How 3D-printing can support and help children with Visual Impairments in education. An Example.

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ABSTRACT

Rich media is becoming more present in everyday education. Today, this includes interactive and multimodal 3d printed models that are finding their way into our classrooms. All this directly impacts the accessibility of education for persons with Visual Impairments (VI).

We have experienced that 3d printing can greatly benefit persons with VI and offer them new opportunities for multimodal exploration and learning that goes far beyond classic paper, webpages or other forms of digital learning and even beyond traditional 3D printed models. Today, creating rich 3d printed models and combining them with conventional modalities can create accessible educative experiences that have not been seen before and that can be easily produced at low cost by every school.

In this paper, we present the preliminary conclusions of our fieldwork study into 3d printing BRABO.

1. INTRODUCTION

We have five senses to choose from in daily life. Only a very small part of them are used in the educational context where we mostly focus on sight and hearing. When sight is taken away, the modalities students can choose from are very limited.

For persons with VI, touch and sound are senses that are often used to compensate, but what about in education? There are a lot of haptic materials available, but education is changing fast and in practice we see that haptic solutions are replace more and more by text descriptions. But does text offer the same information and learning experience? The same question applies to tactile drawings that are 2.5D.

It is important to note that most VI read tactile drawings and 3d models sequentially, piecing information together to form a whole. Their strategy of exploring a model differs significantly from sighted people. Translating an image one on one to something haptic does not automatically make it accessible for the VI as it loses visual aspects like color, scale, perspective etc. without replacing them with tactile information or alternatives in other modalities.

With 3D we can create a haptic experience that represents reality. The problem is: 3D models in education are designed for sighted people. Most designs do not address haptic information and are difficult to adapt.

With the rise of 3D printing adapting and personalizing 3D models has becomes easy and cheap. 3D printing allows users to create physical models from digital models, combing the digital and the physical. There is no (expensive) production chain needed to create a 3D model. You only need a digital blueprint and a 3D printer. You are your own factory.

In this paper, we describe the making of a basic but not less necessary 3d printed tool: the BRABO, a mathematics device for blind students.

2. DUAL-CODING THEORY

3D models allow for the use of multiple senses. While a student uses the haptic model, a teacher adds context and information enriching the experience. The dual-coding theory [1] describes stimulating the non-verbal (3D model) and verbal (teacher) in the brain together, thus enhancing the educational experience. Our colleague Esther Rieken applied this to tactile drawings. Her research [2] shows improved results when tactile drawings are used in comparison to only plain text. Though Riekens tactile drawings are only 2.5D it is the haptic information that allows for better results.

3. 3D PRINTING

3D printing is not difficult. It uses additive manufacturing, which actually means combing materials to create something new. 3D printing is one of the greatest examples of additive manufacturing that you can even do in the classroom. In our research we focused on Fused Deposition Modelling (FDM) that works by melting plastic and stacking this on top of each other in the shape of the model. FDM is the cheapest and most accessible method for 3D printing.

Based on a digital 3D model or a 3D scan it is easy to create and slice a 3D file. Slicing is adding physical properties to the print. This is translated to Gcode which holds the X. Y, Z coordinates for the print (among other things). Besides a basic knowledge of the above no other skills are needed to 3D print. This empowers everyone with access to a printer to create 3D models by simply downloading a model from the internet or making one yourself with simple and online 3d software.

4. DEVELOPMENT OF THE BRABO

BRABO stand for braille bow, a protractor for people with visual impairments. It allows users to not only measure angles but also draw them. It is not the most spectacular 3d model and there is no need for multimodality but the demand by VI was high so we worked on it together. The existing BRABO was heavy and large, made out of 5mm Plexiglas with iron arms sized over 100 x 200 mm. It costs about 25 Euro and there is a long waiting list. We developed a 3D printable model and tested that with 2 end-users (blind students 12-16 years old actually using the BRABO in school). We went through four iterations in a period of 8 weeks applying the comments and findings into the final model.

