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Virtual Research Arena: Presenting Research in 3D Virtual Environments

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Abstract: The paper presents Virtual Research Arena – a framework for creating awareness about educational and research activities, promoting cross-fertilization between different environments and engaging the general public. In the paper, we present initial results of an explorative case study where we apply the framework. The study includes a practical exercise in cooperation technology course and the first Virtual Science Fair in Trondheim, Norway. The data collected during the study are analyzed to explore the technological, educational, social and other issues of using 3D Collaborative Virtual Environments for visualizing research projects and promoting research to the general public. We also present how the current studies fit into our previous research on supporting learning communities in 3D collaborative virtual environments. The paper concludes with outlining future development of the Virtual Research Arena.

Introduction

The use of 3D Collaborative Virtual Environments (CVEs) such as Second Life for educational purposes has been constantly increasing during the recent years (de Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2009).

One of the reasons is the potential and possibility of such environments for supporting collaborative work with various types of content, as discussed in several studies (Arreguin, 2007; Atkins, 2009; Hwang, Park, Cha, & Shin, 2008; van Nederveen, 2007). Most CVEs allow advanced content manipulation, uploading, creating and sharing 3D objects and other media, such as text, graphics, sound and video. The term 'content' can be understood more widely than media objects, as we have discussed in (Prasolova-Førland, Fominykh, & Wyeld, 2010b). As it is noted in (Bessière, Ellis, & Kellogg, 2009), content can be 'objects, places, activities' or any valuable information or experience. CVEs allow creating complex interactive content and use it collaboratively for various purposes. 3D CVEs allow learning communities to create content and leave traces of their activities that become part of the shared repertoire of the community through the process of reification (Wenger, 1998).

Another important reason is an opportunity for participants to interact in a way that conveys a sense of presence (Park, Hwang, & Choi, 2009), lacking in other media (Kelton, 2007). 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). These opportunities result in a number of benefits for establishing and supporting learning communities (Bronack et al., 2008) and in the potential for supporting cross-cultural understanding and collaboration (Wyeld & Prasolova-Førland, 2006).

A growing number of education- and research-intensive institutions have started using CVEs for presentations and promotions, conferencing, sketching, training and other purposes. For example, promotion of the organization is one of the primary reasons for nonprofits establishing their presence in CVEs (Bettger, 2008). Conducting presentations in CVEs is becoming more popular and common and although the technology has some limitations, the potential is apparent and highlighted for example in (Yankelovich & Kaplan, 2008). Advanced universities are building full-scale, highly realistic virtual campuses with various functionality (Prasolova-Førland, Sourin, & Sourina, 2006). Other organizations that are using CVEs include research centers, libraries and museums. In the industry, many companies, such as IBM, Sun, and Cisco, are using 3D CVEs and investing in research and development of new environments.

The virtual world Second Life is one of the most successful CVEs at the moment (www.secondlife.com). It remains one of the most stable, developed and populated, though it has certain limitations, as stressed, for example, in (Crowther & Cox, 2008) and (Bowers, Ragas, & Neely, 2009).

In this paper, we investigate the possibilities of CVEs for learning communities and continue exploring how to support interconnected aspects of city life in an integral virtual environment, experimenting with the area of education and research. In particular, we focus on visualizing and promoting research projects and engaging the general public. We present a qualitative analysis of data from an exploratory case study that involved students from a graduate cooperation technology course, researchers, and the general public.

Despite the great opportunities of CVEs for visualization and the importance of presenting and promoting research, there are few studies in this area (Djorgovski et al., 2010) and the body of knowledge on educational studies in CVEs has not developed enough (Campbell & Jones, 2008). Therefore, the main goals of this paper are: first – to demonstrate that CVEs can be successfully used for presenting and promoting research projects and guide education- and research-intensive institutions in this area and second – to present an improved framework of the Virtual Research Arena (VRA) that is designed to integrate research community into society with its different aspects.

