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vAcademia – Educational Virtual World with 3D Recording

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Abstract—**In this paper, we present a new approach to educational activities in 3D virtual worlds. This approach is based on a new vision of content and learning process in virtual worlds and related to a new platform called vAcademia. This virtual world is designed and developed specially for educational purposes, and it has an integrated set of tools for a number of learning activities. The main original feature of vAcademia is 3D recording, which allows capturing dynamically everything in a given location in the virtual world. A 3D recording looks like a live virtual class providing students with a collaboration space and giving a sense of presence. In such a manner, vAcademia supports a new type of digital content – 3D recording or virtcast, which is created based on synchronous activities and opens new possibilities to explore. In this paper, we present the functionality, scenarios of use, and challenges of the educational virtual world vAcademia.**

Keywords-3D recording; vAcademia; learning in virtual worlds; virtcast

I. INTRODUCTION

Many studies report the potential of 3D virtual worlds for educational activities [1]. There are a number of cases in which this technology can benefit educational process. Most of them are considered to exploit advantages of the 3D virtual worlds, such as low cost and high safety, three-dimensional representation of learners and objects, interaction in simulated contexts with a sense of presence [2]. However, there are a number of challenges in applying this technology for learning.

Despite the demand and interest from educators, in most cases, 3D virtual worlds are adopted for educational purposes, but not specially created for them [3]. Cooperation and co-construction in 3D virtual worlds is a complex task, it needs to be supported and requires additional tools [2]. The design of environments or 'learning spaces' within 3D virtual worlds is considered to be important, however, there are no strong guidelines [4]. In addition, 3D virtual worlds are mostly used for synchronous activities and lack support for learning in the asynchronous mode.

In this paper, we present a new vision and approach to educational activities and content in 3D virtual worlds. This approach is based on an original technological feature – 3D recording, which allows creating a new type of content that comprises both space and time. This type of content can be called 'virtcast' – a 3D recording of activities in virtual reality or a series of such recordings.

Traditional learning approaches require resources, such as teacher time, textbooks, and auditoriums. However, in traditional learning there are little problems with creating content. The product of traditional learning is a live synchronous face-to-face class. Countless classes are conducted in universities and companies all the time, but, unfortunately, most of the classes disappear after ending and nobody can come back to an interesting lecture, seminar or presentation. The information and experience created by the participants disappear as well.

E-Learning offers some technologies for getting content out of traditional classes, such as video recording of face-to-face lectures or recording 'webinars'. These methods allow creating, quite easily, cheap educational content for asynchronous learning [5, 6]. However, video lectures and 'webinars' change the context of learning. These technologies do not provide a sense of presence, a possibility for collaborative work or a method for further developing the content, except for commenting and annotating it.

Virtual worlds are also used for generating educational content. Even though this technology allows creating full context of the real-life educational process, it is usually recorded as flat 2D video, which eliminates many advantages of the technology, such as sense of presence [7]. As of now, though, there are no systematic approaches for combining synchronous and asynchronous learning paradigms [8].

In contrast, 3D recording in virtual worlds allows capturing and saving all educational information together with the context. It allows the students to come back into an immersive environment with more participants, experience the class like a live event, and continue the discussion in both synchronous and asynchronous modes. Using 3D recording, the students can refine acquired knowledge through discussions. In such a way, the approach combines rich interactivity of the 3D space and convenience of the video.

Besides that, in practice, 3D recording of classes in virtual worlds can provide an unlimited source of educational content. The educators receive a technology that allows quick and cheap creation of advanced content.

II. Related Work

The demand for methods supporting asynchronous activities in virtual worlds and creating content out of synchronous activities was acknowledged as early as in the late 90s, e.g. by developers of CAVE and MASSIVE virtual worlds. MASSIVE-3 supported a mechanism called ‘temporal links’, which allowed “real-time virtual environments to be linked to recordings of prior virtual environments so that the two appear to be overlaid” [9]. CAVERN soft system had an application called Vmail which supported recording of an avatar’s gestures and audio together with surrounding environment [10].