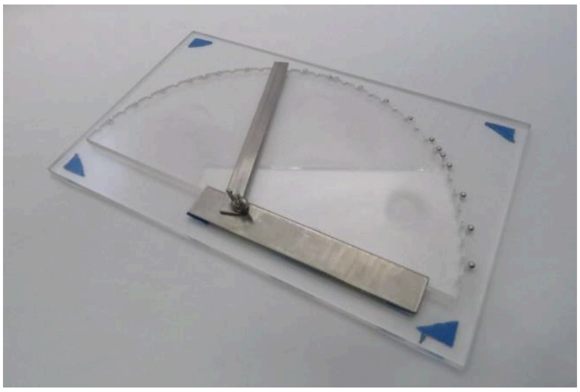

Figure 1. Older heavy version of the Braille Bow.

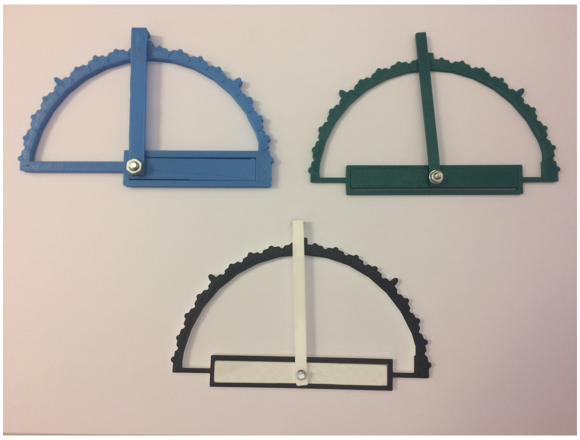

Figure 2. Interactions of the new 3D printed BRABO. Version 1 to the left and the final version below.

During the the iterations, we made it smaller and easier to use. We also limited the amount of material making it cheaper to print (about 1,80 Euro). And we changed the arms because students kept misplacing them the wrong way around. This in turn also helped the accuracy because the point of measurement remained more consistent with measuring angles below 45 degrees. We also added color as additional information for VI who can see color.

But most important, the BRABO 3d file can now be downloaded for free and printed. The latest version can even be ordered online if you do not yet have a 3D printer (Korneels hub prints them at 3Dhubs.com, an online printing service).

Over 50 BRABO's are currently used by persons with VI all over The Netherlands.

5. PRINTER SETTINGS

The physical properties of a 3D printed modal are assigned during slicing. These settings determine the strength, printing time, amount of material and overall quality and feel of the model. FDM printing also allows for several materials to be used on the same machine.

To see what 'feels' best for VI people, we created a model that holds three shapes: angled, round and organic. All 3D models have at least one of these shapes. We printed 5 models in total at: 0.2, 0,1 and 0,05mm layer height and two more models that we treated after printing at 0,2 layer height: ABS treated with acetone and PLA with a XTC 3D coating. We tested with 5 VI students ranging from 15-17 in age, three being blind and two partially-sighted at Bartiméus in Zeist.

The results show a preference for the models that were treated after printing. It also showed that the shape and quality are connected. The angled models scored better on every model while the organic and round shapes scored lower on a smaller layer height.

The direction the model is touched also relates to the haptic experience. Feeling along the lines of printing made it hard to feel the difference while going against the printing lines gave a rougher experience on lower quality.

6. CONCLUSIONS

Based on our finding and experience with 3D printing for people with visual impairments, it can greatly impact education and not only increase the accessibility but also the learning results. There is still a need to empower educators to help them create 3D printed solutions or even just download them from the internet. 3D printing allows for personalization and adaptation at low cost.

While higher quality gives VI persons a better haptic experience, it also depends on the model itself. Printing time and materials influence the feel, but also the cost of a 3D printed model.

We're just at the start and a lot more research is needed to show the added benefits for persons with VI in education. Also more research is needed into multimodal interaction with 3d models adding sound, vibration etc. There is also a need to share more models that are specially designed for VI persons. And most of all, we need to empower educators to use, make and share 3D models.

We developed TEP, a method to connect 3D models to an accessible website that holds all the educational information. TEP uses NFC chips that can be put on any model with a link to the TEP website. This way every model can be made interactive and users can independently explore 3d printed models. TEP even plans to help them with tactile strategies. Further development and testing will start this summer.

REFERENCES

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