The paper is organized in four sections. In the next section we present the concept of Virtual Research Arena and outline its initial use in Norwegian Science Fair and in the practical exercise of cooperation technology course. In the following section we discuss the results of the studies, showing the impact, value and possible application of the VRA and the ideas behind it. In the last section, we outline directions for the future development of the Virtual Research Arena and conclude the paper.

Visualizing research projects

The work presented in this paper was conducted in the Virtual Campus of Norwegian University of Science and Technology (NTNU) in Second Life. Despite the criticism we mentioned, Second Life platform was chosen as it is the most common technology of choice for such educational projects, including other pre-existing Norwegian projects, such as Second Norway. The campus and previous studies there were described in (Prasolova-Førland, Fominykh, & Wyeld, 2010a; Prasolova-Førland, et al., 2010b).

Virtual Research Arena overview

In this paper, we present initial results of implementing and using Virtual Research Arena – a framework for creating awareness about educational and research activities, promoting cross-fertilization between different environments and engaging the general public. The idea of the Virtual Research Arena emerged after we were invited to participate in an annual scientific festival and present our work there. Our goal was to attract scientists who wanted to demonstrate their work on the festival in a virtual mode and to build visualizations of their projects (Fig. 1).

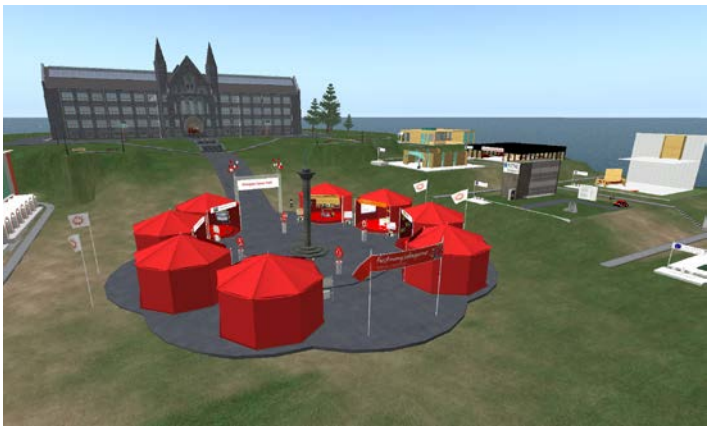

Figure 1: Virtual Research Arena in the Virtual Campus of NTNU

In the previous research, we were exploring collaborative work on 3D content in a virtual campus and virtual city context. The VRA contributes to the conceptual framework 'Universcity', in which we seek to integrate different aspects of city life, such as culture, society, education and entertainment (Fominykh et al., 2010). We consider 'Universcity' as an integral/holistic organism, since in reality all these aspects are interconnected. The 'Universcity' framework has four layers that correspond to the aspects of city life. Each layer has its own specifics and major infrastructure elements or facilities (Fig. 2). These elements of the environment are designed using a tool called Creative Virtual Workshop or CVW that we previously proposed and described in (Fominykh, et al., 2010). In the core of CVW lies collaboration around 3D content that includes creating, sharing, exhibiting, annotating and other manipulations. CVW functions as a pattern for creating infrastructure elements/facilities of the 'Universcity' in such a way that they are connected to all the layers. The VRA functionality was designed based on the basic ideas of CVW.

