On Marginalized Children's Self-Expression Through 3D Printing

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ABSTRACT
We introduced marginalized children from two Palestinian refugee camps in the West Bank to Making and 3D printing during a five week in the wild ethnographic study. Our work proved successful in facilitating new modes and possibilities for the creative and empowering self-expression of those children. In this contribution, we report the five central dimensions of 3D printing we found to relate to this success: *Playfulness*, *approachable complexity*, *individualization*, *immediacy and physicality* and *collaboration*.

Author Keywords
3D printing; ICT4D; children; computer clubs; education; self-expression; storytelling; making; field study

ACM Classification Keywords
K.3.1 Computer Uses in Education

INTRODUCTION AND STATE OF THE ART
Digital fabrication technologies like 3D printing or lasercutting in non-professional settings have gained much traction in recent years in practice as well as research – see e.g. [6] for an excellent literature review. Those technologies are accompanied by the emerging formation of hobbyist or semi-professional *Maker*-communities, a related self-identity as well as dedicated physical spaces like Fab Labs or Makerspaces [8, 4]. One of the core aspects of those developments revolves around empowerment: Being able to actually design and / or customize and subsequently physically make one's own physical artifacts has significant potential for creativity, self-expression and innovation [4, 2]. Those aspects are a natural fit for constructive, innovative ways to approach the education of and work with children. One of the most notable and often referenced educational concepts to frame such work is the notion of *constructionism*, which understands learning as the construction of individual mental models embedded in a situative context best facilitated through the actual, physical construction and the sharing of artifacts [5]. Based on this theoretical foundation as well as a growing public awareness (especially for 3D printing) and increasingly affordable machines, digital fabrication technologies are already being deployed and tested in educational settings today [2]. Recently, we even saw the development of the first specialized 3D printers for children[1].

We contribute to this stream of work from an ICT for development (ICT4D) perspective: Our work centers on marginalized, poorer and less educated children, namely refugees in the West Bank, Palestine. Over the course of a five week *in the wild* study, we introduced two children's computer clubs in refugee camps in the West Bank to 3D printing and worked with the kids on projects with individual meaning for them while ethnographically accompanying the process.

Figure 1. 3D modeling (l) and printing (r) in Palestine

SETTING
Over the last 10 years, we have built an international network of computer clubs for children called *come_IN* [13] which is based on the US computer clubhouse project [7]. Multiple clubs are located in Germany and two in refugee camps in the West Bank, Palestine [1]. The premise of all our clubs is that they are open spaces for children (and sometimes adults) to meet, work, learn, play and collaborate on individually meaningful projects. Self-Expression and Storytelling are important aspects of all come_IN clubs [14] (cf. [11] for a study on the power of storytelling via ICT in settings with marginalized populations). The clubs are grassroots-oriented in that they are always established with empirical local grounding and in a bottom-up fashion together with local actors. Furthermore, we specifically address integration and attempt to help it along by bridging the digital divide [12]: Our clubs are primarily located in places where socio-cultural integration is a problem. In Germany, such problems exist e.g. with the Turkish-German community which still faces significant issues regarding opportunities and especially education. The Palestinian clubs, on which we focus on this contribution, are even more complex:

[1] See `www.printeer.com`

During the 1948 Arab-Israeli war, many Palestinians were expelled or fled from their homes in what is now part of Israel, leading to the establishment of refugee camps in the Palestinian territories and surrounding countries (e.g. Jordan). Originally intended to be short-term camps, they still exist today and face unsustainably growing population, marginalization and instable socio-economic structures – some camps[2] have 40% unemployment rates and a population of up to 60% under the age of 17. The camps have a highly sensitive role in Palestinian society in that they symbolize the perceived *right to return* to the pre-1948 land. Hence, broad societal integration of the camp population is politically undesirable – yet, at the same time, camp inhabitants are often treated as second class citizens. Education is basic, provided by the UN relief organization (UNRWA) in gender-separated camp schools. The Israeli-Palestinian conflict is a matter of daily life in the camps, e.g. through frequent raids of the Israeli Defense Forces which often involve violence and in some cases death. Access to ICT and Internet at home is problematic and further hampered by the fact that especially adults are generally not adept at using such technologies.

