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Constructing a 3D Collaborative Virtual Environment for Creativity Support

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Abstract: In this paper, we focus on creativity support for learning in 3D collaborative virtual environments. We propose a set of requirements and a design for a 3D virtual working environment that supports creative collaboration among university students. This 3D working space is to be used in the university course "Designing e-learning" for developing creative solutions for informal and formal learning in virtual places and involving students from different European countries and partner organizations participating in the EU CoCreat project. The main goal of the project is to develop and evaluate collaborative spaces for learners of different ages in order to promote creative collaboration and to explore new and innovative learning models.

Introduction

Traditional learning practices need to be adapted to the modern society in order to cope with its rapid changes. Innovative solutions that promote problem-solving are required and, in those situations, creativity plays a central role. 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 (Eteläpelto & Lahtia, 2008; Kangas, 2010; Lewis, 2006; Livingston, 2010). However creativity is not a spontaneous process and it needs to be promoted with novel solutions. One of the new technologies, known to be very promising in creativity support, is 3D Collaborative Virtual Environments (CVEs). For example, in (Prasolova-Førland, 2007) CVE technology is used for creative educational visualizations, and in (Peppler & Solomou, 2010) creativity and collaborative learning are explored in the context of virtual 3D architectural building. In (Minochaa & Reevesa, 2010) learning spaces in a 3D CVE were successfully utilized to foster creativity and informal learning among students, in contrast to traditional instructional approaches.

CoCreat (http://www.cocreat.eu/) is a project, supported by the European Commission under the Life Long Learning programe (http://eacea.ec.europa.eu/). The project identified a number of problems in the society (e.g. technological environments, learning landscapes (ecosystems) and interaction between different generations) and the need for a range of new learning practices in complex and dynamic learning environments in order to tackle these problems. The aim of this project is to find out how to enhance creative collaboration by applying the theory of collaborative learning. The outcome of the project will be increased competence in acting and learning in complex and dynamic environments where collaboration and creative solutions of problems are required.

The project will bring students from four different universities (University of Oulu – Finland, Tallinn University – Estonia, Valahia University of Targoviste – Romania, Norwegian University of Science and Technology – Norway) in a 3D virtual space. Other social media technologies (e.g. microblogs, wikis, social networking and web mapping) will be applied in implementation of "Designing e-learning" course as well. Study-process will be structured with the ideas of design- and problem-based learning. Through technological solutions and pedagogical structuring students are encouraged to develop creative solutions for informal and formal learning in virtual places.

In this paper, we present the requirements and design for a 3D CVE that will be used in CoCreat project. Collaborative Virtual Environments are very promising for creativity support because of their possibilities for visualization, communication and self-expression, however the area lacks strong methodological frameworks. The purpose of the paper is to outline a general methodology for facilitating collaborative creative activities in 3D CVEs.

Two Second Life locations will be used as a basement for the project's 3D virtual environment: Virtual Campus of Norwegian University of Science and Technology (NTNU) and the island of Kymenlaakso University of Applied Sciences (KUAS). These locations and the platform Second Life were chosen because of being venues for a number of similar projects before and the availability of some of the required infrastructure.

Background and related work

Different techniques can be used to help students to appropriate the body of knowledge presented in a course. These techniques are often aiming at making students active and triggering their creativity (Eteläpelto & Lahtia, 2008; Kangas, 2010). In this paper, we focus specifically on creativity in a collaborative context. Schneiderman identifies the following main phases in a collaborative creative process (Schneiderman, 2002): collect (searching for material and visualizing it), relate (consulting with peers), create (trying out solutions, creating associations, composing artifacts) and finally donate (disseminating results).

Technology Enhanced Learning (TEL) suggests a number of solutions that can be applied for supporting creativity in educational settings. In this paper, we focus on one of such solutions, 3D Collaborative Virtual Environments (CVEs) that can be defined as three dimensional, multiuser, synchronous, persistent environments, facilitated by networked computers (Bell, 2008; de Freitas, 2008).

The purpose of CoCreat project is to explore creative collaboration among the learners of different ages, and there are a number of reasons for applying 3D CVEs in this context.

