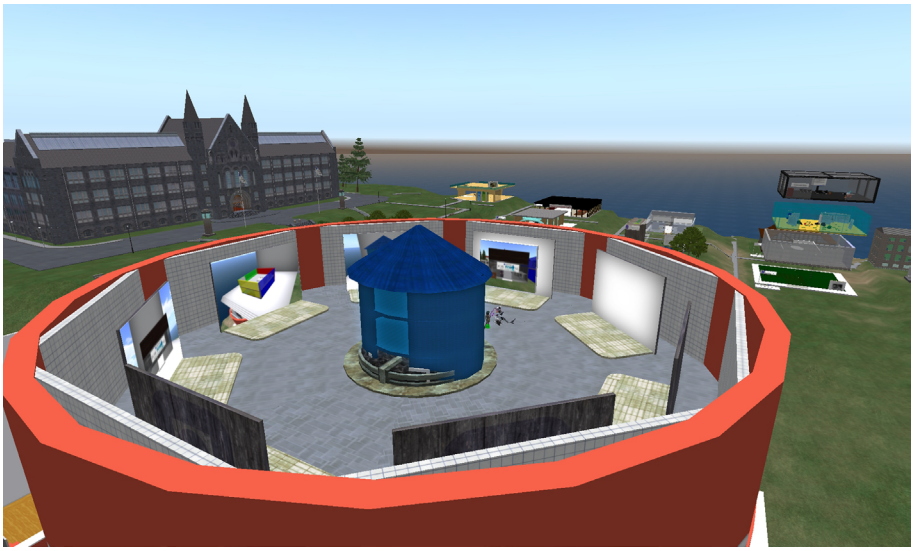

Figure 2. Virtual Gallery prototype

2.3 Virtual events

Two international events were conducted as part of the Summer School. The first was organized as a seminar on EU projects, which included five presentations on relevant topics 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 and to disseminate the results from TARGET, CoCreat, and other EU projects, exploring the possibilities for cooperation. The seminar took place in a formal lecture setting, with an amphitheater for the public, slide show, and interactive posters (Fig. 3). The event involved about 35 participants – presenters and the audience from several countries.

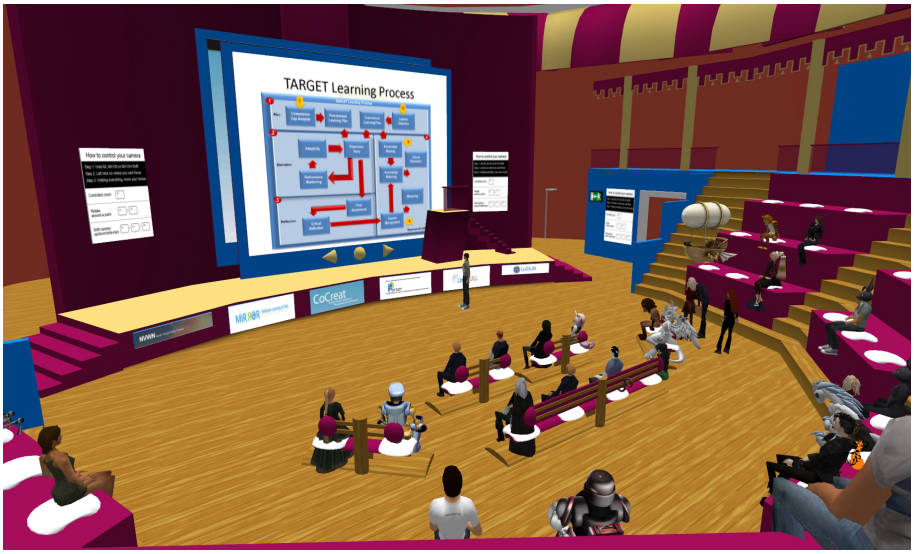

Figure 3. Virtual seminar at NTNU

The second event was organized as a virtual tour to the virtual campus of COE UHM and augmented with a feedback session with an invited expert. The students visited the major highlights of the COE UHM virtual campus. They were informed that the goals for the COE virtual campus are creating places for experimental teaching and research, socializing and collaboration, outreach, culture, and place for entrepreneurship. The visit was followed up by the return visit of the Hawaiian students. The goal of this exchange has been raising awareness of each' other research projects and seeding creative communities based on the joint interests.

