End-User Development in Second Life: Meta-design, Tailoring, and Appropriation

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Abstract. We present a case study of a distance education program for training special needs educators online, using the 3D virtual world Second Life (SL) as the main platform. The study explores two aspects of end-user development (EUD): 1) the professor's role as a designer of the learning environment, and 2) the students' use of the environment to collaboratively tailor virtual 3D objects. We used a qualitative approach to collect and analyze data, and we used the participants' spoken utterances and turn taking as our main source of data. We developed a conceptual framework for analysis using meta-design, tailoring, and appropriation as key concepts. The findings suggest that non-technical users of SL (special needs educators in our case) are able to develop and tailor advanced virtual 3D objects with access to online help resources, and the immersive nature of the 3D environment keeps the participants engaged and motivated during the collaboration and tailoring activities.

Keywords: 3D virtual world · Appropriation · Empirical analysis · End-user tailoring · EUD · Meta-design · Second life · Special education · Teacher education

1 Introduction

Using 3D virtual immersive environments, such as Second Life (SL), offers users the feeling of being together in a real setting [2]. Everyone interacts during live time, while viewing a visual representation of one another, as an avatar. This 3D virtual environment is a great arena for studying end-user development (EUD) because users are provided with tools at multiple levels of abstraction: 1) *Interaction*: specific tools for verbal and nonverbal (mediated) communication, 2) *end-user tailoring (EUT)*: artefacts and generic tools can be tailored by skilled users for their own and other users' purposes, and 3) *meta-design*: SL provides a design environment for advanced users (designers) to create interactive spaces for end-users to interact; these spaces will often include EUT-enabled artifacts and tools.

We studied an online teacher education course designed for special needs educators. The professor created the virtual campus and the students have used this campus to collaboratively create role-play scenarios as part of their online learning activities,

P. Díaz et al. (Eds.): IS-EUD 2015, LNCS 9083, pp. 92–108, 2015.
DOI: 10.1007/978-3-319-18425-8_7

making use of EUT-enabled tools and artifacts during the process. We studied one of the courses in this program with a focus on the role of EUD in this environment. We used a qualitative approach as part of a case study [23] for data collection and analysis and we analyzed participants' spoken utterances and turn-taking using interaction analysis [12]. We developed a conceptual framework for analysis using meta-design [5], tailoring [9, 18] and appropriation [19, 22]. Our findings suggest that non-technical users are able to tailor advanced 3D objects with access to online help (handbook and video instructions), and the immersive nature of the 3D virtual world keeps the users engaged and motivated during the collaboration and tailoring activities. The professor created the flexible learning environment using the embedded Second Life build feature.

The rest of the paper is organized as follows. We describe the related work in the intersection of virtual worlds and EUD. In Section 3, we present the basic concepts we have used to inform data classification and analysis. In Section 4, we present the design of the virtual learning environment. In Section 5, we describe the methods used to collect, classify and analyze data. In Section 6, we present and analyze our data. In Section 7 we compare our findings with the findings reported in the related work. At the end we summarize our findings and suggest directions for further work.

2 Related Work

Second Life (SL) is a multi-user virtual environment (MUVE) where individuals interact in real time as avatars with people and virtual objects in three-dimensional space [20]. MUVEs offer users new opportunities to design advanced learning environments composed of computer-based tools and virtual spaces for interaction and staging of authentic learning activities (e.g. a virtual university campus with classrooms and smaller discussion areas, see Figure 1) with resources that would be difficult to match in a traditional classroom setting.

Fig. 1. Two buildings of virtual campus in Second Life™ used in the distance education program (Left: Main Classroom; right: Small Group Building)

Previous research in MUVEs studied different aspects of interaction in these online environments, such as collaboration and design to create new content. For example, Gürsimsek (2014) carried out a multimodal social semiotic analysis for investigating how several users interpret and use SL resources to communicate, collaborate and co-produce new digital content. His findings have shown that the quality of co-design and co-creation depend on the social interactions and on a variety of resources that the

virtual world can provide (e.g. 3D modeling tools, several marketplaces for reusable 3D objects, etc.). Furthermore, by re-examining the different theories of meta-design in virtual worlds, Koehne et al. [15] show that some open-ended environments have tools and virtual spaces for empowering end-users to tailor the systems toward their needs.

