This is a preprint of the paper to be presented at the First KES International Conference on Smart Technology based Education and Training (STET), Chania, Greece, June 18–20, 2014.

Facilitating Creative Collaborative Activities with Dedicated Tools in a 3D Virtual World

Mikhail FOMINYKH [a], Ekaterina PRASOLOVA-FØRLAND [a], Mikhail MOROZOV [b], Andrey SMORKALOV [b], and Monica DIVITINI [c]

[a] *Program for Learning with ICT, Norwegian University of Science and Technology, Norway*
[b] *Multimedia System Laboratory, Volga State University of Technology, Russia*
[c] *Department of Computer and Information Science, Norwegian University of Science and Technology, Norway*

Abstract. In this paper, we present the results of a preliminary exploratory study that is aiming at exploring the means for facilitating creative collaborative activities in educational context. We argue that 3D virtual worlds can be successfully used for facilitating such activities. The goal of this preliminary study was to evaluate several features and use the results as an input for the future studies. We conducted test collaborative sessions in 3D virtual worlds and several other sessions in a classroom that we used as points of reference for comparison. The data were collected from the direct observation, 3D virtual recordings, and individual and group text assignments. The analysis of the data allowed us to formulate a set of advantages and limitations of 3D virtual worlds for supporting creative collaborative process against the face-to-face settings.

Keywords. 3D virtual worlds, creativity, collaboration, vAcademia

Introduction

Creative collaborative activities, such as brainstorming, round-table discussions, and project work are becoming increasingly common in both the university education and in the industry. Such activities usually require proper facilitation, as cooperation problems among the students are rather common and often lead to frustration and disruptions in the learning process [1, 2]. More and more often creative collaborative activities are conducted remotely using various technologies.

Three-dimensional Virtual Environments and Social Virtual Worlds (3D VWs) have been employed for supporting such activities. This technology provide a unique set of features that can be used for learning, such as low cost and high safety, 3D representation of learners and objects, interaction in simulated contexts with high immersion [3, 4]. However, despite the repeated positive conclusions, 3D VWs have not become as widely used as other technologies in education. Many researchers often report that their studies still have experimental nature. At the same time, the technology is constantly improving, thus new scenarios should be explored and new methodologies developed to make 3D VWs more convenient for students and educators.

In this paper, we focus on learning scenarios that involve creative collaboration. We explore new ways of facilitating such activities with dedicated tools in a 3D VW. We argue that 3D VWs can be successfully used for this purpose and can potentially be superior to the commonly used technologies. We present a preliminary study that was conducted within Cooperation Technology and Social Media course at the Norwegian University of Science and Technology. We conducted few test collaborative sessions in a 3D VW and several other sessions that we used as points of reference for comparison. Based on the data we collected, we formulated a set of advantages and limitations for supporting creative collaborative activities in 3D VWs. In addition, we outlined directions for the future studies.

1. Background and Related Work

1.1. Why Supporting Creative Collaborative Activities Using Natural 3D Navigation?

Creative collaborative activities are generally hard to support using technology, especially for the remote participants. Such activities often require large amounts of textual and graphical information that needs to be on the user's display at a time. This may include constructed shared artefacts and supportive materials, communication and coordination means, and awareness indicators. Such activities are typical for collaborative learning approaches, for example, social constructivism [5]. However, in practice software limitations do not allow implementing them to the full extent on either 2D web-conferencing (webinar) platforms or in 3D VWs.

Modern web-conferencing platforms provide a shared workspace, means for content presentation, and various forms of interaction (see, e.g., [6, 7]). However, it should be noted that in most cases, a passive learning approach is used when the information (e.g., a lecture or a presentation) is delivered. This technology allows interaction (e.g., questions, comments, and discussion) and collaboration (e.g., mind-mapping, posting notes on slides, and using a shared workspace), but a single screen (with the content provided by the teacher) is usually used. The example of using breakout rooms illustrates synchronous collaborative activities in web-conferencing platforms, "allowing small groups to undertake tasks and bring outputs back to a plenary full group discussion" [8]. In this case, each group of learners still works with a single shared workspace/screen, and the results are discussed one by one.