2.4 Method and data collection

Our approach to using educational visualizations in 3D VW has been developed in several previous studies (Fominykh & Prasolova-Førland, 2012). It is based on constructionism – an educational philosophy which implies that learning is more effective through building of personally meaningful artifacts than consuming information alone (Papert & Harel, 1991a). Constructionism is related to social constructivism which proposes that learners co-construct their understanding together with their peers (Vygotsky, 1978). In addition, we applied role-playing, which implies an active behavior in accordance with a specific role (Craciun, 2010).

The data were collected from the direct observation of students' activities, pre- and post-questionnaires, virtual artifacts (chat log and 3D constructions), and user feedback in the form of blogs. For data analysis, we use the constant comparative method (Glaser, 1965) that was originally

developed for the use in grounded theory methodology and is now applied more widely as a method of analysis in qualitative research.

3. SUMMARY OF THE STUDY RESULTS

3.1 Collect phase

3.1.1 Brainstorming the topic to be visualized

For performing the visualization task of the Virtual Summer School, the students had the option of using both Second Life and other tools, both synchronous and asynchronous modes.

Six groups explicitly stated that the process of their project work was creative. In particular, four groups (including some of already mentioned) noted that they had a creative and productive idea generation process:

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

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.

3.1.2 Describing construction design in group blogs

The students were required to describe the design of the constructions in their group blogs to allow the ideas found during the brainstorming to crystalize. Reflecting on this task, they acknowledged its usefulness:

– Exploring and visualizing the topic textually through blogging had the advantage of allowing a more detailed description of the topic and about the functionality of the application.

Blogging technology was found useful at this stage of the project work by many groups. The students mentioned advantages of the technology 17 times, but the disadvantages only five times. Blogging was found easy accessible and simple. At the same time, it has low interactivity and weak support for synchronous activities, which however, was found to be positive by some of the groups:

– Another upside is that your mental work will not be disrupted. That might be the number one advantage of avoiding instant communication.

Disruptive communication may ruin your creative work when you focus on intensive thinking.

3.2 Relate phase

3.2.1 Participating in virtual events

After the first virtual event, the students were asked to provide feedbacks to the seminar in their individual blogs, identifying both positive and negative aspects. Among the positive aspects, the following themes were mentioned most frequently (with the number of students discussing them).

- Geographical independence of the virtual meetings, allowing the attendance of participants from different EU projects and countries (15)
- The novelty and excitement when facing the technology and learning approaches "different from the normal kind of lectures" (5)
- The comfort of use both for the lecturer and the audience, including low threshold for asking questions and the flexibility of giving a talk from own office (8)

– The main advantage is that you can have lectures with both speakers and audience from all over the world. […] Also, comments and discussions with people from around the world might be completely different than what would result from an audience with just Norwegians.

Among the negative aspects, the following items were mentioned most frequently (with the number of students discussing them).

- Technical problems, especially with the sound, diminishing the overall educational experience (15)
- Attention distractions both inside ("unusual surroundings") and outside the virtual environment (e.g. accessing social tools) and therefore difficulties with concentrating on the content (6)

– May be harder to keep focus during the presentation. Easier for the mind to slip when you're at the computer.

The analysis of the feedback from the *second virtual event* showed the different types of learning that occurred during the virtual tour. We identified eleven major themes. Those related to creativity and community support are (with the number of students discussing them) – campus atmosphere (11), campus infrastructure (10), Hawaiian culture (11), sense of

place and immersion (18), and places for informal learning (11). It was evident that the majority of the students felt an immersive Hawaiian sense of place. However, some students were not convinced by the immersive qualities of the environment:

– I did not feel 'transported' to Hawaii as the whole concept of a 3d-simulation does not appeal very strongly to me, and I usually draw a very clear distinction between real life and a virtual imitation.

In the general feedback to both events, the students discussed the possibilities of 3D VWs for international collaboration and discussion, communication, promotion, corporate training, and emergency simulations:

– There might be some merit in using 3D virtual environments in creating communities across boundaries. […] we want to mention the potential of events; one-time happenings where one is able to gather around a common interest at a specified point in time and experience it together with other attendees.