The two come_IN clubs in the West Bank are in the refugee camps Al-Am'ari and Jalazone which are both located near the city of Ramallah. In both camps, the clubs are located in central community buildings and offer about 12 computer workstations, Internet access, a printer and basic office supplies. Weekly sessions are run by student volunteers from the local university of Birzeit in cooperation with the camp administration. Scratch [10] and similar playful, constructionist approaches to programming and ICT are the most frequent topics covered in the clubs.

METHOD

Between May and June 2014, two of our researchers spent five weeks in the field in Ramallah and brought a Printrbot Simple, a relatively cheap, small, plastic-based 3D printer. In cooperation with the volunteers, we went into the computer clubs in both refugee camps and moderated the club sessions for the duration of our stay. We introduced and demonstrated 3D printing and modeling to the children and subsequently invited them to work on their own 3D projects. As a 3D modeling tool, we used CubeTeam[3]. It is similar to the video game Minecraft in that 3D models are assembled from small cubes in a "Lego"-like fashion. CubeTeam is also collaborative in that multiple actors can work in the same world and even on the same models. The children were free to create their own projects with us and the volunteers available for help. Finished projects were then 3D printed by us for the children and given to them to keep. Our participants were between the ages of 8 and 14 and usually worked in groups of 2-4. In total, we worked with about 20 children (participation was somewhat fluctuating) for about 12 hours of session time. We observed the sessions, took extensive field notes as well as photos and talked to the children as well as the volunteers throughout the process (hampered by the language barrier, our talks were not quite full-fledged interviews). The gathered data was subsequently analyzed using pragmatic thematic analysis [3] in the field as well as later at our home university together with researchers not directly involved in the fieldwork.

After the departure of our researchers, the 3D printing infrastructure was left in place to remotely study the more long-term appropriation and projects by monitoring the Facebook group the Palestinian volunteers use to coordinate their work and share pictures of sessions as well as by e-mail and Skype contact to the volunteers. This contribution draws on both our fieldwork as well as the later remote observations.

RESULTS

Broadly speaking, we observed that the playful, collaborative approach was well received by the children and that they were able to create their first printable models quite quickly (sometimes in considerably less than one hour). This is especially remarkable since they never had anything to do with 3D modeling, let alone printing. In the initial sessions, after our introduction of ourselves and the 3D printer, the children quickly started to explore the interface of CubeTeam and figured out its workings on a basic level with on-request help by ourselves and the local volunteers. After some exploration, testing the functions and some random cube placement in the world, the groups usually started a verbal negotiation process about what to build. Subsequently, they started building, facing some difficulties regarding the interface and the orientation in 3D space[4] but generally with rapid successes. During our sessions, we could observe projects getting more ambitious, e.g. regarding usage of all dimensions: Where they had previously treated the building space more like a 2D canvas, only "brushing" models like their name with no real complexity in the z-axis, the children started to attempt building more complex structures. Not only the models themselves but also the negotiation process became more complex and started to include sketches made with pen and paper and more elaborate planning (see fig. 1 (l)).

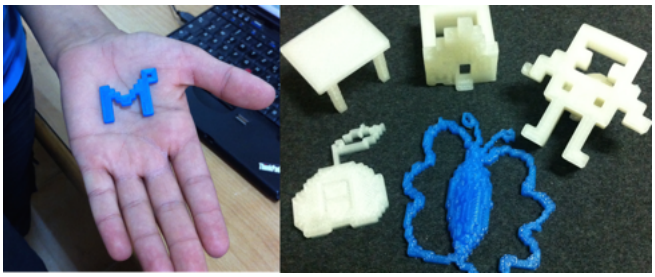

Figure 2. Some sample 3D prints from the field.