First, CVEs provide learners an environment for active and collaborative work with 3D content, which allows to apply 'constructionism' (Harel & Papert, 1991). In addition, 3D visualization is a powerful tool for supporting understanding and memorizing complex concepts already widely used in educational contexts (Börner, 2001). There is some evidence reported in the literature that 3D graphics can be beneficial for memorization and information retrieval (Czerwinski, van Dantzich, Robertson, & Hoffman, 1999). CVEs potential for supporting cross-cultural understandings is another important motivation behind the choice of this technology (Wyeld & Prasolova-Førland, 2006). In an increasingly globalized world, there is an ongoing need for ICT professionals to work in diverse cultural environments. When members of different cultural backgrounds come together to collaborate on a single project they are acculturated to different ways of seeing themselves in relation to others and are able to observe how others behave in the same situations. They come to appreciate different approaches to similar tasks and adjust their own behavior to accommodate these differences (De Blij & Muller, 1986).

Finally, an important reason is an opportunity for participants to interact in a way that conveys a sense of presence, lacking in other media (Kelton, 2007; Park, Hwang, & Choi, 2009). Users are represented by avatars and act in a shared 3D space that gives them awareness of each other's actions. Communication is usually presented in the form of gestures, text-based chat and in-voice chat and allows using CVEs for meetings, performances and role-playing (Sant, 2009). Moreover, the ability of this technology to support informal socialization is also acknowledged by existing research (Börner, 2001; Minochaa & Reevesa, 2010; Prasolova-Førland & Divitini, 2003). These opportunities result in a number of benefits for establishing and supporting learning communities (Bronack et al., 2008).

Establishing and nurturing vibrant learning communities is seen as a highly complex process (Wenger, McDermott, & Snyder, 2002; Wenger, White, & Smith, 2009). Yet, at the same time, such communities are seen as highly important in developing and spreading new skills, insight and innovation (Johnson, 2010). Traditionally, Communities of Practice (CoP) have been the most common form of community.

Describing Communities of Interest (CoI), Fischer et al. state that (Fischer, Rohde, & Wulf, 2007): "CoIs bring together stakeholders … and are defined by their collective concern with the resolution of a particular problem. CoIs can be thought of as "communities of communities" (John Seely Brown & Duguid, 1991) or a community of representatives of communities. Stakeholders within CoIs, as in the CoCreat consortium, are considered informed participants (J. S. Brown, Duguid, & Haviland, 1994; Fischer, et al., 2007), being neither experts nor novices, but both. They are experts in their own domains when they communicate their knowledge and understanding to others. At the same time they are novices and apprentices when they learn from others' areas of expertise. According to (Fischer, 2005; Fischer, et al., 2007). CoIs have potential to be more innovative and transforming that a single CoP if they can exploit "the symmetry of ignorance" for social creativity because different backgrounds and different perspectives can lead to new insights.

Overcoming distances in social creativity and supporting learning in CoIs requires externalizations (Bruner, 1996; Papert & Harel, 1991) in the form of boundary objects (Star, 1989) that have meaning across the boundaries

of the individual knowledge systems/ subcommunities/ different CoPs that join together in a CoI for some purpose (Fischer, 2001).

Creativity support in 3D CVEs

In this section, we present two cases from our own experience in the use of 3D CVEs for educational purposes, which are related to creativity support. In addition, we summarize our experience and provide implications for the CoCreat project environment.

Creative curriculum visualization

Improving students' understanding of the curriculum is one of the most important tasks for the use of technology in education. In case study *Creative curriculum visualization*, we explored advantages and disadvantages of 3D CVEs for collaborative creative elaboration and visualization of educational content. We asked students to build a creative visualized presentation of one of the topics covered in the Cooperation Technology course in Active Worlds (Prasolova-Førland, 2007). Their work was evaluated based on the analysis of the constructions and on the discussion in group essays. The solutions chosen by the students tended to follow the categories:

- '3D shell' – a house or another construction with no apparent connection to the topic and with a content presented by 'traditional' methods such as posters with text and images;
- '3D cartoon' – a 'dramatization/ enactment/ diorama' with avatars and 3D objects, in some cases with animations (Fig. 1);
- 'virtual museum' – a presentation of the topic in a gallery of images or 3D objects illustrating the major concepts (Fig. 2).