The implementation of such scenarios in 2D does not require large amounts of textual and graphical information on the user's display. The reason, however, is not the lack of demand, but, most likely, the technological limitations. When a creative collaborative scenario requires displaying multiple workspaces side by side, they can be located as tiles, but even with a large monitor, this approach is rarely convenient. A video wall could be a good solution, but this technology is usually not affordable. Alternatively, multiple workspaces can be set to different sizes (e.g., a teacher can enlarge them when required [9]).

3D VWs allow building learning environments that can accommodate multiple workspaces or virtual screens and convenient switching between different points of view (i.e. observing multiple screens at the same time or focusing on one). Therefore, when the passive learning approach is implemented in a 3D VW, the display does not need to be split into sections. Instead, natural 3D navigation or camera navigation and zoom are used. This allows using multiple virtual screens, for example, one with presentation slides, another with video or text notes. These affordances of the 3D space allow implementing active teaching methods too, providing each user with personal virtual screen or each group with multiple screens.

However, in practice, existing 3D VWs allow using very limited numbers of virtual workspaces for collaboration on graphical content. For example, an environment may accommodate 2–5 virtual screens within the visibility area. This allows conducting several types of educational activities, including lectures and presentations. However, conducting activities that require active creative collaborative work with media content remains problematic. Another common practice is creating many screens with static images. This allows using virtual galleries which can be explored collaboratively and discussed by a group of learners, but without active involvement in creating or modifying the content displayed. In such a way, the possibilities for conducting educational activities are also limited.

Many 3D VWs offer the "virtual screen" functionality. The simulation of virtual sticky notes on such screens is considered an effective and advanced tool. Generally, the features of the virtual screens often have inferior implementation because of performance limitations related to the use of CPU for processing images. The functionality of the sticky notes is often affected by these limitations. For example, the 3D VW "Sametime 3D" built on Open Simulator platform has a tool for working with sticky notes. However, the notes can only be placed on special square slots, their size is constant, and there is no possibility to use any other tools on the same screen (e.g., drawing). These limitations obstruct the effective use of the tool. Another example is the IBM virtual brainstorming studio built in Second Life. In this implementation, the sticky notes can also be placed only on square slots, and the screens are dedicated to the notes only [10].

1.2. Why Supporting Creative Collaborative Activities Needs Dedicated Tools?

One of the most serious challenges in adapting 3D VWs for learning is the lack of features that educators use in everyday teaching: "Most virtual worlds were not created for educational purposes. Second Life, nonetheless, is being adapted by educators […]. Many of the features educators take for granted in Learning Management Systems do not exist in Second Life" [11]. There is a belief among educators that the 3D VWs should be better used for simulating situations that are difficult or impossible to implement in reality, and not replicating the real-world educational structures [12]. However, the absence (or inaccessibility) of familiar and convenient learning tools in the 3D VWs is also contributing to the general attitude towards the technology.

Therefore, dedicated tools for supporting learning in general and/or specific learning activities in 3D VWs can make this technology much more accessible and decrease the amount of time that is required to design a course or a learning session.

2. Study Design

2.1. Study Settings

The study is based on the data collected during the Cooperation Technology and Social Media course at our university in autumn 2013. The number of participants varied in each of the course activities, but we used data from 40 students who completed the course. They were working in small groups (3–5 students in each) on a group project (counting for 70% of the final grade). In addition, they submitted a final individual essay counted for 30% of the final grading. Lectures were used for introducing core concepts and basic knowledge to be used and extended in the group project.

The group project consisted of one major and some axillary task. We applied a teaching approach that combines knowledge construction and reflection [13]. Following a *social constructivist approach* [5], the main task was designed to promote the collaborative construction of new knowledge on cooperation technology. We applied a game design based learning approach and gave the students a task to design an educational game about cooperation and develop a prototype. The task was designed to require different forms of cooperation, either face-to-face or mediated by technology. In this way, students gained first-hand experience of cooperation and learnt how technology can promote or hinder it. Following the *reflective learning approach* [14], we aimed at promoting rethinking of this experience to learn from it. To this aim, each student group had to deliver reflection notes. A template was provided for the notes to scaffold the reflection process, pointing out specific issues to consider, e.g. the flow of work during the task and how it was affected by the technology used, how different technology influenced cooperation, and creativity in the process. The notes were written collaboratively in groups, so that the students had to discuss their experience.