Wang & Wang [21] argued that the level of co-presence is an essential element that affects significantly the design processes in collaborative virtual worlds by increasing the sense of "being together." Along the same line, Jarmon [11] showed that users report increased social presence in SL, which she termed as an "embodied sense of social presence" (p. 1) and attributed it to being able to move avatars through space in real time. Moreover, Allmendinger [1] suggested that the sense of social presence in virtual worlds also might be related to non-verbal signals made by avatars. However, implementing non-verbal signals in virtual worlds is not an easy task for developers, and successful adoption varies across the virtual worlds available (e.g. a gesture command menu is available in SL inventory, invoked on a Mac by ⌘-G).

Koehne et al. [14] conducted an ethnographic study in LOTRO and Second Life and developed a socio-technical model of 'identity' to further investigate identity formation as a design process in online environments. They found that skillful activities of the online character define the users' identification with the avatar. However, this model of identity is focused on experiences gained mainly from studying the design and use of avatars, as a form of self-presentation. The model's general usefulness needs to be tested by applying the framework to other aspects of identity development as well. We focus on the relationship of end-user development and motivational aspects of learning.

Studies have reported findings that open-ended learning environments with embedded design environments could facilitate appropriation through a wider range of user activities and diverse contexts. For example, Huang et al. (2010) argued that providing highly interactive learning experiences is essential in such virtual learning environments. They also pointed out the appropriation of tools can promote creativity in problem solving and increase motivation for participation. People appropriate a technology by assigning it with personal meanings or associating personal emotions to it, which will sometimes imply making changes to the technology, other times seeing the use of it in a new way [18]. However, based on the literature we have surveyed, little research seems to have addressed the relationship of appropriation and motivation in SL.

3 Basic Concepts: Meta-design, Tailoring and Appropriation

Meta-design has been considered a new conceptual approach to system development where new forms of collaboration and design can take place. According to Fischer et al. [5] "meta-design characterizes objectives, techniques, and processes for creating new media and environments allowing 'owners of problems' (that is, end users) to act as designers. A fundamental objective of meta-design is to create socio-technical environments that empower users to engage actively in the continuous development of systems rather than being restricted to the use of existing systems" (p.1).

Previous research has reported applications of meta-design, e.g. in terms of tools and techniques for design in use, end-user tailoring, and customization. For example, Henderson & Kyng [9] provided a framework for continuous development of application systems at different levels of abstraction, and Mørch [18] suggested tools for customization, integration and extension to support the levels. Moreover, Costabile et al. [4] argue that software environments should be tailorable by domain-expert users at runtime in order to adapt the software to the specific work contexts and the preferences and habits of the users.

Meta-design, as conceived by Fischer and colleagues, is arguable a design concept for describing further development of technology by distinguishing design-time activities from use-time activities [5], whereas later extensions to it have made it a socio-technical framework by including ethnographic studies as part of use-time analysis [14, 15]. Taking this one step further, we define appropriation from a socio-cultural perspective according to Wertsch as "the process of taking something that belongs to others and make it one's own" [22, p.53]. Implied by this perspective is the idea that knowledge is constructed during appropriation, and that students play an active role in the process [3, 7]. The connection between appropriation as a form of advanced technology use and the social construction of knowledge has been studied in teacher education research. For example that appropriation occurs when learners (teachers in training) adapt the information in a way that is meaningful to them [3, 7]. Furthermore, Laffey & Espinosa [16] suggest that teachers appropriate and use a technology (hardware and software) in order to expand their repertoire of teaching strategies, but also found that the technology sometimes fall short of its expectations.