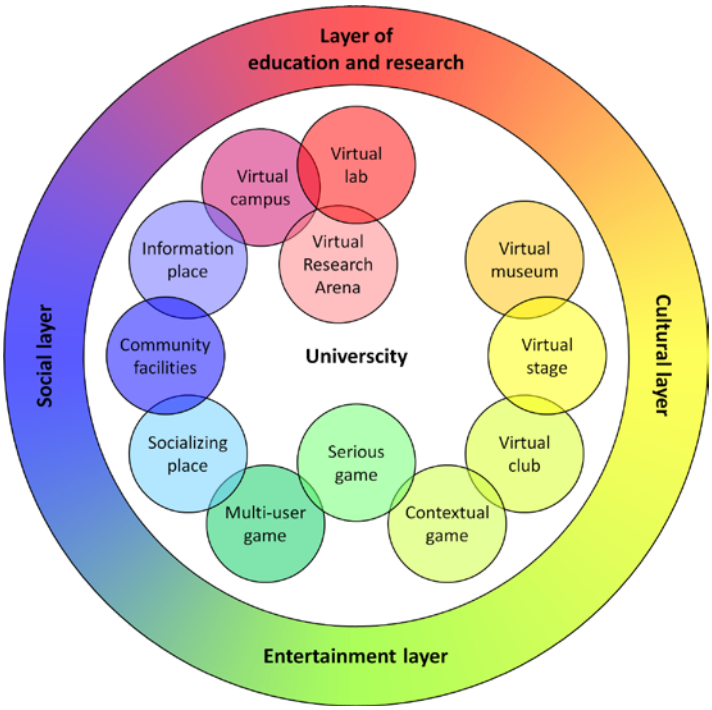

Figure 2: Virtual Research Arena in the 'Universcity' context

In the following, we present the use of VRA in Norwegian Science Fair and in the cooperation technology student exercise.

Presenting research projects at Norwegian Science Fair

Norwegian Science Fair in the city of Trondheim is a part of Norwegian Science Week, an annual festival. The goal of this event is to present science projects to the general public. In Trondheim, which is recognized as a 'student city' and a 'technological capital', the festival is organized in pavilions on the central city square. At this science fair, a number of researchers present their work in appealing yet simple ways.

In September 2010, a virtual science fair was erected in Second Life to mirror the one in reality. One of the major city landmarks – King Olav Tower, was reconstructed in the virtual science fair on the virtual 'central square', in the same place where the fair was organized in reality, to create a familiar atmosphere for the local visitors. At the same time, the Virtual Science Fair could be visited from around the globe through Second Life. In this way, it contributed to creating a meeting place for researchers, students and public. Moreover, while the physical pavilions at the fair were deconstructed at the end of the event after two days, the virtual pavilions have been preserved and available for future use.

Furthermore, the Virtual Science Fair was presented at the fair in real life as one of the projects. The visitors in the real life could come to the pavilion and immerse themselves into the virtual extension of the fair,

exploring a number of projects (Fig. 3). Such a mix of real and virtual is especially interesting and should be further improved, according to the feedback.

Figure 3: Real-life pavilion of the Virtual Science Fair in Second Life

The Virtual Science Fair in Second Life has eight pavilions, each presenting a research project from NTNU and other research environments. Most pavilions presented major ideas of projects with posters, slides, video clips and links to web pages. Also, some interactive elements were used, such as teleports to other regions in Second Life, interactive models and feedback boxes. The following virtual pavilions were presented:

- "Virtual Eidsvoll" – an educational region in Second Life for studying Norwegian history;
- "ArTe New Media Art" – research and dissemination activities at the intersection of art and technology;
- "Middelalderens Nidaros i virtuell virkelighet" – a reconstruction of medieval city in virtual reality;
- EU project "TARGET" – a 3D virtual serious game;
- "WAVE" – Women Academics in Virtual Environments;
- "Multi-lingual text annotator Typecraft" – a free online tool for language experts and anthropologists;
- "Digital stil" – a project advertizing social networking and mobile technologies;
- "vAcademia" – an educational virtual world.

The number of people who visited the real-life pavilion of the Virtual Science Fair shows that this topic is interesting for the general public. An article dedicated to the Virtual Science Fair published in a national newspaper "VG" is also a sign of interest.

Visualizing research projects at cooperation technology course

In the autumn of 2010, we conducted a practical exercise in a course TDT4245 – cooperation technology in the Virtual Campus of NTNU. This is a regular exercise and we applied most of the lessons learned from the earlier work, especially from the previous case study conducted in 2009 and described in (Prasolova-Førland, et al., 2010a).

The data in the recent study were gathered from three sources of evidence: direct observation of students' activities online, virtual artifacts, such as chat log and 3D constructions, and users' feedback in a form of group essays. After the study, the data were qualitatively analyzed.