The course included several creative collaborative activities that are used as the primary source of data for the study presented in this paper. One of the lectures was given in our virtual campus in Second Life [15]. Another one was conducted in the 3D virtual world of vAcademia [16]. On the early stage of the course, the students were gathered in a classroom for a brainstorming session in a face-to-face setting to generate and discuss ideas for their course projects. Later, we conducted three seminars (different from lectures), where the student groups explored projects from the previous generations of students and presented the status of their projects. One of these seminars was conducted in a classroom, another one – in Second Life, and the last one in vAcademia. In such a way, we conducted similar activities in vAcademia, Second Life, and in face-to-face settings.

2.2. Technology

In this study, we used a 3D VW vAcademia, as it is designed for learning and has a set of dedicated tools for supporting several types of collaborative activities. In this section, we will briefly present some of vAcademia tools that we used in the study we present.

The most distinctive feature of vAcademia is 3D recording, which allows capturing everything in a given location in the VW in process, including positions of the objects, appearance and movement of the avatars, contents on the whiteboards, text and voice chat messages. Similar functionalities were realized earlier in few VWs or desktop virtual reality systems. However, 3D recording was never developed into a convenient tool and never adopted for specific use as in vAcademia. In addition, no convenient tools for working with the resultant recordings were developed [16].

Interactive virtual whiteboard (VWB) is the main tool (or a container of tools) for collaborative work on 2D graphical content in vAcademia [17]. Multiple VWBs of different sizes can be set up in any location of vAcademia (Fig. 1). In addition, every participant can set up an extra VWB during a class and present some content on it. Multiple users can stream or share their content simultaneously by simple mechanisms such as drag-and-drop [18]. A colored laser pointer can be used for focusing attention on a certain element of the board. Additional auxiliary mechanisms allow user to switch between the displayed data for better overview. VWBs of different sizes and designs are stored in the Object Gallery and available for every user. User-created whiteboards are put on the ground, but can be moved and rotated.

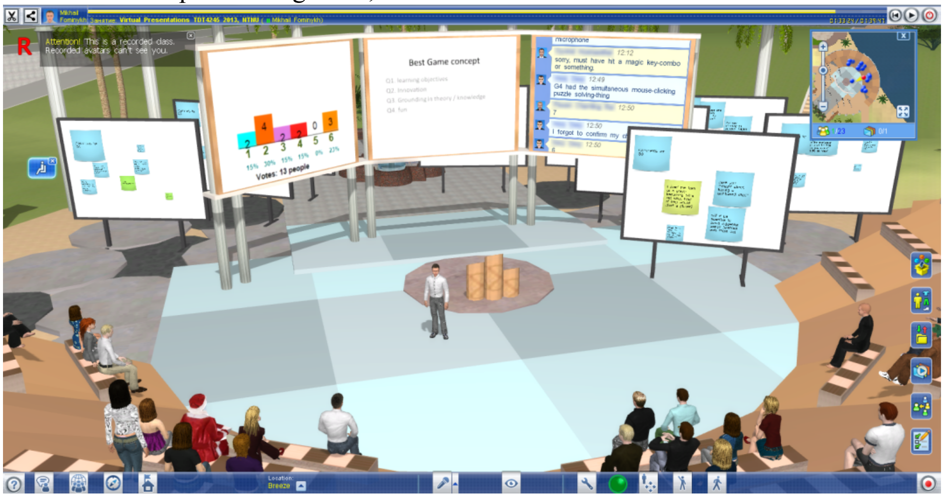

Figure 1. Virtual seminar in vAcademia

During the sessions in vAcademia, we used multiple VWBs for displaying slides, sharing the desktop, sharing the application that runs on the teacher's or student's computer, sharing the web camera, drawing figures, typing text, displaying backchannel, posting sticky notes (Fig. 1), and posting results of voting for the best presentation. All vAcademia sessions were recorded and available for revisiting. In comparison to the regular presentations with slideshows, we used tools that supported creative process as well as enabled reflection through the 3D virtual recording.