Figure 1: 'Awareness' as a '3D cartoon', student project

Figure 2: Museum of communication means, student project

Constructing visualizations of the major curriculum concepts in a 3D collaborative virtual environment, the students spent a significant effort on elaborating on educational content and their understanding was on several occasions improved, as followed from their feedbacks. The students acknowledged that the technology provides a creative atmosphere and a set of means for self-expression. However the students experienced a number of problems working on this task. It was rather time-consuming and required much more effort than simply reading a textbook. The students also experienced some misunderstandings with the ambiguity of visualizing abstract concepts in a 3D environment.

During this case study we explored the support for the different phases of the creative collaborative process (Schneiderman, 2002) and also the typology of the 3D content and visualization means in 3D CVEs, which will serve as an input for the CoCreat case study, especially the requirements.

Research projects visualization

Collaborative virtual environments can be used as an alternative technology for presenting information. In the case study *Research projects visualization*, we asked students to build a creative visualized presentation of a

research project and present it at a joint session by role-playing within the Cooperation Technology course in Second Life (Fominykh & Prasolova-Førland, 2011a).

Having a great degree of freedom, the students expressed their creativity in a number of ways, selecting diverse and interesting projects, applying different metaphors and using different types of content presentation technics (Fig. 3).

After the practical part of the exercise, the students reflected on their experience in group essays. The analysis of the data collected during the study showed that the exercise in the 3D environment helped the students to get some practical experience on the cooperative technologies and to gain deeper understanding of the course concepts (Fominykh & Prasolova-Førland, 2011a).

This case study demonstrated the range of possible topics that can be visualized and also the variety of presentation methods. The topics included research projects or concepts from both technical disciplines and humanities. A number of different metaphors were used, including a museum, a gallery, a meeting room and a workshop. Construction presentations revealed the possibilities for immersing visitors into the project environment or process, live discussions and demonstrations.

In addition to the student group work, we studied the possibilities of 3D CVEs for research project visualizations in other settings. Developing a framework called Virtual Research Arena (Fominykh & Prasolova-Førland, 2011b), we constructed a Virtual Science Fair in Second Life to explore an alternative and creative way for presenting research. The Virtual Science Fair has 8 pavilions, each presenting a research project (Fig. 4).

Figure 3: Art and technology project, role-play project presentation

Figure 4: TARGET EEU project, Virtual science fair pavilion

In this case study, we gain additional experience in conducting creative collaborative activities on 3D content and further developed the typology of the 3D content and visualization means in 3D CVEs. In addition, the structure of the requirements for the CoCreat virtual environment is taken from the results of this study.

Experience summary

Based on the several case studies, including the mentioned above examples, we are developing a theoretical framework and a tool called Creative Virtual Workshop or CVW that we previously proposed and described in (Fominykh & Prasolova-Førland, 2011b). In the core of CVW lies creative collaboration around 3D content that includes building, sharing, exhibiting, annotating and other manipulations.

In addition, previously we developed a set of recommendations for collaborative work on 3D content in CVEs, presented in (Fominykh & Prasolova-Førland, 2011a).

All this work served as a background for constructing the CoCreat 3D virtual working environment.

CoCreat 3D collaborative virtual environment

Based on the results from the case studies presented in the previous section, related work and a series of discussions with CoCreat partners, we propose a set of requirements and the design for the CoCreat 3D collaborative virtual environment to be used in the “Designing e-learning” course as described below.

Pedagogical model

"Designing e-learning" course aims at familiarizing students with the key concepts, competing theories and approaches of designing TEL. In collaboration with international students, they will develop practical skills of setting up, implementing and evaluating the use of distributed set of integrated TEL systems and tools, and they will design a prototype of an advanced TEL course.

The course will be taught in the spring semester 2012. However, we will conduct the preparatory study already in the autumn 2011 within the course on Cooperation Technology at NTNU. This preparatory will serve as 'a proof of concept' for the main course, but, at the same time, the result of the students' work will be actively used in the later "Designing e-learning" course as examples of 3D educational visualizations and associated infrastructure. Moreover, the preparatory case study in the autumn will allow us to get additional insights on supporting collaborative creative processes in a 3D CVE.