The recent study was conducted with 25 students in seven groups, 2-4 students in each, both regular NTNU students (master and PhD level) and international students, participating in the NTNU international master program. The students were asked to build a visualization representing any research project and present it at a joint session by role-playing. This method is based on 'constructionism' (Papert & Harel, 1991) – an educational philosophy, which implies that learning is more effective through the design and building of personally meaningful artifacts than consuming information alone (Bessière, et al., 2009; Papert & Harel, 1991). Constructionism is related to the social constructivist approach (Vygotsky, 1978), where the main idea is that learners co-construct their environment and understanding together with their peers. We also 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 (Craciun, 2010; McSharry & Jones, 2000).

Prior to the competition, the students had a tutorial on Second Life in a classroom (for those who were located in Trondheim). Following this, they came online into Second Life, presented their project proposals,

identified building spots and received additional training. The total building period was about 1 month. During this time we were available for questions and assistance both in a real-life computer-room and online in Second Life. Assessment was based on participation in the construction effort and on a group essay where the students reflected on their experience.

This year the exercise was conducted in conjunction with an "International Summer School on Collaborative Technologies, Serious Games and Educational Visualizations", organized by the EU TARGET project (http://www.reachyourtarget.org/). The summer school provided 2 virtual events: a seminar "Using Virtual Worlds to Improve Business Presentation Skills" by Judith Molka Danielsen and a seminar "TARGET EEU – A step toward new e-learning technologies", by Albena Antonova. Each of the seminars attracted 20-30 participants from different countries (China, United States, UK, Russia, Bulgaria, etc.). TARGET announced a prize for the best student project, which was later divided between two groups that got an equal amount of votes. Almost finished student constructions were available in the Virtual Campus of NTNU during the Norwegian Science Week and demonstrated on the Virtual Science Fair.

During the joint session the students presented their projects in the form of role-plays, evaluated each other's constructions and received feedbacks from the visitors. The following provides an overview of the session.

Group 1 created a programming history museum. The group constructed 4 floating platforms symbolizing eras of programming and presenting important concepts. Each platform has interactive schemes or challenging quests (for example reconstruction of a motherboard and if-then loops) as well as slides explaining the topic. For a role-play presentation group members appeared as robot-like avatars, guiding the visitors through the museum and explaining the central concepts.

Group 2 visualized the effect of Kung-Fu training on health. The group created a very realistic and authentic Chinese-inspired environment that impressed the public, including Chinese visitors. The building was decorated with traditional Chinese furniture, an animated statue of Buddha, an authentic fireplace, a gong and other elements. Posters and slides on the walls provided information about the martial art and its influence on the human health. The leader of the group has an authentic avatar.

Group 3 created and presented a research project "BP Solar Energy" – the biggest solar skin in Norway. The solar skin is located at the NTNU campus south wall and provides an additional energy supply. The students constructed a piece of wall with an interactive virtual solar skin that could be switched on and off, emanating light and thus visualizing conversion of the solar energy. The construction also included posters and slides providing more information about the project and presenting group members. The students also prepared a scenario and performed a role play highlighting the importance of solar energy and presenting the project in an informal yet informative way (Fig. 4).

Groups 4 presented the work of the designer Enzo Mari called "Autoprogettazione" and who was known by using simple pieces of wood for constructing furniture. The group built several pieces of furniture and placed them in a workshop. The construction also included a presentation area showing a video clip and posters, providing additional information. During the performance, one of the group members impersonated Enzo Mari.

Group 5 tried to visualize the idea of proposing prototypes and selecting the best solution. The construction included a room with a set of random interactive objects, and a half-working voting system. The presentation was done by simply naming "the prototypes" and soon became a discussion on the CVE technology.

Group 6 created a visualization of a concurrent design methodology by constructing a "Concurrent Design Facility". The students sought to re-create real-life design facilities and built a room with a few tables and large screens on the walls for different expert groups. An additional screen displayed the central aspects of the presented methodology. During the presentation the group members played the key roles of facilitator, session secretary and customer, while the public was invited to be members of the expert groups. In such a manner, a demonstrative session "How to make a good project presentation in a virtual environment" was played.

Group 7 visualized a project called "ArTeNTNU" that aimed at increasing knowledge about the interdisciplinary intersection between digital art and software technology. The students built a simple two-floor building, filling it with posters, slides and web links with information about the artifacts created within the projects.