2.3. Data Collection and Analysis

The data were collected from the direct observation of students' activities online, the 3D virtual recordings of the test activities in vAcademia, and the semi-structured feedback in the form of group reflective notes (written with templates provided by teachers on different stages) and individual essays (contained discussions on advantages and limitations of 3D VWs for creativity support). Reviewing the 3D virtual recording, we were able to reproduce the activity as it was live and do the observation again, paying attention to different details.

For analyzing the data from the reflective notes and individual essays, we use the constant comparative method [19]. We applied coding to identify the major themes and triangulated them with the direct observations done by the course staff and with the outcomes of the student projects. We used some “priori codes” [20] on the first stage and then a technique close to “cutting and sorting” [21] for identifying the themes. In this paper, we present the results we acquired from analyzing two major themes: advantages or 3D VWs for creative collaboration and their limitations. Most of the students discussed these themes in their individual essays, comparing their experience in 3D VWs against the face-to-face mode. We sorted all mentioned advantages and disadvantages into categories, including those of the dedicated tools that we used in vAcademia. Analyzing the contents of this category, we evaluated the usefulness of the tools. Finally, we used the relevant codes in the group reflection notes for triangulation.

3. Results and Discussion

In this section, we present the data as lists of the main advantages and disadvantages of 3D VWs for supporting creative collaborative process. We provide citations to illustrate the data for each category.

Awareness and Presence. Several students reflected on the convenience of 3D space for awareness. A part of the discussions was related to working on a project in 3D (two groups chosen 3D platforms for designing game prototypes): “*When building mazes or puzzles […], each group member will control a [Minecraft] Avatar. This makes it easy to see what part of the game each member is working on, as the others can see their movement and object placement in real time”*.

Another part of the feedback on awareness was related to the spatial awareness and presence. Reflecting on their experience from the virtual seminars, many students mentioned vAcademia tools, especially the virtual laser pointer that was often used to direct attention of the audience to a specific place in the environment or on a VWB: “*vAcademia has also a pointer tool where you can show […] what you are looking at. It could be useful in a creative process if diagram and large table are used”*.

Leaving Traces for Later Reference and Structuring Communication. Capturing traces of activities through vAcademia’s 3D recording was one of the most popular student comments. Often, when comparing 3D recording to the real-world activities, the students noted that activities and ideas could be captured automatically and special recording equipment in not required in a 3D VW: “*In a Face-to-Face world, we are used to write ideas on a board so that to keep a trace of the brainstorming […]. With virtual worlds, it’s easy to store the brainstorming (i.e. Virtual Academia). Thus, generated ideas can be reused”*. Several students devoted their attention to the fact that 3D VWs allow efficient coordination and structuring communications. The most common arguments were related to spatial organization of activities and managing groups: “*In [3D VWs] users can write to a specific group (i.e. a single person or a whole class), and voice chat cover- age can be limited by area or person parameters. This potentially complex activity structuring would be harder to conduct in face-to-face communication activities, requiring groups to be situated in different areas or rooms to achieve the same structure*”.

Co-construction, Direct Experimentation and Brainstorming. Several students appreciated creativity support in 3D VWs. Co-constructing virtual objects was seen as a way of expressing ideas and even brainstorming: “*Users can describe things more specific by building objects. If used correctly, large-group brainstorming can lead to higher performance than nominal group”*.

Direct experimentation and testing during the development of the projects was seen as an advantage for collaboration too: "*Controlling avatars similar to those that will be used playing the game makes testing as we develop easy. Two developers can quickly meet up at a puzzle and test whether it works as intended"*.

Exploration and Inspiration. The technology of 3D VWs (not game, but social/serious worlds) was new to most of the students. As participating in a new type of activities, some students reported that the experience was unusual and interesting and that it brought new ideas: "*Experience of virtual classroom on vAcademia and Second Life eliminated our concern on game prototype implementation and thus generated more ideas which were based on virtual platform*". Few students stated that they acquired their best ideas for the projects during virtual sessions in 3D VWs: "*Our game idea came after we had the virtual lecture in second life where someone had built a maze that was used in a game to learn about cooperation. After seeing that maze we thought it could be interesting to make something similar"*.