However, the community building was understood as a long-term process that requires time:

– We could not really develop a bigger community based on our virtual events, because there was only very little time to communicate informally with other participants, but nevertheless they are vital for developing a community.

3.2.2 Exploring other constructions

We explored in what way the students were inspired by other constructions available in the virtual campus, including the constructions resulting from the First Virtual Summer School in 2010. The students expressed very different opinions from stressing the importance of studying previous students' constructions to mentioning a minor effect of this kind of studying for inexperienced users. Five groups stated that they were inspired by the available resources and examples of constructions:

– […] the student constructions can stimulate the community development by providing new ideas and inspire other people to create their own constructions.

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:

– 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 […].

3.3 Create phase

3.3.1 Collaborative construction

The students applied different metaphors and design approaches that can be sorted into three main categories. They are 'scenes for their role-plays' (purposes were too unclear without the presentations), 'facilities' (workplaces, which visitors could use, games, where they could play, or tools, where a single user could learn), and 'museums' (exhibition and guided tour instead of the role-play).

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 […]. So when we were supposed to start building, we did not know what was possible, and how to do the things that were possible.

3.3.2 Accessing building resources

The building resources available in the Virtual Campus were used to a limited degree. Most of the groups did not see them contributing to the community support. However, three groups explicitly mentioned these resources ease the constructing process:

– We discovered elements from other projects and generally around in second life that we wanted to incorporate into our [project]. Other things gave us inspiration to try to make ourselves or improve […].

– The amount of previous constructions was small, but it still showed what could be done, and what to aim for. Especially the latter might be inhibiting to creativity, as it might not be especially motivating to surpass the previously created work […]. The already available scripts and textures made building cheap, although it might lock participant into a narrow thought process […].

3.4 Donate phase

3.4.1 Role-play presentations

During the final phase of the Summer School, the students were presenting their constructions to other participants. In the discussions, all the groups

noted advantages of role-playing as a learning activity. The most popular of them include efficiency and safety comparing to the real-life training, possibility to have a good contact with the audience, and offering experience together with information:

– 3D role-plays can be useful and sometimes necessary for imitations of real-life situations that can be dangerous, or that can happen (but still useful) with some lesser probability.

The students identified two most serious challenges for such type of activity: not enough realistic experience and the amount of effort required to make a play. Half of the groups discussed these challenges:

– […] even though we are presenting something based on a role-play we are still in a virtual environment. We think that it is not the same having a role-play in virtual environment or in real life.

Role-playing activity was also found to be an important part of the visualizations. In some cases, they clarified the purpose of static constructions. In some other cases, role-playing became the central part of the projects, while 3D constructions were serving as a stage.

3.4.2 Preserving constructions in the Virtual Gallery

The students acknowledged the possibilities of 3D VWs for international collaboration, virtual visits, and knowledge sharing as it was done in the Summer School events. Virtual Campus of NTNU and generally 3D VWs were talked about as suitable for supporting communities in the long term.

Sharing 3D constructions received a positive feedback. Most of the groups stressed the importance of studying previous students' constructions to have inspiration. Some of the groups stated also that they 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 VWs […] are capable of, what is possible to do, what types of collaboration are possible.

However, a number of strong limitations were identified, such as low accessibility, technical problems, and that experience is not realistic enough:

– The "general public" uses small computers, mobiles and other platforms that don't have the power to run 3D VWs […]. That's more barriers added to the task.

4. RETRIEVING CRYSTALLIZED KNOWLEDGE FROM EDUCATIONAL VISUALIZATIONS

During three autumn semesters (2009, 2010, and 2011), three generations of Cooperation Technology students were creating 3D visualizations and role-plays as one of their course assignments. Most of their projects are preserved in our Second Life virtual campus and in the VG. Students who worked on the projects in 2010, and especially, in 2011 provided a positive feedback on the gallery of 3D visualizations that had been created earlier. However, they mainly emphasized the possibility of having examples and leaning different visualization methods and techniques. The students were extracting the knowledge embedded into the 3D visualizations when trying to understand how it was represented with space, objects, and interaction.