Appropriation is also a technology concept, and Pipek [19] connects appropriation with design in use and tailoring. He describes appropriation as "an ongoing design process that end users perform largely without any involvement of professional developers" [19, p. 5]. Based on two long-term empirical studies, he identified advanced user activities with collaboration tools (groupware) in two workplace settings, and proposed appropriation support to aid the activities. Pipek characterized this appropriation as "a collaborative effort of end users ... to make sense of the software in their work context" [19, p. 5]. The appropriation support combines communication, demonstration and negotiation with tailoring tools. This would help the teams to create a shared understanding of how the collaboration tools worked and thus contribute to a more informed and shared work context for the team members.

4 Designing the Learning Environment: Buildings and Activities

The second author created the learning environment from scratch, using Second Life's build feature (a design environment) based on skills she acquired through a workshop offered by Sloan Consortium (now called Online Learning Consortium), where she learned how to build a "box" and how to put content inside of a box. Below we describe two types of functionality that can be built with the SL box as basic building block: virtual buildings and learning activities and tools.

4.1 Designing Virtual Buildings

After taking the workshop, the professor-as-designer spent time playing in SL to practice making virtual buildings. She built the buildings by creating multiple boxes and linking them together, as shown in Figure 2a. There were restrictions on the size of an individual object; therefore, multiple boxes were put together to create the size of the building that was needed.

Fig. 2. a) Left: Building a box in Second Life, b) right: changing the size attributes of a box

In order for the main classroom to appear as one large lecture hall, the interior walls of the boxes were set to “phantom” and made transparent, as shown in Figure 2b. When an object is phantom in SL, one can walk through the object compared to merely being transparent. While fewer boxes could have been used, the main classroom had six boxes linked together in order to create the look and feel the designer wanted. Originally, the room was built with fewer boxes, but the interior windows looked too large and stretched in this configuration, so more boxes were added to make the buildings appear more natural. Once the walls were created, faculty built one large floor from a box so that the texture on the floor would look uniform.

After the interior walls were created, the professor changed each "texture" of the exterior of each box to give the objects the appearance of a building. It was the intent to make the buildings look similar to the architectural design of the downtown campus in real life (Figure 1). She then linked the boxes and the floor together. After the main area was created, she built a foyer by adding another box and making the interior walls of the box transparent and "phantom." The professor then built the floor for the foyer by building a box and adjusting the dimensions (Figure 2B). Several other pieces were also created and finally linked together.

In addition to the main classroom, it was necessary to build small group buildings for collaborative work. Each group building included a group table with chairs, as well as a lounge area with a sofa and chairs. The group buildings were 60 (virtual) meters apart to avoid sound interference between groups while talking. The small group buildings the professor created by combining two boxes and making the interior walls of the boxes transparent and "phantom," and the texture of the boxes was changed to account for floors and walls (including windows) without building separate boxes. After the prototype group building had been created, multiple copies were made by duplication of the original, in total five group rooms per instructor have been created.

4.2 Designing Learning Activities and Tools

The learning environment was designed to maximize collaboration and student engagement. When envisioning the main classroom, the online instructors wanted a space where students could meet as a large group (N=30-40) and engage in interactive lecture. The professor had visited other instructors' classes in SL and thought that flipping through slides in SL while students sat in a seat and watched was less engaging than students physically moving their avatar to participate. Therefore, a decision was made to design the space so that students would walk from display board to display board (Figure 3).

Fig. 3. Professor lecturing and asking questions at each display board, walking through slides

Each lesson begins with an activator, where students' prior knowledge is activated to begin the lesson. The activator typically involved a review of the previous lesson, or a question involving content to be discussed in the current lesson. The activator was one of the slides for the day's lesson. After the slides were uploaded using Keynote (Macintosh version of PowerPoint) as jpeg files into SL, the professor changed the texture of each display board to show each slide. Students participated in the activator by creating a notecard, writing their answer on the notecard, i.e. Activator_Studentname, and then sending it to their professor.