One of the *TARGET seminars* was held between the presentations. Most of the students and a number of international visitors participated in the event.

During the discussion in the end of the session, the central question debated was usefulness of 3D virtual environments for presenting projects. A group of students argued that using tools like Second Life requires too much time and effort, even though the presentation is more vivid and appealing. Another group was less critical and proposed that there is a number of cases where using a 3D environment is feasible and the effort spent is rewarding. Analyzing the chat log showed that the students learnt a lot about advantages and limitations of using CVE technology for collaboration and moreover they understand more clearly the roles of other tools and technologies.

Figure 4. BP Solar Energy project: role-play project presentation

After the sessions, the students had two weeks for reflecting on their activities in group essays. We provided a guideline for this task in the form of a set of points to discuss. According to the guideline, the students had to talk over potential use of their constructions, a number of aspects related to collaborative work and learning and other topics. In this paper, however, we explore the one related to the VRA design.

Evaluating general usefulness and the potential of the Virtual Research Arena in group essays, the students provided different opinions. Positive feedbacks were related to conceptual opportunities of the VRA, while the criticism was mostly focused on some imperfections of the current design and limitations of the technology. The potential of the VRA was mostly seen in promoting presented research environments by creating a socializing and gathering place around project presentations. Increased awareness among researchers, students, university departments, research groups, institutions and general public was emphasized as a way for promoting collaboration and an important opportunity. In the current VRA design, the students appreciated appealing reconstructions of real-life places.

> [Essay citations]:
> *VRA is a cost efficient, social place to meet researcher colleagues, and discuss with them in a natural setting.*
> *It's easy to create a small interesting taste of a topic in VRA, and then link further to external information on the web.*
> *We like that there are some physical and design similarities with the real "Norwegian Research Week" event.*

Many students expressed their appreciation for the global nature of the VRA and potential for supporting collaboration between researchers, students, and the general public.

> [Essay citations]:
> *People from other cities can take a look of what NTNU and Trondheim has to offer. VRA can be a source to trigger the willingness to visit Trondheim and NTNU.*
> *This is an extraordinary way to promote collaborations among different projects. Using this approach new cross boundary projects may come out.*
> *Visitors/Students from other places can also find it useful to discover the inner working of the university, visit some of the buildings and know the activities developed in the university by students and teachers.*

The negative impression was based on a general frustration about the early stage of the VRA development. Some were disappointed that proposed functionality is not yet implemented.

> [Essay citations]:
> *VRA does not provide any support for research activities, but it does provide the users with an interactive experience*

The problems in this kind of technology are time required to make a presentation and a lot of system resources to use it smoothly.
The quality of objects is too undeveloped to fairly illustrate all types of research projects.

Several technical comments were related to navigation problems, overage of objects and complexity for inexperienced users.

Discussion

In this section, we discuss how the development of the Virtual Research Arena changed the students' experience. Furthermore, we discuss the context the VRA and summarize the major implications for presenting research projects in CVEs.

Virtual Research Arena impact

Analyzing the studies presented in the paper, we noticed a change in how the participants reflected on their experience. In comparison to the previous study in the undeveloped campus (Prasolova-Førland, et al., 2010a), we observed several trends that were related to the development of the VRA and improvement of the study settings.

According to the observations and feedbacks, the students were inspired by the other constructions in the Virtual Campus, intentionally or not. They could explore existing project visualizations both from the previous year cooperation technology course and the Virtual Science Fair. There was no plagiarism since the topics were different, but the students could grasp some interesting and effective solutions and estimate approximate effort required. Reconstruction of several real places in the Virtual Campus helped the students to adapt to the environment and feel comfortable, as almost all the groups noted in the essays. According to the feedbacks, attracting attention to the neighborhood of the Second Norway region in Second Life encouraged some of the students to explore the region and expect visitors to their own projects.