We further explored the possibility of extracting knowledge crystallized in 3D visualizations towards the end of the visualization project in 2011. We invited a group of post-graduate students from COE UHM to visit our virtual campus to analyze and review the 3D visualizations created by our students. Apart from few other aspects, we asked to describe how understandable the topic presented is and how informative the construction is. In order to complete such a task, the students had to try extracting as much knowledge crystallized in the 3D constructions as possible. It should be noted that the COE UHM students did not attend the role-playing presentations of the 3D constructions.

The results were the following. In five out of 10 constructions, the main topics were easily identified by the COE UHM students. Four of these constructions were found informative, although with the limited number of learning objects. In three other constructions, the topics were found vague or too dependent on the observer. One of these constructions was described as informative. In the remaining two construction projects, the students failed to understand the topic. Most of the elements in both of them were found confusing.

In 2013, we continued exploring the possibilities for retrieving knowledge crystallized in 3D visualizations and activities conducted there. This year, our students of the same course (renamed to Cooperation Technology and Social Media) were given a different task – designing an educational game about one of the course concepts. However, we conducted an activity in our virtual campus, exploring and discussing the 3D visualizations made in 2011 and representing the core course concepts. Each group was assigned to one construction that they had to explore, try to understand which course topic it visualizes, and propose a game concept for it. After that, we went through 3D constructions all together, discussed the topics visualized and ideas of game concept. The task was not easy for

almost half of the student groups. However, the groups were able to identify all the topics (in some cases with the help of other groups) and suggest ideas for games that could be designed using these 3D constructions.

The feedback from this activity was collected by a questionnaire and individually. The data shows that 44 % of the students found the topics and ideas behind the constructions clear, while 33 % found then vague. At the same time, 11 % of the students stated that the topics become clear after discussing the constructions with peers and the teacher.

We also found that 44 % of the students consider that the 3D visualizations are informative, but the educational content they present is limited. Some students (27%) considered that more than half of the visualizations are informative, and 22% voted that less than half are informative. When the students were suggested to answer how such visualizations could be reused, 56 % were not sure, and 39 % could think of reusing them to some extent.

5. SUMMER SCHOOL SUMMARY

The objective of Virtual Summer School was to explore learning environments by inviting participants into practices where knowledge and insight is emergent from the diversity of the contributions. The virtual format of the Summer School demonstrated the possibilities of modern educational technologies for working and learning. It was a deliberate choice to organize the Summer School and the corresponding environment in accordance with the four phases of creative collaborative process by Schneiderman.

Based on our experiences, we can outline the following general implications for the use of the major elements of the virtual summer school.

- 3D visualizations are important for community building and dissemination of educational content, supporting exchange of ideas in a virtual workplace as well as enhancing creativity across boundaries of different CoIs. Therefore, there is a need to explore alternative and innovative ways of visualizing, storing, and managing community knowledge.
- 3D visualizations provide alternative possibilities for teaching and presenting innovative concepts and research results in an easy-to-understand way. These possibilities should be further explored.
- Virtual events are an integral part of the educational process and, therefore, of the Summer School organization and planning. We have explored different types of events and corresponding modes of

learning. In order to facilitate such events and different learning modes, it is necessary to provide both social and educational spaces for community building and collaborative creative activities.

- Role-playing in 3D VWs constitutes a powerful disseminating tool and an integral part of the collaborative creative process. Role-plays can also serve as workplace training for students (as identified by their feedback). Therefore, a further exploration of the potentials of role-playing and serious games for supporting learning at the workplace is recommended.
- All the mentioned elements, i.e. 3D visualizations, associated role-plays, and virtual events, are interconnected, supplementary to each other, and necessary for creative communities support. For example, without the role-plays, the knowledge embedded into the constructions during the creative process was not fully retrievable. The 3D visualizations served as boundary objects and were, therefore, necessary to create joint understanding between different CoIs.

6. IMPLICATIONS

In this section, we present the main implications derived from analyzing the data collected during the Virtual Summer School and the follow-up events. We focus on our lessons learned from conducting creative activities in the course of the summer school, supporting these activities by the features of the 3D environment, and retrieving the knowledge from the visualizations and activities held around them.