After the activator, students walk over to the display boards in the room for interactive lecture (Figure 3). The display boards showed content for the lesson, and there were individual activities throughout the lesson. After interactive lecture, students worked in groups for the remainder of the session. During this time, students worked collaboratively to solve problems. In addition to solving problems, students were asked to create a role-play scenario for their classmates to practice skills surrounding one of the topic areas taught in class (i.e. interpersonal problem solving, effective communication skills, etc.).

As part of this assignment, students had to learn how to build boxes to disseminate their materials, create notecards and put them inside the boxes, and allow their boxes to be "purchased" for $0L. These were the same kind of boxes the professor used to create the campus buildings described in the previous section, but in this case the students did not have to connect boxes. They changed the texture of their box to customize the look and feel. To add content to their box, students dragged a notecard from their box and dropped it into the "Content" section in the building editor (in Figure 4 all of these skills are demonstrated).

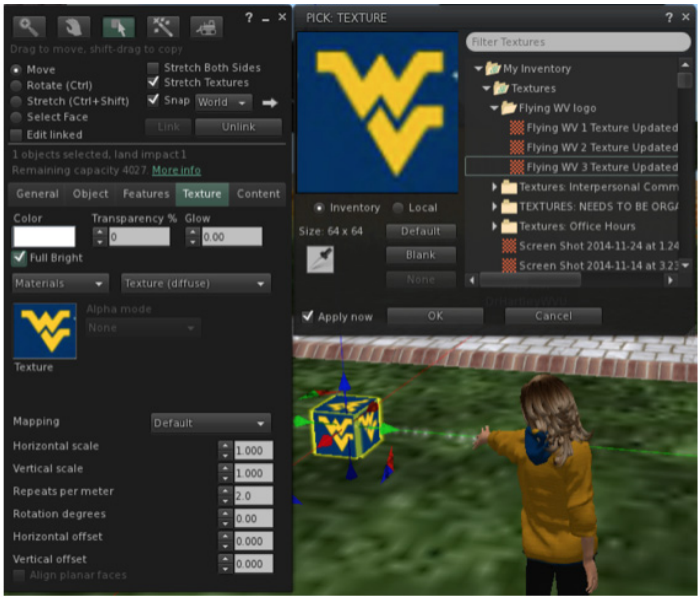

Fig. 4. Skills demonstrations for use of boxes in students' learning task of giving presentations

5 Methods

Collaboration and tailoring (i.e. appropriation) were investigated in two sections of a graduate-level special education teacher preparation course held at a North-American University. The course was arranged after working hours and used Second Life as the primary educational platform and all course sessions were held online. Thirty four (N=34) preservice teacher students took part in seven one-hour class sessions, divided into: interactive lectures of theoretical concepts (15 minutes), individual activities (5 minutes), small group activities in separate rooms (30 minutes), and role-play activities (10 minutes). The students were novice SL users before starting. The data we show (Excerpts 1-3 in Section 6) are extracts from a 30-minute group activity.

A qualitative research analysis was employed, combining a case study [23] and virtual ethnography [10]. According to Yin [23], a case study is the appropriate method when 'how' or 'why' questions are being investigated, and when the researchers have no influence over the participants who were interviewed, or during the observation of the online course. Data collection techniques were video-recorded observation and interviews. The first and third authors were the observers, and the first author carried out the interviews. According to virtual ethnography [10], all sessions were observed at a distance in the virtual world and video-recorded with screen capture software, using BSR, Camtasia and SnagIt (in total 15 hours of raw video data). Afterwards, some interviews were conducted with voluntary students and the professor, using chat and voice (headset), according to the interviewees' preferences.

In order to manage and classify the data material each session and interview were stored in a separate file, and transcribed in its entirety using linguistic conventions according to interaction analysis [12]. When selecting the data excerpts, we focused on a common scenario where groups of students created and customized boxes allowing them to perform the learning tasks. Within the same scenario, we organized the data thematically into four macro categories: meta-design, customization, collaboration and tailoring, and scaffolding for appropriation. Thus we categorized our data by a combination of top-down (theory based) and a bottom-up (data-driven, open coding) iterative classification process. Selected data are reproduced as excerpts numbered 1-4 in next section, which serve to illustrate and substantiate the claims we make.