Anonymity and Self-expression. Most of the students considered anonymity of the 3D VWs as an important advantage for the success of the creative activities. According to the student feedback, expressing ideas and providing feedback is easier in the 3D VW than in a classroom. Many of them reflected on their own experience: "*[In face-to-face…], the brainstorming was led by a small group of people who were more at ease to speak within a group. […] When we have used virtual world, […] people were more willing to give their ideas"*.

Even though the lack of body language was often mentioned as a limitation of 3D VWs, there were discussions that having complete control over your gestures (and time to think before you commit them) might be an advantage for a creative collaborative process: *"[Creative collaboration in 3D VWs] may lead to easier sharing of ideas since there are no immediately visible "gut reactions" via body language*".

Lack of Subtle Communication Cues. The inability of using body language as easy as in real world was the most popular limitation of 3D VWs for supporting creative collaboration. Most of the students described the use of body language and direct eye contact as vital for mediating ideas and sharing understanding: *"[…] in a Face-to-Face environment, the body language and the expression of other people are determinant to establish a good communication. Also, in a Face-2- face environment it's easy to see [if] our interlocutor are listening or understanding […]. Through an avatar, this is not possible. This could lead to a lack of information"*.

Generally, even though the voice communication is available in the modern 3D VWs (and it was used in the virtual seminars we organized along with several text-based means), the students tended to see the available set of communication means as limited and somewhat rough: *"The counterpart of the chat is that it is a brut way of explain something. I mean that for the reader, something said in the chat, could feel like a truth or a statement that cannot be revisited"*.

Distraction and Information Overload. Many students discussed various factors that can distract the creative collaborative processes in 3D VWs. For example, the relative complexity of the technology was seen as something that diverts the attention of the participants away from the creative process: *"The technological aspects of [3D VWs] require some attention in the beginning, and take some time getting used to. My belief is that collaboration might happen more fluidly after having "learnt" the technology properly"*. Another common feedback is related to the novelty of the technology. Some places or features of a 3D VW can be interesting and fun to explore, and therefore, they often draw the focus of the participants: "*Even though some social* *conventions apply, one cannot expect all participants at all times to be focused and not fool around […]. It seems that users of virtual academia/second life, especially those that are new to the software, can easily get distracted*".

Information overload was also named among the distracting factors. Few students referred to the combination of tools we used during the virtual seminars as it provided too many information sources, and therefore was distracting: *"Having to follow many streams of information may distract from creative process"*.

Low Accessibility. 3D VWs are generally known to be less accessible than e.g., web-based environments. At the same time, few students have considered it as a serious barrier for creativity: "*One drawback of [3D VWs] is the fact that all the ideas must be taken during the virtual meeting. […] Indeed, it's common in companies to have ideas at any time of the day […].This face-to-face interaction is not possible in [3D VWs]. From this point of view, [3D VWs are] a brake for creativity*".

Very often, the students discussed other general advantages and limitations of 3D VWs (not necessarily related to creative collaboration). Such advantages included the possibility for remote collaboration, dynamic facilitation of workspaces, and natural navigation. The most commonly discussed general limitations of 3D VWs were technological issues, unfamiliarity with the technology, and the requirement of faster than average network connection.

Face-to-face Format Summary. As the results were presented from the point of view of 3D VWs, we would like to summarize the major advantages and limitations that the students considered for the face-to-face format. The main three advantages are:

- Social contact, being friends, getting to know each other
- Feedback through body language, acceptance of ideas
- Easy to communicate and learn from each other

The three major disadvantages of conducting creative collaborative activities in face-to-face against the 3D VWs are:

- Social conformity, difficult to say and criticize ideas
- Power issues, extraverts vs introverts
- Social inhibitions, the role of a leader