6.1 Conducting creative activities in the course of the virtual summer school

In the following, we discuss how the activities in the different phases contributed to seeding and nurturing creative communities as well as how the existing Summer School facilities supported these activities.

- *Collect phase:* Brainstorming the topic to be visualized and discussing the design in group blogs contributed to establishing an initial domain, engaging issues, insights, and practices for learning communities. A set of resources in the Summer Schools such as existing student construction, tutorials, and joint feedbacks sessions in Second Life as well as feedbacks to the blogs provided initial

motivation and facilitation for collaboration and brainstorming in blogs and other arenas.

- *Relate phase:* Participating in virtual events and exploring other constructions contributed to establishing new connections and multi-membership in learning communities involved. These processes were supported in the Virtual Summer School by providing boundary objects to enable dialog and collaboration between learners from diverse backgrounds and disciplines (such as exhibition booths and slides from different projects) and by supporting a flexible infrastructure, enabling both formal and informal meeting and workplaces for members of different creative communities.
- *Create phase:* Collaborative construction of 3D visualizations contributed to unleashing and supporting social creativity in the participating communities during the Create phase, establishing a joint practice and trying out different solutions. This process was supported and motivated by the possibility of accessing building resources in the Summer School, both student constructions from earlier generations and various building tools and facilities.
- *Donate phase:* Presenting the 3D constructions with the role-plays contributed to disseminating the results from the participants and projects involved and enriching the reflective dialog in the communities with innovative expression forms. In addition, the visualized results are available 24/7 in Second Life as a part of the Virtual Gallery, thus constituting a shared repository of community knowledge. These activities have been supported in the Summer School by providing seminars on role-playing in a workplace context as well as storage and retrieval facilities for 3D content.

6.2 Supporting creative activities by the features of the environment

The Virtual Summer School we describe in this paper was the second in a series of similar events. The first summer school was also held our virtual campus in Second Life. However, for the second school, we improved the environment based on the results of the first school and a study on supporting creative communities conducted earlier (Fominykh, Prasolova-Førland, & Divitini, 2011).

The structure of the requirements is based on our previous research into collaborative work with 3D content (Fominykh & Prasolova-Førland, 2011) and was evaluated during the first summer school. The virtual environment

was developed on three levels: content, service, and community, as shortly outlines below:

- *Content level* (basic tools and methods for facilitating 3D construction process and elaborating on 3D content in VWs)
- *Service level* (tools and facilities for supporting collaborative educational activities in 3D VWs)
- *Community level* (methods and tools for creating and maintaining learning communities around educational activities in 3D VWs)

As we focused on collaborative creativity in the Second Virtual Summer School, we emphasized the support for the four phases of the creative collaborative process (Schneiderman, 2002) in the set of our lessons learnt from supporting creative activities with the features of the environment.

- Content level:
    1. To facilitate the *Collect* phase of the creative collaborative process, it is necessary to provide similar projects or examples from previous student generations. A library of pre-made objects and tools assists learners with searching for material and visualizing it.

    2. To facilitate the *Create* phase of the creative collaborative process, the environment should provide basic and advanced tutorials and a workplace, allowing the participants to try out different solutions, with minimized time/effort investment and a required degree of flexibility, in collaboration with peers.

    3. To facilitate creation and appropriate use of virtual objects and media of different kinds, the environment should provide explicit examples of their use for presenting different types of information. In addition, it is necessary to provide explicit explanation and examples of content presentation forms, including the use of decoration and aesthetics, functionality, visual symbols, metaphors, and space organization. A set of tools and/or examples for supporting the development of dynamic content and interactive elements benefits the visualization process.

- Service level:

1. The environment should provide basic and advanced (specific domain oriented) tutorials, always available at hand. Additional materials and links to external resources related to the activity or the topic being discussed should be provided.

2. The environment should provide basic building resources, allowing the participants to start composing structures from ready-to-use blocks at an early stage.

- Community level:
    1. Collaborative facilities, such as seminar rooms, community spaces, and annotation and feedback facilities, should be available to provide support for consultations with peers and experts/visitors during the *Relate* phase of the collaborative creative process.

    2. Community repository (VG) should be available to allow learners to share and disseminate their projects, supporting the *Donate* phase of the collaborative creative process and exhibiting the results of the community activities through the process of reification (Wenger, et al., 2002).