6 Data and Analysis

Each subsection below is organized as follows: 1) short context description, 2) illustrative example of "raw" data (italicized) and 3) brief description of findings in common sense terms. The transcript notation used in the data presentations includes these symbols: (..) short pause, ((text)) comment by researcher, [..] excluded (not audible) speech, :: abruption of talk.

6.1 Customizing The Box Tool (Excerpt 1)

In the first excerpt, pre-service teachers are working in small groups (four or five members). We follow the group consisting of Heather, Janet, Mandy, and Stacy. After creating a scenario for the role-play activities, they need to create notecards, intended as instructions for the actors, which are then put in the boxes. When we start on the excerpt below the group is ready to make the box:

Stacy:	*OK, now we need somebody to make the box.*
Heather:	*Y'all go together and do that. I kind of… can we build it in here?*
Stacy:	*I'm not sure if we can or not.*
Heather:	*I think we can build it here ((wherever they are in SL)), we just have to put it in our inventory before we leave. I have one (…) started; I'll try to get it so you can see it.*
Janet:	*Exactly.*
Stacy:	*Ok.*
Heather:	*That's a fancy box. Is it changing:: the scenery on it or are you changing that? (..)*
Mandy:	*Yeah, can you see it?*
Heather:	*Yeah, I can ((laughs)) (..) OK, tell me when you… we get something that you like.*

In this instance, the group of learners attempts to collaboratively design the box, wishing to simultaneously perform the joint tasks. By creating and working on the same artifacts at the same time, the learning experiences becomes more collaborative and artifact-oriented than just communicating with peers. However, one of the students (Stacy) is unsure if this is possible ("*I'm not sure if we can or not*"). Heather has already started to do it on her own and works on a local version of the box to be shared by the others through the SL inventory. In other words, the work in the group is not exactly collaborative design (simultaneously performing joint design tasks); rather it is collaboration by seeing and talking, individual tailoring, and sharing.

6.2 Further Adjustments to The Box Tool by Collaboration and Tailoring (Excerpt 2)

The following excerpt shows the same group of preservice teachers, now trying to understand how to further modify the box to allow for information sharing of a document describing a role-play. The information to be put in boxes are referred to as note cards, and intended as instructions for the role-players.

Mandy: *How do I make the box (..) ahm:: have a price of nothing? What do I…?*

Stacy: *There should be a spot on there that says… with a… I think it's down toward the bottom where it says ahm, the price or whatever and you have to set it to zero dollars. Let me see if I can…*

Mandy: *Oh pay… about object (..) I'll have to make it for sale.*

Stacy: *Yeah.*

Mandy: *Features, ahm:: (..) I'll have to look it up. I'm trying to build. If you guys want to talk, I'll still listen (..) All right. I did have the note (..) So:: what exactly do we want to put in this box? I'm guessing do we need to put a little snippet of (..) what part of this case we're going to talk about and what skill we want them to practice on?*

Janet: *yes prolly*

Janet: *Mandy, are you still looking up how to make box zero dollars*

Mandy: *no, found it*

Mandy: *trying to put a note card inside*

Janet: *ok cause it said it was zero just making sure*

Mandy: *OK, see if you can access that notecard in there now.*

Stacy: *When I try to click… you mean when you click on it?*

Mandy: *Right.*

Heather: *I can buy the box. I'm trying to get the notecard that says Franklin, right? Mandy, did you label it Franklin?*

Mandy: *Yes, that's it.*

In the excerpt, Mandy takes the active role of modifying the box tool ("*I'm trying to build. If you guys want to talk, I'll still listen")*. The other students comment on the work, test it, and eventually they get it to work. The students struggle with understanding the notion of a box having a value of zero Linden dollars. The "business metaphor" permeates in SL, in this case that boxes must be made for sale in order to be used. This is not obvious to the students who are newcomers to SL. However, when this is understood, they figure out how to make a work around by setting the value to zero Linden dollars. Now, the note card can be accessed and they have accomplished their task.