The main idea of the preparatory study is to give the students some basic information on the "Designing e-learning" course and ask them to come up with a design for the technological infrastructure in the 3D CVE with the focus on supporting cooperation among students (information sharing, coordination, synchronous and asynchronous communication, etc.). Norwegian students will work in groups and create small 'educational modules' or practical tutorials in Second Life, illustrating different concepts within the course such as coordination, information sharing, awareness and so on.

Working on this task, the students will have the following plan:

- Developing a web-based educational module (an extended blog post) on a certain topic/course concept (1 week);
- Writing a plan for a 3D visualization/a 3D CVE infrastructure element on the topic chosen (1 week);
- Creating a group construction in the NTNU Virtual Campus according to the plan (4 weeks);
- Preparing a role-play presentation of the 3D construction (1 week);
- Analyzing and reflecting on their activities by blogging during the whole semester and presenting a summary in an essay by the end of the course;
- Discussing their activities, design ideas and final results as well as receiving feedbacks during a virtual "Summer School". This summer school will include a number of virtual seminars with participation of students, teachers and researchers from European and other countries, including CoCreat partners, partners from other EU-funded projects and visitors from other institutions.

International students in the spring semester will be able to explore visualizations ('educational modules') prepared by the Norwegian students. Any visitor will be able to learn about cooperative technologies in general and get some ideas on how educational content can be presented in a 3D CVE. Blogs of the Norwegian students will be linked to the virtual environment and available to the visitors/CoCreat participants, providing a source for inspiration and discussion.

Requirements

Each of the points of the requirements has its grounding in theory and/or based on the results of our previous empirical studies as well as discussions with CoCreat partners. The structure of the requirements is based on our previous research into collaborative work with 3D content (Fominykh & Prasolova-Førland, 2011a) and was evaluated in another educational project – Virtual Research Arena (Fominykh & Prasolova-Førland, 2011b):

- *Content level* (basic methods for facilitating 3D construction process and elaborating on 3D content in CVEs). 3D construction is described along 3 main dimensions: virtual exhibits, visual shells and dynamics (building further on the 3 categories from the "Creative curriculum visualization" study). A successful construction provides a harmony between these dimensions.
    - Virtual exhibits or 'types of content' is the first dimension for describing 3D constructions (Fominykh & Prasolova-Førland, 2011a). Virtual exhibits have 3 main categories: text, 2D graphics and multimedia, and 3D visual symbols.
    - Visual shell or 'content presentation form' is the second dimension for describing 3D constructions (Fominykh & Prasolova-Førland, 2011a). A visual shell can be described using 3 dimensions: aesthetics (appropriate atmosphere and decorations, e.g. in a 'medieval' style), functionality (interactivity and navigation, e.g. a 'museum'-like pre-defined path through an exhibition) and expressed meaning (symbols and metaphors, e.g. an Egyptian history museum in the form of a pyramid).

    - Dynamics of the content considers how the virtual exhibits are presented to the viewer in terms of 'story-telling', e.g. a development of the narrative as the visitor moves along the construction and facilitation of roleplaying.
- *Service level* (tools and facilities for supporting collaborative educational activities in CVEs).
- *Community level* (methods and tools for creating and maintaining learning communities around educational activities in CVEs).

As we focus on collaborative creativity in this work, we focus on the support for the 4 phases of the creative collaborative process (Schneiderman, 2002) in the requirements set for the CoCreat collaborative environment.

Content level:

- 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 will assist learners with searching for material and visualizing it.
- 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.
- To facilitate creation and appropriate use of *virtual exhibits* of different kinds, the environment should provide explicit examples of their use for presenting different types of information.
- To facilitate elaborating aesthetics, functionality and expressed meaning of the *visual shell,* it is necessary to provide explicit explanation and examples of visual shells for different contexts.
- There should be created a set of tools and aids for supporting development of *dynamic* content.