4. Conclusion and Future Work

In this study, we have explored the advantages and disadvantages of 3D VWs in comparison to face-to-dace communication. In particular, we explored supporting creative collaborative activities in 3D VWs of vAcademia and Second Life. When discussing advantages, we have identified the following major categories (including both general features for 3D VWs and dedicated tools in vAcademia):

- Supporting sense of presence and workspace awareness
  - By avatars, their actions and positions
  - Awareness of activities by traces and changes left in the environments (such as constructions raised)
  - Dedicated tools in vAcademia: pointing tool, chat, and IM
- Brainstorming and structuring communication
  - Brainstorming through different channels: 3D building, voice, chat, leaving traces, visualized 3D brainstorming

    - Structuring communication through designated chat channels and places for 3D objects
    - Dedicated tools in vAcademia: Sticky Notes and Backchannel tools
- 3D environment as a source of inspiration
    - The overall atmosphere
    - Existing constructions and facilities, e.g. previous students' constructions, classrooms, and live sessions
    - Constructing designated environment to support creativity
    - vAcademia tools: pre-made classrooms and meeting areas, 3D recording
- Supporting uninhibited communication
    - More inhibited communication and expression of ideas, due to 'anonymization' and limited influence of groupthink and social press
    - Meeting facilities for communication across distances and brainstorming
    - Dedicated tools in vAcademia: meeting facilities with VWBs and chat
- Leaving traces, co-constructing, and experimenting in the 3D environment
    - Leaving contextualized 3D objects, notes and other traces
    - Recording discussion and brainstorming sessions for later reference
    - Creating 3D constructions and visualize ideas, also for later reference
    - Experimenting by role playing and direct manipulation
    - vAcademia facilities: 3D recording, user objects, modifying locations

At the same time, we have identified following limitations:

- General technical issues
    - High resource demand (Network, graphics, etc.)
    - Time and resource consuming construction/brainstorming
- Complexity
    - Unfamiliarity hinders creativity
    - Information overload is distracting
    - Navigation might be confusing and hinder creativity
- Communication problems
    - Lacking subtle communication cues (mimics and body language)
    - Problems with voice communication
    - Asynchronous brainstorming is not intuitive

In the future, we plan to work further on exploring and developing mechanisms in 3D VWs for creativity support. In particular, we suggest the following directions for improvement of vAcademia to overcome the identified limitations (also following direct recommendations from the students):

- Developing text-based mobile apps integrated with the virtual environments to be used in situations with low internet access, 'on the go' etc.
- Supplementing vAcademia with Virtual Reality components (such as head-mounted display) to ease navigation and increase user-friendliness
- Improving the Sticky Notes tool for asynchronous communication and generally making leaving traces easier, introduction of inventory facilities
- Further developing avatar facilities in terms of improved gestures and ways of displaying workspace awareness

References

[1] P. Anisetty and P. Young, "Collaboration problems in conducting a group project in a software engineering course," *Journal of Computing Sciences in Colleges,* vol. 26(5), 2011, pp. 45–52.

[2] L. Shuangyan, M. Joy, and N. Griffiths, "Students' Perceptions of the Factors Leading to Unsuccessful Group Collaboration," in *10th International Conference on Advanced Learning Technologies (ICALT)*, Sousse, Tunisia, 2010, pp. 565–569, doi:10.1109/ICALT.2010.161.

[3] C. Dede, "Immersive Interfaces for Engagement and Learning," *Science,* vol. 323(5910), 2009, pp. 66–69, doi:10.1126/science.1167311.

[4] R. Mckerlich, M. Riis, T. Anderson, and B. Eastman, "Student Perceptions of Teaching Presence, Social Presence, and Cognitive Presence in a Virtual World," *Journal of Online Learning and Teaching,* vol. 7(3), 2011, pp. 324–336.

[5] L. S. Vygotsky, *Mind in society: the development of higher psychological processes*. Cambridge, MA, USA: Harvard University Press, 1978.

[6] A. Mavridis, T. Tsiatsos, and S. Tegos, "Exploiting Web Conferencing to Support Collaborative Learning," in *15th Panhellenic Conference on Informatics (PCI)*, Kastoria, Greece, 2011, pp. 78–82, doi:10.1109/PCI.2011.26.