Another example is the system called Asynchronous Virtual Classroom or AVC. The developers were focused on solving the problem of time-sharing in distance learning. AVC allowed learners to watch a video image of a certain lecture and to control it, while software agents were playing some of the displayed participants and created a presence effect [11].

Later, N*Vector (Networked Virtual Environment Collaboration Trans-Oceanic Research) project was focused on developing a virtual reality technology for overcoming time-zone differences and time management problems. Within the project, there were developed three approaches to support annotations for asynchronous collaboration in virtual reality. These approaches included: VR-annotator – an annotation tool that allows collaborators to attach 3D VR recordings to objects; VR-mail – an email system built to work entirely in virtual reality; VR-vcr – a streaming recorder to record all transactions that occur in a collaborative session [12].

Educational process is not usually limited with activities in a 3D virtual environment. It requires a web-based complement, since in some cases a web-tool is preferable, especially in organization and management. There exists a significant demand for integrating virtual worlds with web-based learning systems [13]. There were attempts at integrating a web-support for educational process conducted primary in a virtual world. A well-known example is Sloodle – a free and open source project which integrates the multi-user virtual environments of Second Life and/or OpenSim with the Moodle learning-management system.

III. Virtual Academia

Virtual Academia (vAcademia) is an educational 3D virtual world developed by Virtual Spaces LLC in cooperation with the Multimedia System Laboratory at the Mari State Technical University, Russia. The system is currently under beta testing and free to use, however, it is planned to be commercialized.

A. *Functionality of the 3D Virtual World: 3D Recording*

Among all the other features of the vAcademia virtual world, one is truly original. This feature is called 3D recording and allows to dynamically capture everything in a given location, including positions of the objects, appearance and movement of the avatars, contents on the whiteboards, text and voice chat messages. In addition, the platform offers convenient tools for working with the resultant recordings.

3D recording of classes allows getting a new type of learning content and applying new types of activities. A user can attend and work at a recorded class, not just view it as a spectator. In addition, any recorded classes can be attended by a group of users. A new group can work within a recorded class and record it again, but with their participation. Thus, there is an opportunity to build up content of recorded classes and layer realities on top of each other. In addition, 3D recordings in vAcademia are user-generated content, since the process of their creation is fully automated and simple.

Figure 1. 3D recording in vAcademia

From the user point of view, 3D recording control is very similar to the regular video player (Fig. 1). A 3D recording can be fast-forwarded and rewound, paused and played again from any point of time. A replayed 3D recording looks exactly like a real class. Of cause, the recorded avatars will always behave the way they were recorded. However, it is possible to use all the functionality of the virtual world inside a recording. Moreover, a replayed 3D recording can be recorded again together with new actions. In such a way, new recordings and new content can be created based on the same event.

Some of the 3D recordings (for example, the most interesting ones) can be made ‘periodical’ and replayed constantly in the locations. This feature makes it possible to create a better atmosphere in the virtual world, since a visitor of vAcademia does not observe empty constructions, which often happens in other virtual worlds. Instead, the visitors can explore some of the classes going on with teachers and students involved. This might attract their attention and trigger curiosity.

B. *Functionality of the 3D Virtual World: Teaching Tools*

Other vAcademia features include a set of teaching tools for collaborative learning. These tools ease the teachers’ work, so they do not need to search for an opportunity to bring learning tools into the virtual world, they are already built in. The following teaching tools are available:

- *Interactive whiteboards* can be used for displaying and annotating slides, sharing the desktop, sharing the application that runs on the teacher's or student's computer, sharing the web camera, and pasting text or graphics from the buffer. Multiple whiteboards of different sizes can be used in any classes, and users can focus their view on them, by special controls. In addition, every participant can set up an extra whiteboard during the class and present some content on it. A colored pointer can be used for focusing attention on a certain element of the board.
- *Drawing panel* replaces the traditional physical whiteboard. When this panel is used together with a graphic tablet, it allows a teacher to make handwritten notes on a board.
- The polling and voting tool called *Clicker* allows conducting quizzes based on single-choice or multiple-choice tests. In addition, the tool allows displaying the results immediately on any interactive whiteboard in the form of several types of diagrams.
- *Class Control* tool gives a teacher the ability to control students' access to the interactive whiteboards, ability to use their microphones, and ability to use virtual laser pointers. In addition, this tool allows the teacher to expel a disturbing student or a stranger.
- *Notes* allow enhancing classes and 3D recordings with additional information. vAcademia supports three types of notes: textual, graphical, and sound. A note may be posted on any object in the 3D world, during a live class or in a 3D recording. In addition, users post comments to any note.
- *Backchannel* allows displaying text-chat messages on an interactive whiteboard. This tool helps the teacher to have a better contact with the audience during the classes without being interrupted.
- *Object Gallery* allows extending educational environment by locating additional objects. This tool is presented below in more detail.
- The tool called *Collection* can be used for uploading, storing, and sharing educational materials. This tool is presented below in more detail.