The three most frequent categories of projects our children choose were: Their *names* or the initials of names, *buildings* with meaning to them such as a tower with a Palestinian flag on top (inspired by a similar site in Ramallah's city center) as well as *creatures*, either inspired by fantasy / media[5] or

[2]Percentages relate to the camp of Jalazone and are estimates by the camp administration, gathered by our researchers in the field

[3]**www.cubteteam.io**

[4]We are working on another publication specifically about how to build better tools for digital fabrication in educational settings, so we will not address those issues in depth here.

[5]Such as Spongebob, who apparently does not only reside under the sea but also in the Middle East...

the real world (usually their favorite animal). Other projects included furniture for dolls or decorational items. The central theme was always personal meaning, the narration of a story / expression of some facet of the self a value or a need. Some sample prints can be seen in fig. 2. In our analysis, five main aspects which relate to this central theme emerged:

Playfulness

The first aspect is deeply rooted in constructionism itself as well as the approach taken by game-inspired tools such as CubeTeam: Freely building things *you want* from Lego-like cubes while zooming around in a virtual world with your friends is *fun* and actually seeing your creations taking shape in a whirring, whizzing machine is even more fun. This sense of playfulness and ludic exploration seems to be inherent in digital fabrication technologies and is not a new insight in itself but it especially emerges in settings where children usually face dire straits in their daily lives, suffering poor living conditions, limited access to toys and having scant access to play areas. The collaborative and playful tinkering and making resulted in lots of laughter, joy and beaming faces – which in turn sparked motivation: Motivation to come back for the next sessions, to attempt more challenging models and to learn more functions of CubeTeam. This is especially noteworthy because the refugee children frequently exhibit lack of motivation and distracting behavior due to their living and educational standards (as per reflection by the local volunteers, coordinators and camp administration).

Approachable complexity

Through the 3D printer and a playful tool such as CubeTeam, our children had the means to create shapes which would have required significant skills, resources and equipment to make by hand. This allowed for new degrees of freedom regarding self expression and storytelling through artifacts – an example can be found in the butterfly depicted in fig. 2: The girl who built this model really liked butterflies but was only able to draw them previously which she frequently did. Through 3D printing, she is now also able to make their own physical butterfly models which she can incorporate in her playing. This aspect proved to be be especially powerful in the marginalized camps because of the children's usually limited access to tinkering material such as Lego, coping saws, etc.

However, it also has to be reported that not the whole 3D printing operation proved to be easily approachable – 3D modeling worked well (see above), but the 3D printing process itself was beyond the children. It requires putting the finished models through a separate, rather complex software (a *Slicer*) in order to generate toolpaths for the printer. Furthermore, the printer needs calibration and at least some technical knowledge. Hence, we had to carry out the printing ourselves. In some cases, we tried to explain what we did to some interested children but generally, they quickly lost interest because through the degree of complexity involved, such attempts turned into lectures which clashed with the free constructionist atmosphere of the project. Another aspect of this is that current affordable 3D printers are often quite open resulting in us having to stop many prying, curious fingers on their way to dangerously hot and / or moving parts.

Individualization

It is notable that the children also quickly realized that they could not only make things but also customize and individualize them. A group of children figured out that they could model eyelets attached to their finished models in order to make their creations wearable (see fig. 1, left side) – this discovery happened in both camps we worked independently and each time, it spread quickly by word of mouth in the groups. The children expressed satisfaction regarding being able to carry around *their* creations on their bodies and some of them proudly showed off their brand-new bracelets or necklaces fashioned from string and the 3D prints in the next sessions. Individualization of models through inscriptions or favorite motives became also quickly popular. Incidentally, this led the children to discover a basic 3D modeling operation on their own and in an observably intuitive fashion – namely boolean subtracting in order to cut out their names.