[7] K. Kear, F. Chetwynd, J. Williams, and H. Donelan, "Web conferencing for synchronous online tutorials: Perspectives of tutors using a new medium," *Computers & Education,* vol. 58(3), 2012, pp. 953–963, doi:10.1016/j.compedu.2011.10.015.

[8] S. Cornelius and C. Gordon, "Facilitating learning with web conferencing recommendations based on learners' experiences," *Education and Information Technologies,* vol. 18(2), 2013/06/01 2013, pp. 275–285, doi:10.1007/s10639-012-9241-9.

[9] D. Gronn, G. Romeo, S. McNamara, and Y. H. Teo, "Web conferencing of pre-service teachers' practicum in remote schools," *Journal of Technology and Teacher Education,* vol. 21(2), 2013, pp. 247–271.

[10] M. Dodgson, D. M. Gann, and N. Phillips, "Organizational Learning and the Technology of Foolishness: The Case of Virtual Worlds at IBM," *Organization Science,* vol. 24(5), Sep–Oct 2013, pp. 1358–1376, doi:DOI 10.1287/orsc.1120.0807.

[11] S. Kluge and E. Riley, "Teaching in Virtual Worlds: Opportunities and Challenges," *The Journal of Issues in Informing Science and Information Technology,* vol. 5(1), 2008, pp. 127–135.

[12] P. Twining, "Exploring the Educational Potential of Virtual Worlds – Some Reflections from the SPP," *British Journal of Educational Technology,* vol. 40(3), 2009, pp. 496–514, doi:10.1111/j.1467-8535.2009.00963.x.

[13] M. Fominykh, E. Prasolova-Forland, M. Divitini, and S. A. Petersen, "Hands-on learning of Cooperation Technology: Combining knowledge construction and reflection," in *International Conference on Teaching, Assessment and Learning for Engineering (TALE)*, Bali, Indonesia, 2013, pp. 213–218, doi:10.1109/TALE.2013.6654431.

[14] D. Boud, R. Keogh, and D. Walker, "Reflection: Turning Experience into Learning," London: Kogan Page, 1985.

[15] M. Fominykh, E. Prasolova-Førland, and M. Divitini, "Creative Collaboration in a 3D Virtual World Conducting Educational Activities, Designing Environments, and Preserving Results," in *Digital Systems for Open Access to Formal and Informal Learning*, D. G. Sampson, D. Ifenthaler, M. Spector, and P. Isaias, Eds.: Springer, 2014.

[16] M. Morozov, A. Gerasimov, M. Fominykh, and A. Smorkalov, "Asynchronous Immersive Classes in a 3D Virtual World: Extended Description of vAcademia," in *Transactions on Computational Science XVIII.* vol. 7848, M. Gavrilova, C. J. K. Tan, and A. Kuijper, Eds.: Springer Berlin Heidelberg, 2013, pp. 81–100, doi:10.1007/978-3-642-38803-3_5.

[17] A. Smorkalov, M. Fominykh, and M. Morozov, "Stream Processors Texture Generation Model for 3D Virtual Worlds: Learning Tools in vAcademia," in *9th International Symposium on Multimedia (ISM)*, Anaheim, CA, USA, 2013, pp. 17–24, doi:17 10.1109/ISM.2013.13.

[18] A. Smorkalov, M. Fominykh, and M. Morozov, "Collaborative Work with Large Amount of Graphical Content in a 3D Virtual World: Evaluation of Learning Tools in vAcademia," in *16th International Conference on Interactive Collaborative Learning (ICL)*, Kazan, Russia, 2013, pp. 303–312, doi:10.1109/ICL.2013.6644587.

[19] B. G. Glaser, "The Constant Comparative Method of Qualitative Analysis," *Social Problems,* vol. 12(4), 1965, pp. 436–445.

[20] G. R. Gibbs, *Analysing Qualitative Data*. London, UK: SAGE Publications, 2008.

[21] G. W. Ryan and H. R. Bernard, "Techniques to Identify Themes," *Field Methods,* vol. 15(1), February 2003 2003, pp. 85–109, doi:10.1177/1525822X02239569.