Service level:

- The environment should provide basic and advanced (specific domain oriented) *tutorials*, always available at hand. Additional materials and links to external resources should also be provided.
- The environment should provide basic *building resources*, allowing the participants to start early composing structures from ready-to-use blocks.

Community level:

- Collaborative facilities, such as seminar rooms, community spaces, and annotation and feedback facilities, should be available to provide support for consultations with peers during the *Relate* phase of the collaborative creative process.
- Community repository (CVW virtual gallery) should be available to allow learners to share and disseminate their projects, supporting the *Donate* phase of the collaborative creative process.
- 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 tools for social activities and collaborative work, facilitating interactions between stakeholders from different domains.
- The environment should comprise ideas, insights and practices that are to be shared in the community at the early phase (domain), such as collaborative technologies and educational visualizations.
- Dedicated *community spaces* should be present in the environment, such as group rooms and meeting places with corresponding initial community events (tutorials, discussions and seminars). In these spaces, *connections between different communities* should be supported, such as students and teachers, external experts and the general public by facilitating a series of community events.
- 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 have a *Community repository* (Wenger, et al., 2002), such as a virtual gallery, exhibiting the results of the activities of community members (reification).

As a part of the evaluation process, we are planning to investigate to what extent the system designed according to these requirements supports the 4 phases of the creative collaborative process (Schneiderman, 2002). To further validate the proposed set of requirements, we are planning to compare student accomplishments (including 3D constructions) in this study to the previous ones conducted in 3D CVEs.

Design

In this sub-section, we present the design of an educational CVE that supports creativity. The environment will be used in the CoCreat pre-study and built in the Virtual Campus of NTNU in Second Life. Later it will be improved and used in the project together with the KUAS island.

Content level:

- Facilitating the *Collect* phase of the creative collaborative process in the environment will be carried out by adding functionality to the library of pre-made objects and the virtual gallery to assist learners with searching for material and visualizing it.
- Facilitating the *Create* phase of the creative collaborative process will be carried out by making tutorials and building resources available at hand, but also by constructing a common working area (an advanced sandbox).
- Facilitating appropriate and creative use of virtual exhibits will be realized by constructing an exhibition, presenting different types of *virtual exhibits*, such as text, posters, videos, interactive elements and visual symbols (Fominykh & Prasolova-Førland, 2011a). The exhibits may provide information on their appropriateness in different situations.
- Facilitating elaboration of *visual shells* will be realized by constructing an exhibition, presenting different aspects of *visual shells*, such as aesthetics, functionality and expressed meaning. The exhibition will provide information on the appropriate use of those aspects in different situations, based on our previous experience with collaborative work on 3D content (Fominykh & Prasolova-Førland, 2011a).
- The *dynamics* component of the content will be supported by constructing a virtual stage for live performances around the content, such as presentations and role-playing.

Service level:

- *Tutorials* for introducing technology basics for participants are already present in the NTNU Virtual Campus, including some references to external resources. These tutorials will be renovated and complemented by the new ones, introducing specific project related issues.
- Basic *building resources and ready-to-use blocks* are also present in the NTNU Virtual Campus. The library of resources will be renovated and extended.

Community level:

- To support the *Relate* phase of the creative collaborative process, a number of facilities available in the NTNU virtual campus (such as seminar rooms, community spaces, and annotation and feedback facilities) will be renovated to provide better support for communication and consultations.
- To support the *Donate* phase of the creative collaborative process, the CVW virtual gallery will be used to serve as a community repository. The virtual gallery will be connected to the library of resources, to the workshop with tutorials and to the common working area.
- Resources related to the community domain (e.g. e-learning course design, project documents, related literature on collaboration and creativity support with 3D CVEs) will be provided in the form of textual, graphical and multimedia artifacts within the virtual environment as well as links to external resources.
- Some of the *community spaces* are already present in the NTNU virtual campus. Group work areas will be allocated to students in advance and provided with navigational infrastructure/collaborative tools. To support *connections between different communities*, a set of designated community spaces will be created. A number of international visitors (including researchers, teachers and students) will be invited to participate in the joint events, taking place in these spaces.
- *Boundary objects* will be realized as a common area with realistic and recognizable reconstructions of landmarks or monuments (later for each university participating in the project), with corresponding information about the partners. This area will serve as a point of focus, around which the interaction and collaboration will be structured, with corresponding informational resources from the partners to address “symmetry of ignorance”.
- *Community repository* will be organized on the basis of the CVW virtual gallery, which is already functioning. The gallery will contain and exhibit any 3D constructions, including previous student projects and contributions from the CoCreat community.