Within TARGET summer school two virtual seminars were organized, which provided the students with an outlook of the latest trends in the area of CVEs. On the seminars, some recent and current projects were presented, from which the students could learn more about the practical use of the technology. Besides that, the students could experience how the virtual lecturing works in general, its benefits and limitations. Moreover, the summer school attracted some international participants, which resulted in a bigger and more independent audience. Another difference of the study this year was initiation of a prize for the best project.

The introduction of role-playing as a presentation method had also influenced the students' experience, according to their feedbacks. First of all, calling this activity "role-playing" placed more emphasis and improved the general attitude of the students. Although not all the groups did really play roles, the overall quality of the presentations increased. As distinct from last year's presentation, this time none of the groups reported the problem identifying who is presenting. The students prepared scenarios, some wore authentic avatars and many used voice chat in addition to the text. Moreover, the audience was expecting a play and therefore more focused. In many plays, the presenters engaged the audience into the play, which was appreciated both by the visitors and the students.

The VRA helped the students to extend their understanding of cooperation with the CVE technology. Discussing the possibilities and the future of the CVEs in essays, most of the groups mentioned their potential for supporting social networks and collaboration among various groups of people, institutions and countries. Describing scenarios of use for their own constructions, the students often considered them as a part of the Virtual Science Fair that is closely connected to the university and local community.

The 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.

Our observation of the students' work and their feedbacks can be summarized as a set of recommendations for presenting research projects in CVEs. The following recommendations are developed for teachers, instructors and technicians working with the CVE technology.

- Demonstrate the possibilities of the technology, including interactive elements, various types of content and ways of presenting information.

- Provide tutorials introducing technology basics and building resources for composing structures from ready-to use blocks.
- Involve presenters and visitors from different social groups, such as researchers, students, and the general public.
- Support activities in a virtual environment with real-life events or places to attract more visitors for both virtual and real-life environments.

Conceptualizing Virtual Research Arena

The results of the presented study contribute to three major areas that are connected by the VRA: first, collaborative work on 3D content; second, virtual campus as an environment for learning, researching and socializing; and third, virtual city as an environment integrating different aspects of city life. In the following, we attempt to form a concept of VRA out of our observations, experience and case study data.

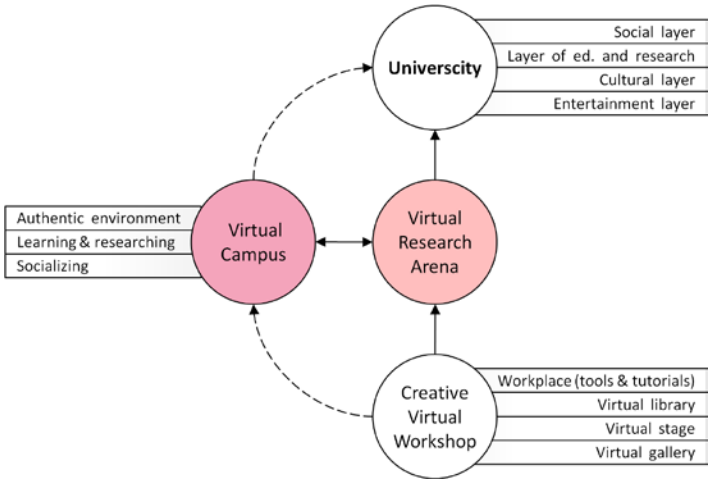

Figure 5. Virtual Research Arena context

Collaborative work on 3D content is the major activity that Virtual Research Arena supports. Tools and features that provide this support within the VRA are designed based on the basic ideas of CVW. The VRA has a virtual workplace equipped with tutorials and tools, providing assistance for control and navigation, communication and work with content. The workplace is linked to a library with ready-to-use 3D objects, textures, scripts and other resources. To provide support for sharing and presenting content, there is a virtual stage (under development), equipped with corresponding facilities, such as a slide-show screen and a place for presenting 3D constructions. The stage is surrounded by a virtual gallery (under development), which contains and exhibits constructions.