C. Functionality of the 3D Virtual World: Locations

vAcademia virtual world has a common space – a single island 600 meters by 600 meters – with 70 different standard locations on it. Each location can be used in different levels of reality, so the number of live classes is not limited. Instructors can create an instance of a standard location and add the required set of tools to conduct specific activities.

The common space can be used for learners' communication between classes and serendipity meetings. The map of the virtual world displays the number of participants in each location from both the time when they were recorded and those who are currently online. Live or recorded classes can be simultaneously held in all locations.

In addition to the standard locations, every user in vAcademia has a personal location, called "My home". This location is separated from the common space and has a size of 100 meters by 100 meters. Such locations are created automatically for each new registered user. Initially, there are no objects in it, just a flat surface. However, users can build their own educational arenas for conducting classes, taking standard objects from their Object Galleries or upload their own objects. The owner can set the properties of "My home" to make it accessible only if there is a class scheduled to be held there or to allow or disallow other users to visit it.

D. Functionality of the 3D Virtual World: Content

Setting up a new place for their classes, users can use their *Object Galleries*. The Object Gallery of a new user contains a minimal choice of 3D objects that are usually required for conducting simple virtual classes. These include two types of interactive whiteboards and various objects for accommodating participants, such as chairs.

In addition, users can upload their own 3D objects for creating specific learning environments. vAcademia allows users uploading 3D objects up to 50000 polygons and 12 textures each in Collada format (the support for 3DS Max format is planned). The legitimacy of the uploaded content is regulated by the user agreement, however, in addition, it is controlled by moderation. In order to reduce the risk of the overloading by (possibly inappropriate) user content, they are allowed only in standard locations and "My home" locations. In such a manner, user content can affect only visitors of certain classes. There is another limitation for setting user objects in locations – the platform supports a maximum of 50000 polygons for all objects in instances of standard locations and 100000 polygons in "My home" locations.

After uploading a 3D model, a user can add interactivity to it using a special tool. The following choice of interactive actions is allowed:

- Automatic rotation of the objects around one or several axes with setting rotation speed;
- Ability of the object to be rotated by users;
- Replacing any texture on a surface of the object with pictures uploaded in advance;
- Displaying a text message by clicking on the object;
- Teleporting the user into a specific 3D recording by clicking on the objects;
- Teleporting the user into a specific location in the common space by clicking on the object;
- Playing a preliminary uploaded or recorded sound by clicking the object;
- Setting up one or several sitting places on the object, including position, rotation, and avatar position.

The specified interactive properties of the object are saved in a special template of this object in the gallery. This allows creating different interactive objects from a single 3D model and re-using them at any time. The above list of standard interactive actions is created based on the user's feedback and will be extended.

Conducting learning activities in 3D virtual worlds often requires sharing different types of educational content, such as slides, documents, and 3D objects. Teachers need a place to store and share learning materials and students – results of their work. A special tool called *Collection* was developed in vAcademia for these purposes. This is an individual repository that each user has. It allows uploading documents from hard drive, storing them, and sharing, for example, by dragging them onto a whiteboard.

E. *Functionality of the 3D Virtual World: Avatars*

The platform provides a set of pre-made avatars that can be customized by the users. The skeleton-skin approach is used for the design of the avatars. The skeleton allows playing motion capture animations, such as a set of standard gestures. The skin allows creating avatars easily. The avatar is divided into elements, such as body, face, hair, clothing, and shoes. The shape of these elements can be modified by morphing geometry. vAcademia supports generation of avatars with random selection of all available parameters.

