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Playful, collaborative approaches to 3D modeling and 3D printing

Thomas von Rekowski[1], Alexander Boden[2], Oliver Stickel[1], Dominik Hornung[1], Gunnar Stevens[1]

Universität Siegen[1], Fraunhofer FIT St. Augustin[2]

Abstract

Cheaper and more prevalent 3D printing technology offers new and emerging opportunities for non-experts to make and produce their very own physical items and products. However, most 3D modeling software is still geared towards experts and not as inclusive as the printing technology itself. At the same time, tools are usually limited in their possibilities for collaboration. Against this backdrop, we are conducting qualitative studies with children in Germany and Palestine on practices of co-constructive 3D modeling in virtual worlds. We aim to understand how children negotiate and cooperate on joint projects and how to lead non-experts playfully into 3D modeling. For this, we utilize the game Minecraft as well as the similar browser-based tool Cubeteam. In this paper, we present first results as well as design implications for co-constructive 3D modeling tools.

1 Introduction and State of the Art

Recently, there has been a growing proliferation of 3D printers and similar digital fabrication technologies. Due to sinking prices and progress in the availability and usability of such machines, new trends and opportunities for self-production are emerging. This goes along with a spread of related structures like Fab Labs and other, similar DIY oriented communities (Gershenfeld, 2007; Tanenbaum, Williams, Desjardins, & Tanenbaum, 2013). Given the potential of those technologies for fostering user-driven innovation as well as self-expression and creativity, it is prudent to carefully think about how to educate people in their usage from an early age in order to enable their participation in digital fabrication.

However, common tools for 3D modeling such as AutoCAD or 3Ds Max pose huge entrance hurdles since they are mostly geared towards experts and require training to be used properly. Hence, new interfaces and new HCI strategies are needed to democratize the 3D modeling process further (Sadar & Chyon, 2011). One such strategy is the utilization of playful 3D environments to playfully educate children in 3D modeling and to keep their motivation up. Such environments offer opportunities for collaboration in virtual worlds, which fits very well in established computer related learning theories such as constructionism (Harel & Papert, 1991). One of the most popular games in this fashion is Minecraft (https://minecraft.net), an open world game which places the player in a virtual environment resembling a fantasy world in which she or he can build almost anything easily from small cubes. Minecraft is increasingly being used in educational settings (e.g. Short & Short, 2012) and offers a co-constructive and co-creative, immersive, virtual environment. Tools such as Mineways (www.mineways.com) allow to export Minecraft creations to 3d printable models. Cubeteam (www.cubeteam.io) is a similar tool that is browser-based, needs no local installation / infrastructure and is expressly geared towards 3D printing.

In our ongoing work, we explore the viability of such playful tools for early education towards digital fabrication. Through the research project *Come_IN*, we have access to well-established (running for ten years) computer clubs, which are located in elementary schools in Germany, as well as two such clubs in refugee camps in Palestine. The clubs are geared towards constructionist, collaborative learning around the computer, ranging from programming with Scratch through basic electronics up to 3D printing.

2 Methodology

The majority of our study up until the time of writing was conducted for six months in one of the come_IN computer clubs hosted by a secondary school in Bonn, Germany. The club is part of the school's curriculum and for the 30 pupils aged twelve to fourteen, weekly participation in the club was obligatory. The kids received a basic introduction to 3d printing and were allowed to design whatever they desired (usually house-like structures such as castles) in groups of 4-5. We attended all sessions, being able to interact with the children and observe social interactions in situ. We also used remote monitoring to map onscreen interactions with real life situations. Photos, videos and field notes were taken and compiled into detailed protocols at the end of each session (28 so far). These were supplemented by server logs (player's activities, chats and evolution of the world). Furthermore, two group interviews (25 and 45min) regarding the children's experiences were conducted and transcribed. Analysis was done following a pragmatic Grounded Theory approach (Strauss & Corbin, 2008). The basic research questions were how children used the game for co-constructive practices, how they negotiated common projects in terms of communication and coordination and how their cooperation emerged over the course of the project.

At the time of writing, two of our researchers are at the come_IN club in Palestine with a 3D printer and will carry out a similar study there. This will hopefully yield highly contrastive results given the very different social background in the Middle East, and more specifically, a hard and threatened life as a refugee, supplementing and broadening our findings. Other 3D-printing and Maker-related work in hard social surroundings has proved valuable in the past (e.g. Dlodlo & Beyers, 2009; Mikhak et al., 2002). Our researchers will utilize the browser-based Cubeteam instead of Minecraft because the local infrastructure is limited and our intention to explore a wide variety of playful modeling tools. In doing so, they will pursue similar research questions as in the first study in Germany.

3 Findings and corresponding design implications

In this section, we present some of our most central findings and map them to possible design challenges for educational, non-professional 3D modeling and printing software tools.

On a technical level, Minecraft turned out to be surprisingly efficient for creating simple 3D models collaboratively. Despite some initial problems with learning the basic control functions of the game such as moving the avatar around, placing blocks in the game world and orienting in a 3d environment, all groups learned quickly how to use the game and were able to produce models suitable for 3d printing with very little instructions by the tutors. At the same time, it became apparent that the game lacked sophisticated coordination and awareness features other than a simple chat, which limited possibilities for in-game negotiation considerably. Especially for complex projects, more sophisticated mechanisms for coordination and awareness seem sensible (e.g. discussions mapped to specific structures or ownership signifiers for constructions through automatic color or signs). Furthermore, Minecraft does not take technological 3D printing limitations like difficulties in printing overhanging or floating structures as well as interior voids and cube size / scaling into account as of now which can become problematic during the printing process in some cases.

On the social level, we found that a lot of coordination work happened around the use of the game. In this regard, several practices emerged in the groups: *Instruction* (Children with advanced skills instruct others to build something according to given specifications), *Orientation* (Children use the in-game chat feature to allocate the position of team mates, certain building sites or even their own position), *Support* (in case of problems with certain tasks, children request support from tutors or use the chat to ask other players for help) and *Arbitrating* (some children take a stand for arbitrating in in-game conflict situations). Based on these patterns, we thus can identify a number of social roles that the children took on in the context of their activities: *Leader* – give instructions, experienced in the game, are asked for decisions on buildings. *Executive* – familiar with game controls, like to build according to instructions of the creative or leaders. *Creative* – assume creative activities (planning, personalization, giving creative advice and input, etc.). *Beginner/learner* – still in the process of appropriation of controls, ask others for help or 'work/tasks'. Like the technical aspects, the social ones should be reflected in the modeling tool. One example would be a video-game-inspired system which supports different roles as well as different stages in expertise and maps both aspects to specific tools, e.g. for support, for arbitration or for leading (in other games, leaders can e.g. get access to tools like birds' eye maps for better coordination).

4 Discussion and Outlook

Our analysis resulted in findings regarding *technical* and *social* aspects for playful, educational 3D modeling tools to facilitate early participation in digital fabrication. This includes – but is not limited to – coordination and awareness support features as well as the video-game inspired support for different roles children take on during collaborative 3D modeling as well as their learning and appropriation progress. Our results until now mostly concern *Minecraft*, embedded in western socio-cultural/political backgrounds and will be conveyed into more in-depth implications for design for 3D modeling/printing tools. This research will be supplemented by experimentation with different playful 3D modeling tools. Furthermore, we will continue our contrastive research in the Middle East - It will be interesting to see how the different context there influences practices regarding interaction, roles and choice of projects. Our superordinate goal is to broaden and ground our findings and design implications in a manner appropriate to the, global, spreading and increasingly important Maker culture which empowers and connects people around the world.

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