Appropriation in this context (as well as in Excerpt 1) reveals two dimensions, one technical (building, modifying, testing) and the other verbal (explaining to each other, asking questions, confirming partial results, etc.), and both dimensions are clearly present in the data and relevant for the activity and motivation. What is actually "built" by one student is not extraordinary advanced from the point of view of computer science; i.e. setting parameters in property sheets (see Figures 2 & 4). However,

when accomplished, it gives them a feeling of pride that we hear when listening to the video conversations.

6.3 Scaffolding Appropriation by Using an Online Handbook (Excerpt 3)

The users we observed were newcomers to SL, and the professor prepared multiple ways of scaffolding the learning activities. She created a "getting started handbook" [8] and several instructional videos for specific situations. The use of the handbook is shown in the following excerpt where the students create a notecard for giving instructions for the role-play.

Mandy: *In our handbook that we have did it say how to put a card in there (..) or was it on-line that the instructions were there?*

Janet: *Give me a second, Mandy, I think I have the instructions but I need to walk away from the computer real fast.*

Heather: *I'll see if I can help too. I remember doing it for that activity but let me go play around, see what I can find (..) Mandy, what did you put under ahm:: content permission?*

Mandy: *I didn't even click on that, ahm::*

Heather: *Go under content and click on permissions and see what you have selected there.*

Mandy: *It has all checked ahm:: (..) Maybe I need to put share there (..) Anyone (..) ok (..) see if that works and you can buy it now.*

Heather: *How did you pick it up, Mandy?*

Mandy: *I have no idea. I just started cracking up laughing because I have no idea why it's on my lap ((laughs)).*

Heather: *Somebody else has it. Janet, you have it on you.*

Janet: *How do I get it off, it's squashing me!*

Heather: *If you right click it'll say drop ((laughs)) (..) It's floating above the window (..) (..) There are two tie-dye boxes floating above the window.*

Mandy: *Yeah, I see them.*

The excerpt shows the necessity of giving students some examples and instructions for scaffolding their activities. When the professor incorporates an online handbook and short video instructions, she ensures that students feel more confident with the virtual environment.

When creating the box, the students need to set permission for sharing documents. They refer to the online handbook for this task, and as a result they make changes to some attribute values in the property sheet of the box. They enjoy the activity because they can *"play around"* with the various configurations and move the box in different orientations and shapes (e.g. *"it's on my lap", "it's squashing me!"* and *"it's floating*

above the window"). Afterward, the students insert the note card, which will be read by other students to start educational role-playing and concept application. It is worth noticing that the work to do this takes some time and is partly done individually as Janet needs to *"walk away from the computer real fast"* and Heather needs to *"play around"*. Thus appropriation reveals a "two-mode" process, involving collaboration and coordination on one hand and individual tailoring (customization) on the other.

6.4 Immersive Nature of Second Life Engages Students in Learning Activities (Excerpt 4)

This excerpt is part of the interview with the professor at the end of the course. It addresses a question raised by the interviewer regarding getting her students engaged for the educational activities and how it compares to a face-to-face class.

> *Professor: That's a good question. I would say, engagement (..) - wise (..) it's the same on-task behavior, from what I've seen, I've seen more on-task learning, um (..) in Second Life, so for example, when (..) um. And this is a different course, but, like, when I assigned, um, students to work to::like, collaboratively in my face to face courses. As I'm coming around, they're doing other things, and th::like, when I'm coming around in Second Life, and I'm flying around the buildings, the students are (..) actively engaged in what they're doing. They're not having side conversations, and I don't know - I don't know why that is, but they're:: they're typically, like, engaged in the content the whole time. And sometimes, they don't even know I'm there, like I'll fly around the outside of the building, and not even come in (..) And so they don't know that I'm there, but they're actually talking about the content instead of having a side conversation about something else.*

When immersed in the virtual world, students perform their tasks in a realistic manner. In addition, the students were deeply involved in the task all the time and less side tracked, which is different from the professor's face-to-face classroom experiences where students often have side-conversations.