Lip synchronization system is automatically adjusted to the avatar. Voice volume decreases with distance, and cuts off automatically when an avatar leaves a location.

F. *Website support*

vAcademia virtual world has strong web support. While the main function of the 3D environment of vAcademia is offering tools for online classes, the website provides support for planning and managing classes and courses, searching and organizing 3D recordings. In addition, the website supports social groups and has social networking functionalities (http://www.vacademia.com/).

The main page of the website has *Activity* section, which syndicates what happens in the vAcademia community (Fig. 2). It displays the main activities of Academia users, including scheduling meetings, publishing 3D recordings, and sharing text messages written directly into the section, plus messages from Twitter™ and Facebook™. Activity messages appear on the front page only after moderation.

Figure 2. vAcademia website interface

The website provides all types of support and information about the virtual world. In addition, a course management system is developed and available through the site. The website has several sections that deliver a particular set of tools.

My account section contains personal information and provides access to the friend list, the list of communities, access to the Collection, internal messages, and the list of 3D recordings created by the user. *Study* section gives the learners access to the list of all attended classes, lists of course participants, the list of favorite classes, and the schedule. *Teach* section provides educators with a tool for planning classes and courses, lists of conducted classes and their 3D recordings, the register of classes' attendance, and a tool for making groups of learners.

In addition, vAcademia provides a possibility for integration with external course management systems, such as Moodle. This allows introducing new possibilities that virtual worlds can provide in an already smoothly working learning process. The following plugins were developed to allow using some of the vAcademia functionality in any Moodle-based system.

- A plugin for scheduling classed in vAcademia and binding those classes with Moodle classes: Moodle users can use the plugin to add a vAcademia class as a resource for a Moodle class and set parameters directly from Moodle, including class topic, description, date and time, location in the virtual worlds, number of allowed participants, and expected duration of the class;
- A plugin for inserting vAcademia 3D recordings as resources into Moodle courses: Moodle users can select required 3D recordings and web-links to locate them. 3D recording can be accessed by clicking on a link.

In order to have a more flexible way of working with 3D recordings, each of them is complemented with a 2D flash preview which is recorded automatically during the session. Such a preview consists of the audio of the lecture as well as a series of pictures. It is made based on the images from different cameras: for every whiteboard, for the lecturer, and for the audience. The reviews are available on the vAcademia website, but can also be embedded in any web page, blog or a social networking site. The preview player has a toolbox, which allows opening recordings in a 3D mode if the vAcademia client is installed. The preview player is currently based on flash technology. However, the next version of the preview player is being developed on HTML 5, which will extend the potential audience.

G. *Technical realization*

vAcademia was developed from scratch, using previous experience in developing 3D virtual worlds, which includes the project called Virtual City of Yoshkar-Ola [14], available at http://www.virtyola.ru/.

Most of the system components were also developed from scratch. However, many well-known libraries and components, such as, audiere, freetype, freeimage, and curl, were used for programming the networking, image processing, and sound.

vAcademia has a client-server architecture, its main components are:

- vAcademia application – client software that visualizes the virtual world and provides all functionality for conducting classes;
- vAcademia servers – a scalable system that provides network interaction between clients. In order to ensure stability and data processing speed, the platform uses multiple servers, such as authentication servers, resource management servers, synchronization servers, and SOAP-service servers;
- Access Control List (ACL) – a system that manages user access permissions for the resources, such as classes and 3D recordings;
- Virtual world content repository – a storage system for the users' collection resources and 3D world data
- Virtcast repository – a storage system for 3D recordings.

The graphical engine of vAcademia was developed specially for the project based on OpenGL. vAcademia has four levels of graphics quality: low, normal, high, and very high. The graphics change according to these levels, including the number of objects and polygons in them, quality of textures, antialiasing, and the distance of visibility. In addition, vAcademia uses levels of details for 3D objects and avatars, which simplifies geometry of the long-distance objects. Together with exploiting possibilities of central and graphical processors, it allows displaying a large number of 3D objects and avatars without significant reduction in the system's performance.