    3. The environment should support "creative communities", taking advantage of the mutual "symmetry of ignorance" (Fischer, 2000; Rittel, 1984), allowing social creativity to be unleashed at the boundaries of different domains. This can be realized by providing dedicated community spaces, such as group rooms and meeting places with corresponding initial community events (tutorials, discussions, and seminars). In these spaces, connections between different communities can be supported, such as students and teachers, external experts and the general public by facilitating a series of community events.

    4. Initial boundary objects should be created, providing shared understanding and vocabulary among community members in the situation of "symmetry of ignorance" (Fischer, 2000; Rittel, 1984). Shared artifacts should be introduced as catalysts of collaboration, such as an infrastructure supporting interactive communication and 'points of focus' around which the interaction and collaboration will be structured (Thompson, 2005). The environment should comprise ideas, insights, and practices that are to be shared in the community at the early phase.

6.3 Crystallizing and reusing virtual summer school activities

Exploring the possibilities 3D VWs for supporting community memory and experimenting with the VG, we discovered that knowledge can in fact be retrieved from both visualizations and traces of the activities held around them. In this section, we discuss the results of the two summer school follow-up activities (presented in Section 4), in which we studied the knowledge retrieval process. In both activities, the participants were trying to retrieve knowledge from constructions without seeing the role-playing presentations of these constructions.

The visiting COE UHM students could easily see the topics presented and the purpose of half of the constructions. We consider this result as an argument for the possibility of knowledge retrieval, as those constructions that COE UHM students considered ambiguous or vague were created as 'scenes for role-plays' or 'facilities' (see Section 3.3.1). At the same type, it was very easy to extract the knowledge from the constructions of the 'museum' type.

Discussing game design ideas using the 3D visualizations with Cooperation Technology and Social Media students can be seen as both retrieving knowledge from constructions (understanding what they are representing) and investing them with new activities (proposing games that can be designed there). The feedback we collected about this activity demonstrates that the students were rather positive towards retrieving knowledge from 3D visualizations. However, it should be considered that students have different learning styles, and perceiving the visual information is naturally easier for some of them and harder for the others. In addition, the 3D visualizations were a new type of information for all the participants. Therefore, we can conclude that ideas and knowledge can be conveyed by 3D visualizations.

Most of the students have also reflected that the 3D visualizations being informative had limited educational content. This result confirms that the purpose of visualizing concepts in a 3D environment was rather to present less information, but vividly, engaging, and entertaining. Most of the students replied individually that they are not sure if 3D visualizations could be reused, but several suggestions were made during the live discussion. This fact stresses that this form representing information is new to the students, and further research is required to understand how to reuse 3D visualizations.

Our experiences show that crystallization of collaborative activities and 3D visualization enriched the reflective dialog in the communities with innovative expression forms and contributed to creation of a shared

repository of community knowledge. In particular, findings suggest that 3D VWs allow storing community memory directly in the form of crystallized activities, something that allows grasping complex concepts and access tacit knowledge. The 3D virtual environments may thus be a valuable add-on and contribute to the educational repertoire. We consider these conclusions preliminary, as they are the results of exploratory studies and need to be further investigated.

7. CONCLUSIONS AND FUTURE WORK

In this paper, we have presented our experience from conducting the Virtual Summer School in Second Life as an attempt to provide a systematized support for creative communities in a multi-cultural, cross-disciplinary context. In this way, a virtual summer school could be thought of as a framework or a technique that provides support for community building, collaborative creativity, and idea dissemination. Based on the data we collected during the summer school and the follow-up events, we identified implications for conducting creative activities, supporting these activities by the features of the 3D environment, and retrieving the knowledge from them.

In addition, we identified several challenges both related to the fluid and diverse nature of creative communities and the technology, in particular Second Life. Although the latter was chosen for its general popularity and accessibility, the results will be relevant for other social VWs as long as they support collaborative co-construction.

In our future work, we will explore further the possibilities of 3D VWs for supporting creative communities, in terms of organizational forms for educational and social activities, virtual environment design, and retrieving knowledge created during such activities and crystallized in the environment.

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