Immediacy and physicality

The ability to bring their digital creations into the physical realm was a huge motivational factor for our children and fascinated them. With new groups, there always was the same development: At the beginning when we demonstrated the 3D printer, the children were rather interested but not fascinated yet. We then told them that *they* could make things and we could print them *right now, right here*. However, this did never really sink in until the first kid tentatively showed us her or his model which he wanted printed. After we then initialized the print and the children saw that what we promised was actually possible and one of their own was *really making* something, a significant boost of motivation went through the room, interest became fascination and efforts to build 3D models were redoubled – a short time later, we usually were buried in models to print and were hardly able to meet the demand. Our children really liked being able to take their prints home, to show them to their friends and parents and to explain to them how they had created the models and what they meant to them. This led to a certain continuity in attendance of club sessions (which is often hard to achieve in the refugee camp setting) as well as to conversations of the children with their parents about what they did in the club. Those conversations could actually revolve around the project's objects (the 3D prints), unlike with many previous projects, e.g. with Scratch which the children simply could not show to their parents due to the lack of a computer and / or Internet at home.

Collaboration

As mentioned, CubeTeam is inherently collaborative in that users can work in the same world and at the same models. Most children expressed curiosity about what their friends did and were able to see it directly in CubeTeam, which generated a certain awareness and had beneficial effects (e.g. dissemination of possibility of the loopholes on models mentioned above). Virtual live collaboration on the same model did not happen – instead, the children rather changed or expanded groups in real life depending on current interest. However, a few children figured out how to copy models which led to one child starting a model and another one (in one case even at the other refugee camp) copying and then modifying it. Notably,

there were also inter-generational collaborations: The older student volunteers were also rather fascinated by the technology and some of them started not just to supervise and help but to actually work together with the children. A very powerful and expressive example of such a project (which was built after we departed) that also serves as testament to the local conditions can be seen in fig. 3 – the 3D model itself was downloaded from the Internet but its coloring and the way it was put together was done together with the student volunteers and was inspired by the recent Gaza conflict.

Figure 3. 3D print of a rocket on a truck.

DISCUSSION AND OUTLOOK

We believe it is safe to state that 3D printing and, more generally, Digital Fabrication constitute powerful and innovative tools for the self-expression of children. We showed that, especially in ICT4D settings with marginalized populations, they provide not just instruments to unleash creative potential in children but can also serve in a boundary-object-like capacity, sparking meaningful collaboration and conversation, e.g. between children and their parents. Through its capabilities for playfulness, 3D printing evokes significant motivation and lets children design and create or share and remix *their* very own, individualized artifacts they can actually take home, show off and use to tell stories with and about them (cf. e.g. [11]). Through those playful steps, there is also major potential for bottom-up, constructionist education and learning, aspects which are sorely lacking and needed in such dire settings as in the refugee camps we worked with, not least to help bridge the digital divide especially prevalent in such situations.

As we showed, there are also problems – most notable is the disruption between 3D modeling and printing. We believe the whole process and consequently, the aspects of empowerment and self expression would work even better if modeling and printing were better integrated and especially the latter part of the process would be easier to understand, appropriate and use (cf. [9]) – an area in which HCI can and should help. We need more studies in this field to ground work towards more human-centered, user friendly and sociable tools for digital fabrication.

For our future work, we will continue to remotely follow the appropriation process and the emerging 3D printing projects in the Palestinian come_IN clubs. We also will expand on the aspect of collaborative, expressive storytelling in an international fashion by fostering collaboration on 3D printing projects between our German and Palestinian clubs. This could be especially powerful because meaningful artifacts created by children thousands of kilometers away can be printed *right here* and convey a physicality and directness impossible to achieve by purely digital collaboration. Furthermore, we will extend our fieldwork to other digital fabrication technologies such as lasercutting and -engraving which will give the children we work with even more diverse means for learning, tinkering and self-expression.

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