On an average computer configuration (comparing the minimal system requirements and the computers most popular on the market), vAcademia performs at 50–60 FPS displaying standard locations and surroundings with the presence of 75 avatars.

To implement the interactivity of our world, a Jscript-based scripting language is used. This language can later be given to the users for programing the behavior of 3D objects.

IV. Scenarios of Use

In this section, we elaborated several scenarios of use to illustrate the current functionality of vAcademia and some features that are under development. The application domain of vAcademia is defined by the set of teaching tools integrated in the virtual environment and by the 3D-recording feature. While teaching tools allow using existing approaches that are used in face-to-face and virtual modes, the 3D recording opens a new direction in e-Learning, methods and techniques for which are yet to be developed.

3D recording is a new trend in learning in virtual worlds, and therefore its potential is not yet fully discovered. This feature raises the use of class recordings to a new level, providing a possibility for active learning inside a recording. Learning activities with 3D recordings or virtcasts can be conducted in two basic formats: first – visiting a 3D recording, and second – creating a new 3D recording while conducting activities being inside one.

Simply visiting a 3D recording partly looks like working with a recorded lecture or a 'webinar'. It is possible to watch a 3D recording at any convenient time focusing on difficult parts and skipping acquired ones. However, virtcasts have significant differences from other types of recordings. First, 3D recordings can be visited by a group of learners who can actively work inside the recording. Second, a 3D recording is a copy of a live class, but it is not different from the original. Inside the 3D recording, at any point of time, all the objects are on the same positions as they were in the live class (Fig. 3). All the interaction that happens in the 3D recording can be observed in the same way as in the live class. However, the visiting avatars cannot interact with the recorded ones.

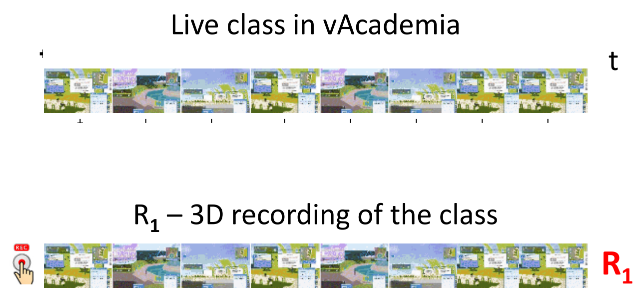

Figure 3. 3D recording effect

The second format – creating a new 3D recording, being inside one is even more different and promising. A teacher can enhance a 3D-recorded class by visiting it with another group of learners and recording over again. As a result, there will appear another 3D recording, containing new discussions, questions, and comments. Working inside a 3D recording, the users can set up and use additional whiteboards. The information presented in a 3D recording can also be enhanced by text, graphic, and sound notes.

In addition, the teacher can guide learners only through some parts of the original class, which are, for example, unclear for them. In order to do that, the teacher can fast-forward the 3D recording through the places that should be skipped (see red pieces in fig. 4). In such a way, the skipped places of the original recording will not appear in the new one (Fig. 4).

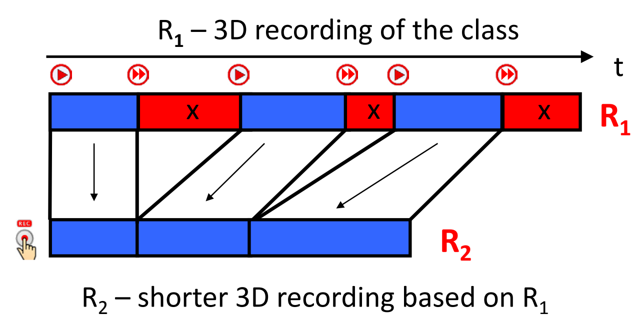

Figure 4. New 3D recording with skipped parts

On the contrary, the teacher can pause the original 3D recording and add some missing material or discuss a particular part with the students (see green pieces in fig. 5).

Some parts of the original 3D recording can also be replaced. The new 3D recording will contain this additional material (Fig. 5).