7 Discussion

We discuss our findings by identifying recurrent patterns in our data and comparing them with the findings reported in the related work we surveyed in sections 2 & 3.

7.1 Meta-design, Tailoring, and Appropriation

The findings show that professional educators (a professor of education and a class of pre-service teachers) are able to design and appropriate advanced 3D objects through an engaging process of collaboration in the 3D virtual environment Second Life (SL), despite little knowledge of computer science. This was possible by the professor's training and an environment created according to principles of meta-design, which according to Fischer et al. [5] include that "owners of problems" act as designers. In our case the owners of problems are a professor and the preservice teachers, who act in their capacity as domain-expert users [4]. The preservice teachers (students) created notecards for preparing learning activities such as role-play scenarios, and they customized boxes for sharing the notecards with peers.

The basic building block used by the professor to create the learning environment is the "box tool", allowing both buildings and boxes for students' further tailoring to be created (see Section 4). Buildings required connecting boxes (a form of tailoring by integration) whereas modifying them required customization [18]. In spite of the generic nature of the SL box (i.e. serving multiple purposes, allowing multiple forms of collaborative activity), they were also specific enough so that in combination they gave the users a sense of being immersed in a "real" world (e.g. Excerpt 4).

The appropriation process revealed that learners were able to accomplish demanding technical tasks (as seen by preservice teachers) by collaboration and tailoring, and by suggesting multiple alternatives to resolve open-ended issues (e.g. Excerpt 3). Despite the fact that in some instances customizing the box tool gave the users some unforeseen challenges (as shown in Excerpt 2), we firmly believe that this form of appropriation was beneficial for them in terms of self-confidence in accomplishing an online learning activity in real time (this is evident in that they had a lot of fun and were able to "play around", see Excerpt 3 and Section 4).

7.2 The Relationship of Collaboration and Tailoring

Appropriation combines collaboration and tailoring [19]. In Pipek's studies collaboration included activities such as communication, demonstration and negotiation. Our data shows detailed examples of the intertwining of collaboration (talk to coordinate a group's common task) and tailoring (e.g. Excerpts 1 & 2). Asynchronous and synchronous communication tools support collaboration in distributed work (as opposed to collaboration in front of same computer). Whereas in the previous work the focus has been on asynchronous communication tools, e.g. sharing tailoring files [13], our work focuses on real-time (synchronous) communication in a virtual world. Using interaction analysis as our main method, we could study the moment-by-moment spoken utterances exchanged in the groups as they worked on their learning tasks.

Furthermore, we have focused our analysis on appropriation and its sub-processes. In related work we study and provide support for other aspects of interaction in virtual worlds as well, such as role-play and collaboration [2] and scaffolding [17]. Our data shows that tailoring is an individual activity separate from but intertwined with small group collaboration. The group members take turn in doing customization work

(see Excerpts 1-3). Despite being separate sub-processes, collaboration and tailoring are integrated. Collaboration involves talking (testing a modification, asking questions, confirming status, etc.), whereas tailoring is for the most part non-verbal activity (supported by the tailor's individual reasoning and local problem solving, which we could not capture with our data collection techniques). On the other hand, if we had interviewed those participants who customized the boxes (e.g. Heather in Excerpt 1, Mandy in Excerpt 2, Janet in Excerpt 3), we could perhaps get a more detailed transcript of how this sub-process of appropriation unfolded at the level of retrospectively thinking aloud. This is one shortcoming of our work and identifies an area for further work by combining social science and cognitive science research methods.

7.3 Scaffolding Complex Tasks

Scaffolding is essential to make appropriation manageable and not hindering the learning activities. In our complete data set, we have examples of three types of scaffolding: 1) teacher intervention, not shown in this paper [17], 2) online handbook (Excerpt 2), and 3) video instructions (not shown for space reasons).