Virtual Campus framework was elaborated based on the results of the presented study. The Virtual Campus of NTNU was used as a venue for the study. It provided appealing atmosphere, tools and facilities for seminars, meetings and discussions. Besides that, the campus contains crystallized activities or traces (Wenger, 1998) from past events, creating a cultural component of the environment and a base for further development. In the virtual campus context, the VRA is a place, where students and researchers can try out their ideas, express themselves, create visualizations and exhibit them.

'Universcity' framework was improved based on the results of the study. In the 'Universcity' context, Virtual Research Arena and Virtual Campus are infrastructure elements. They represent the layer of education and research, which is considered for supporting educational/research activities and networks. At the same time, the VRA is connected to all other layers: cultural, social and entertainment. The VRA contributes to the cultural layer by attracting international visitors in the virtual environment and after that perhaps in real life as well. In the virtual city, the research arena is embedded into the architectural/cultural environment and replicates a real place. The VRA contributes to the social layer by connecting research environment and the general public. It allows scientists to present their work to the public, facilitates communication and creates awareness about the local and international research. For many people, visiting events within the VRA is an entertainment, since one of the main goals of the

arena is presenting scientific models and projects in an interesting and engaging way. The results of the study can be generalized and used for designing other infrastructure elements in all the layers.

Conclusions and future work

In this paper we present the results of a case study conducted to evaluate the Virtual Research Arena framework. Conducting events both in the virtual environment and in reality, we collected empirical data and feedbacks from participants, including university students, researchers, and the general public. The results show the potential and possibilities of the VRA for supporting collaborative work with 3D content in the research area. In addition, the experience with developing and studying the VRA contributed to the Virtual Campus and Virtual City frameworks.

Future work will include more studies in the area of collaborative work and learning in 3D CVEs and further development of the Virtual Research Arena framework. We are planning to use the arena more widely in the city life and connecting it more clearly to other 'Universcity' layers. Furthermore, we have in focus strengthening the link between the virtual environment and reality and attracting more participants from various society groups.

References

Arreguin, C. (2007). *Reports from the Field: Second Life Community Convention 2007 Education Track Summary*. New York, USA: Global Kids.

Atkins, C. (2009). Virtual Experience: Observations on Second Life. In Purvis, M. & Savarimuthu, B. (Eds.), *Computer-Mediated Social Networking* (Vol. 5322, pp. 7–17). Berlin / Heidelberg: Springer.

Bessière, K., Ellis, J. B., & Kellogg, W. A. (2009). *Acquiring a professional "second life": problems and prospects for the use of virtual worlds in business*. Paper presented at the 27th CHI International Conference extended abstracts on Human factors in computing systems, Boston, MA, USA, 2883–2898.

Bettger, S. (2008). Nonprofits in Second Life: Promoting Causes Inside Second Life for Real World Impact. Giving Circles Network. Retrieved from http://npsl.wiki.techsoup.org/file/view/Non+Profits+and+Second+Life+Report+1008.pdf

Bowers, K. W., Ragas, M. W., & Neely, J. C. (2009). Assessing the Value of Virtual Worlds for Post-Secondary Instructors: A Survey of Innovators, Early Adopters and the Early Majority in Second Life. *International Journal of Humanities and Social Sciences, 3*(1), 40–50.

Bronack, S., Sanders, R., Cheney, A., Riedl, R., Tashner, J., & Matzen, N. (2008). Presence Pedagogy: Teaching and Learning in a 3D Virtual Immersive World. *International Journal of Teaching and Learning in Higher Education, 20*(1), 59–69.

Campbell, C., & Jones, S. (2008). *Using Second Life as an Educational Instructional Tool with Pre-service Education Students: A Work in Progress*. Paper presented at the 20th World Conference on Educational Multimedia, Hypermedia and Telecommunications (Ed-Media), Vienna, Austria, 3638–3642.

Craciun, D. (2010). Role – playing as a Creative Method in Science Education. *Journal of Science and Arts, 1*(12), 175–182.