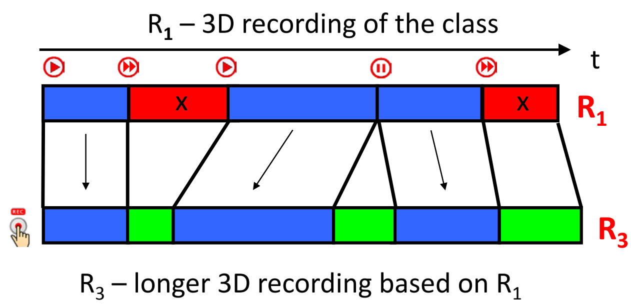

Figure 5. New 3D recording with additional and replaced parts

In addition, 3D recordings can be extended with notes. Being in a 3D recording, the teacher and students can add textual, graphical, and sound notes to any of the objects in the recorded locations. These notes can contain questions or additional clarifying material. When re-visiting the new 3D recording, these notes will appear in the same place and in the same moment of time (Fig. 6).

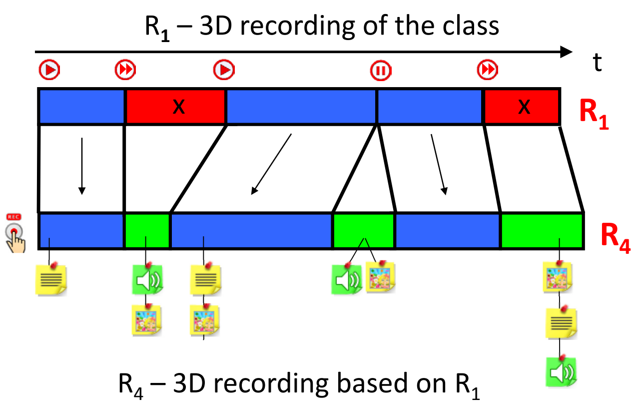

Figure 6. New 3D recording enhanced with notes

Recording new activities being inside 3D recordings, the teacher will have additional virtual classes, focused on specific parts which extends and improves the original one. In such a way, vAcademia allows editing content of asynchronous recordings of synchronous activities. This feature is especially useful in the cases when a certain class has to be repeated frequently. For example, educators can create a template of a class with demonstrations or lecture parts completed, but performing live discussions with each group of students. This approach can increase the efficiency of virtual classes reusing the content and avoiding unnecessary duplicating.

3D recording creates new possibilities for combining synchronous and asynchronous sessions within one scenario. The students might not even notice that they experience a past/recorded session, which can be followed by another one, which is live and interactive. For example, a class template for language learning can consist of three parts (Fig. 7):

In the first part, the students can attend a 3D recording, in which the teacher explains the material. The avatar of the teacher who is explaining the material inside the 3D recording will not be able to answers questions. However, the teacher can be present in this session, sitting next to the-recorded-himself, and answer the question after the lecture if necessary. The first part can also be prepared in advance and be available as a pre-class activity.

In the second part, students can be given practical exercises to be performed in groups, such as composing and practicing dialogs. The students can record their dialogs in separate locations.

In the third part, the students together with the teacher can visit all the 3D recordings created in the second part one after another analyzing and discussing positive and negative aspects.

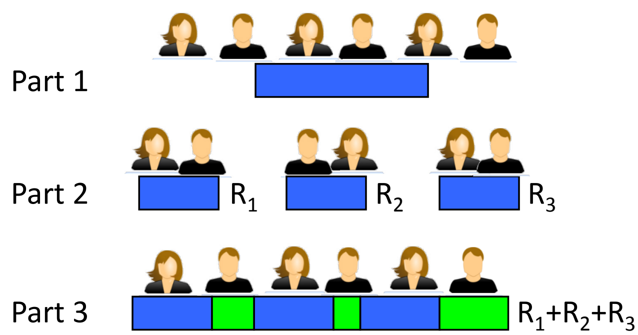

Figure 7. Using 3D recording in Jigsaw learning approach

In the same way, the combination of synchronous and asynchronous sessions can be used for improving collaborative learning experience of Jigsaw approach. According to this approach, each student within a group becomes an expert in a certain topic of a course. The 'experts' work together and bring their knowledge to the initial groups. Usually, this knowledge is presented as a written text. However, using 3D recording, each expert group can record their discussion, while the initial groups will be able to attend all the 3D recordings of all experts groups.