Evaluation plans and discussion

The collaborative spaces resulting from the design presented in the previous section will be further developed and redesigned by the students as a result of their activities during the planned case studies in autumn 2011 and spring 2012. The participants of these studies will be students from the participating organizations of the CoCreat project, involving several European and non-European countries is planned. The international scope of the studies will make it possible to explore the aspects of diversity, cross-cultural and cross-curriculum interaction in regards to supporting creativity. During these case studies, the collaborative spaces and their support for collaborative creative activities will be evaluated, exploring the possibilities and limitations of 3D Collaborative Virtual Environments in this context.

The *evaluation* of creativity support is rather complicated by objective and qualitative measures. For this reason, we will adopt different techniques for collecting multiple data from different sources. These will include observations of student activities in the virtual environment, analysis of the constructions and interviews.

Different indicators of creativity will be studied. In particular, considering the starting conceptualization of creativity, one important aspect will be to study "symmetry of ignorance" and creativity. In this perspective, we will put particular attention in studying interaction among participants with different backgrounds to observe the impact on creativity. This analysis will be conducted at the group and at the community level. Our hypothesis is that groups with students with varied background will be more creative than homogeneous groups. At the community level, we hypothesize that sessions with the presence of external experts and students from other universities will trigger high level of creativity.

Different resources are provided to make construction easier. Though this is essential to promote usage of the system, it might also hinder creativity. In the study we therefore aim at evaluating the final constructions to identify whether they can be considered as original or simply a re-use of the provided resources. Breakdowns in construction processes will be studied since they might actually lead to creative problem solving.

We also want to investigate whether exploration of the virtual spaces leads to exploration of related learning content. Our hypothesis is that exploration of the space and visits to others' constructions leads to exploration of learning content, with cross-pollination, and learning. In this perspective, it is important to consider the impact on creativity of physical navigation vs. interaction within the community without navigation (e.g. during a meeting in an auditorium).

Relation between learning and creativity is also an important aspect. Though the constructions might be very creative from an esthetic or experiential perspective, this does not necessarily lead to learning. In the analysis, we will therefore evaluate whether the constructions reflect a deep understanding of the syllabus content. Indicators that have been identified are the richness and variety of visualized material, references to external sources, and links across different constructions to visualize deep connections among the topics of the course.

We have identified a number of specific challenges associated with implementing collaborative creative spaces and their evaluation. Technical challenges include the importance of sharing/donating and security issues/limitations imposed by Second Life as well as connectivity issues, stability, complexity and a steep learning curve. Organizational challenges include supporting collaboration between actors with diverse backgrounds (organizational, cultural and geographical) and attitudes to the technology will require finding and optimal balance between different communication modes (e.g. asynchronous vs. synchronous communication across different time zones. In the core of the study lies the complexity and, in certain cases, ambiguity of 3D visualizations. The role of the pre-made resources is twofold since they make the construction process easier, but may be inhibiting for the creative process. Methodological challenges include high complexity of creation, supporting and especially evaluation of creative communities (Fischer, et al., 2007; Wenger, et al., 2002; Wenger, et al., 2009).

Conclusions

In this paper, we have focused on collaborative spaces for creativity support in a university context. We have presented a set of requirement and a corresponding design for such a space to be used in the university course "Designing e-learning" for developing creative solutions for informal and formal learning, as a part of CoCreat EU project. The initial collaborative spaces will be further developed and redesigned by the students as a result of their activities. The future work will contain an evaluation of the collaborative spaces and their support for creativity during the course of two case studies involving students from different European countries during autumn 2011 and

spring 2012. The result of these studies will be lessons learned on supporting creativity in educational context with 3D Collaborative Virtual Environments.

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