Scaffolding is the fine art of striking a balance in instruction, between the "soft liner" (under constrained; hindering completion by giving excessive space for trial and error) and the "hardliner" (over constrained; hindering completion by limiting experimentation and exploration of alternatives).

Fischer [6] distinguished three *learning levels* corresponding to the scaffolding continuum from soft liner to hardliner for social media learning environments: 1) Fix-it level (learning does not delay work, but little understanding is required), 2) reflect level (temporary interruption, fragmented understanding), and 3) tutorial level (systematic presentation of a coherent body of knowledge, substantial time committment). Our preservice teachers could relate to all of the three levels in their appropriation work. Designers of computer-based learning environments need to identify the levels of learning of relevance to the task, to design optimal scaffolds.

7.4 Engagement and Motivation

The findings from our study indicate that the SL experience and the "feeling of being together" keep the pre-service teachers engaged and motivated in all of their learning activities. When the professor in Excerpt 4 describes the sense of social presence created by avatars and the immersion created by the 3D environment, she acknowledges the prevalence of student engagement. The environment did not easily lead to distraction of the learning activity as it could happen in a real classroom. However, we do not know enough of the individual activities of the students to suggest how these off-line activities unfolded and what, if any, intermediate results that could have contributed to the collaborative work were (other than the time spent off-line and the results individual students brought back to the group). For example, did they they encounter any problems, or explored alternative strategies of tailoring.

7.5 Implications for Design

We have studied an online teacher education course arranged entirely in the virtual world of Second Life, enrolling 34 students. We hypothesize that a synchronous collaboration environment like Second Life will not be suitable for much larger groups of simultaneously interacting participants due to the complexity of managing the learning activities. On the other hand, large online courses, referred to as MOOCs, enroll up to thousands of students around the world (although a large percentage of the students may not intend or will be able to complete an online course). Further work ought to explore the integration of asynchronous discussion forums prevalent in today's MOOCs (e.g. cMOOCs) with 3D virtual worlds to enable immersive and motivating interactions. This integration could bridge the synchronous/asynchronous divide and offer a chance to introduce experiential and social learning in open and distance education through immersive simulations. For example, students could be divided into smaller communities (N<40) with time slots for joint problem solving and learning activities, and provided with tools for collaboration and tailoring.

8 Summary and Conclusions

This paper presented a case study of a distance education program for training special needs educators online, using Second Life. The study explored two aspects of EUD: 1) the professor's role as a designer of the learning environment, and 2) the students' use of the environment to collaboratively tailor virtual 3D objects.

Our findings suggest that non-technical users of SL are able to develop a flexible learning environment with basic training (the professor) and the users (pre service teachers) could tailor advanced virtual 3D objects with access to online help resources. Furthermore, we explored the role of engagement and motivation for learning, and found that the immersive nature of the 3D environment keeps the participants motivated and engaged during the collaboration and tailoring activities.

Moreover, we analyzed the moment-moment-interaction of the activity to identify sub processes of appropriation. Despite revealing a "two mode" process composed of collaboration and coordination as verbal activity (e.g. asking questions, confirming status, etc.) and tailoring as individual non-verbal activity (e.g. customizing boxes), users integrated collaboration and tailoring.

However, these findings are in part limited by the lack of sufficient interviews with students to investigate further private (off line) tailoring activities.

Our findings suggest directions for further work, including exploring the implications (for education, for computer science) of non-expert users profiting from engaging in collaboration and tailoring digital artifacts in a dynamic and immersive virtual environment. Further work should also explore the combination of collecting and analyzing data with research methods from social and cognitive sciences, and employing qualitative and quantitative methods.

Acknowledgements. The first author (Caruso) was a visiting researcher at InterMedia, University of Oslo while the research was carried out. The second author (Hartley) built the virtual campus on a private island provided by WVU's College of Education & Human Services. The third author (Mørch) received funding from Dept. of Education, University of Oslo, to explore Second Life as a platform for distance education courses.

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