A recorded brainstorming session can be discussed on a live collaborative session, but also recorded again with new discussion topics for later use.

V. CURRENT USAGE

Although vAcademia is currently under beta testing, possible scenarios of use are evaluated in the real educational process. The qualitative data is not presented in this paper, but will soon be available.

First, the virtual world is used in several IT courses at the Mari State Technical University in Yoshkar-Ola, Russia. A number of different activities are conducted, such as lectures, seminars, project presentations, and study group discussions. Interactive whiteboards are used for live demonstrations of work in software development environments and the performance of resultant applications (Fig. 8). A distinct tendency can be observed in visiting statistics of the

University level classes conducted in vAcademia. The number of visits to a 3D recording is approximately three times larger than the number of students that were present in the corresponding live class, which means that students visit 3D recordings several times.

The vAcademia platform is now being integrated into the university's course management system, which is based on Moodle.

Figure 8. Developing Scratch application class in vAcademia

Second, vAcademia is used for language learning. Professor Mike McKay from Mukogawa Women's University in Japan is teaching an introductory a nine-week English course for beginners. Students and teachers from different countries take part in the course. The professor is using three whiteboards during his classes: two for presenting educational content and the third one for displaying the image from his web camera. 3D recordings are used for home work and preparation for the next class (Fig. 9).

Figure 9. English for beginners class in vAcademia

The third example of the current use of the platform is a high school chemistry course at school 30 in Yoshkar-Ola, Russia. Teacher Valery Cvirco is conducting optional classes for an advanced chemistry course. In these classes, the teacher is using whiteboards for displaying interactive multimedia resources from the Virtual Chemistry Laboratory which are normally used at the school [15]. The students are also actively using whiteboards for presentations and practical exercises (Fig. 10).

Figure 10. Chemistry class in vAcademia

The user experience shows that classes in vAcademia are engaging for students, however, the possibilities of the new types of activities require more exploration.

VI. Future Directions

The further development of vAcademia project will be focused on widening its use in education and will include the development of additional functionality for the 3D world, extending possibilities for accessing the platform, improving the social and community support, and designing new learning scenarios which would benefit from integrating synchronous classes and 3D recordings.

The development of additional functionality of the 3D worlds of vAcademia will be focused on extending possibilities for using custom 3D objects uploaded by users and programming the behavior of such objects. This will allow creating custom learning environments, which can be used, for example, for simulations. Another direction is improving the working environment and teaching tools to make them more convenient for teachers and learners.

Extending possibilities for accessing the vAcademia platform includes developing client applications for different operating systems and a light version of a 3D environment for mobile devices. The second direction here is developing a browser-based client.

A number of improvements in socializing support are planned. This will include the following:

- Ability to follow activities of other users, including subscription to the scheduled classes, new 3D-recordings, and Activity messages;
- Extension of the friend list functionality, including personal messages and teleportation to the location of a friend;
- A text chat across the website and the 3D world;
- Improvement of user profiles which will be more oriented toward the community of learners and educators and include academic degree, learning and research interest tags, current courses, and others;
- Integration with popular social networking sites.

Designing new learning scenarios is necessary for discovering all the possibilities of 3D recording in virtual worlds. There will be a possibility for creating a library of class patterns, which can be based on certain pedagogical scripts. Such patterns could provide a 3D environment, all necessary tools, and a timeline. Some scenarios can be based on 3D recorded classes playing the role of a new type of user-generated content. Educational simulations and serious games will provide additional value, for example, for later analysis, when 3D recorded.

VII. Conclusion

In this paper, we propose a new approach to learning in 3D virtual worlds, which is available in vAcademia. We also present a new type of content that is called virtcast and can be created by 3D recording.

Applying 3D virtual worlds in education is a significant step forward as they provide a natural environment for learning enhancing it with technological power. 3D recording of classes in vAcademia expands the educational potential of the technology by combining advantages of synchronous and asynchronous approaches. In addition, it allows designing and exploring new approaches and learning environments which were not available before.

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