Crowther, P. S., & Cox, R. J. (2008). *Building Content in Second Life – Issues Facing Content Creators and Residents*. Paper presented at the 1st International Conference on Computer-Mediated Social Networking (ICCMSN), Dunedin, New Zealand, 28–34.

de Freitas, S., Rebolledo-Mendez, G., Liarokapis, F., Magoulas, G., & Poulovassilis, A. (2009). *Developing an Evaluation Methodology for Immersive Learning Experiences in a Virtual World*. Paper presented at the 1st International Conference in Games and Virtual Worlds for Serious Applications (VS-GAMES), Coventry, UK, 43–50.

Djorgovski, S. G., Hut, P., McMillan, S., Vesperini, E., Knop, R., Farr, W., et al. (2010). Exploring the Use of Virtual Worlds as a Scientific Research Platform: The Meta-Institute for Computational Astrophysics (MICA). In Lehmann-Grube, F. & Sablatnig, J. (Eds.), *Facets of Virtual Environments* (Vol. 33, pp. 29–43): Springer Berlin Heidelberg.

Fominykh, M., Prasolova-Førland, E., Morozov, M., Gerasimov, A., Bellotti, F., De Gloria, A., et al. (2010). *Universcity: Towards a Holistic Approach to Educational Virtual City Design*. Paper presented at the 16th International Conference on Virtual Systems and Multimedia (VSMM), Seoul, Korea, 371–374.

Hwang, J., Park, H., Cha, J., & Shin, B. (2008). *Effects of Object Building Activities in Second Life on Players' Spatial Reasoning*. Paper presented at the 2nd International Conference on Digital Game and Intelligent Toy Enhanced Learning, Banff, Canada, 62–69.

Kelton, A. J. (2007). Second Life: Reaching into the Virtual World for Real-World Learning. *ECAR Research Bulletin, 2007*(17).

McSharry, G., & Jones, S. (2000). Role-Play in Science Teaching and Learning. *School Science Review, 82*(298), 73–82.

Papert, S., & Harel, I. (1991). Situating Constructionism. In Papert, S. & Harel, I. (Eds.), *Constructionism*. Westport, CT, USA: Ablex Publishing Corporation.

Park, S., Hwang, H. S., & Choi, M. (2009). *The Experience of Presence in 3D Web Environment: An Analysis of Korean Second Life*. Paper presented at the 13th International Conference on Human-Computer Interaction. Part IV: Interacting in Various Application Domains, San Diego, CA, USA, 387–395.

Prasolova-Førland, E., Fominykh, M., & Wyeld, T. G. (2010a). *Virtual Campus of NTNU as a place for 3D Educational Visualizations*. Paper presented at the 1st Global Conference on Learning and Technology (Global Learn Asia Pacific), Penang, Malaysia, 3593–3600.

Prasolova-Førland, E., Fominykh, M., & Wyeld, T. G. (2010b). *Working on Educational Content in 3D Collaborative Virtual Environments: Challenges and Implications*. Paper presented at the 13th International Conference on Computers and Advanced Technologies in Education (CATE), Maui, Hawaii, USA, 183–190.

Prasolova-Førland, E., Sourin, A., & Sourina, O. (2006). Cybercampuses: design issues and future directions. *Visual Computer, 22*(12), 1015–1028.

Sant, T. (2009). Performance in Second Life: some possibilities for learning and teaching. In Molka-Danielsen, J. & Deutschmann, M. (Eds.), *Learning and Teaching in the Virtual World of Second Life* (pp. 145–166). Trondheim: Tapir Academic Press.

van Nederveen, S. (2007). *Collaborative Design in Second Life*. Paper presented at the 2nd International Conference World of Construction Project Management, The Netherlands, 1–6.

Vygotsky, L. S. (1978). *Mind in society: the development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. New York/Cambridge: Cambridge University Press.

Wyeld, T. G., & Prasolova-Førland, E. (2006). *Online 3D CVE performance of T.S. Elliot's coctail party: an example of virtual stage*. Paper presented at the 5th International Conference on Web-Based Education (WBE), Puerto Vallarta, Mexico, 31–36.

Yankelovich, N., & Kaplan, J. (2008). *Improving Virtual World Presentations*. Paper presented at the Computer Supported Collaborative Work (CSCW), Virtual Worlds, Collaboration, and Workplace Productivity Workshop, San Diego, CA, USA.

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