Alternative 3D Education for Children: Course Design of 3D Printing Interactivity for Beijing's Primary Schools.

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ABSTRACT

New forms of extracurricular programs on creativity in primary schools are bound to emerge in the near future due to the popularization of 3D printing technology. This paper acknowledges the current situation of development of the extracurricular creative programs in China's primary schools, underlining the importance to introduce 3D printing and rapid prototyping technologies in the extracurricular activities. To sustain this argument, the activities of several creative 3D printing courses will be explained and discussed in the paper. Moreover, it will be shown how the particularity of the courses came from the combination of 3D printing technologies with culinary arts, bringing together traditional recipes with immersive and unexpected culinary experiences.

The paper is divided in three parts. In the first part the state of the art of the extracurricular activities in primary schools in China will be shown. The second part will introduce the educational action research as the main methodological framework used in the teaching activities. In the third part the examples will be presented emphasizing on the importance and advantages of experiential learning. The conclusion will present the level of satisfaction of the students, and the benefits of introducing rapid prototyping technologies in the primary schools.

Author Keywords

Beijing, 3D printing, food DIY, educational action research, extracurricular program, primary school

CURRENT SITUATION OF EXTRACURRICULAR ACTIVITIES IN PRIMARY SCHOOLS

There are various extracurricular programs in China's primary schools including Drawing, Bubbling Math, Ceramic Arts, Flower Cultivation, Cooking, Music, Physical Exercise and so forth. Taking as an example Beijing Sun-Li-Tun Primary School, out of a total of 400 students, only 59.6% attend to extracurricular activities (source?). In the year 2015, the Ministry of Education established a program of incentives for the middle and primary schools to open extracurricular art courses and ideally these courses can make up 11% of total class time by the end of the year [1]. Despite the encouragement from the government, the number of these courses implemented in the schools raised less than expected. In this sense private schools have introduced more easily 3D printing activities in their curriculum. Moreover, these activities are more popular with both students and parents. The above evidence shows the lack of extracurricular courses in our primary schools, but also indicates a potential for improvement.

Digital Technologies to Support Primary School Education

In the last decade 3D printing is more and more present in children's extracurricular programs in so far that it became a news reports topic worldwide. Digital fabrication and 3d printing technologies have been used to support social inclusion [2], encourage digital literacy in schools [3], addressing special education issues for students and teachers [4] and has been widely recognized as improving the STEM education worldwide [5]. Moreover Jeroyj 3D Printing (http://www.nanjixiong.com/) published Magic 3D Printing in 2014, which marks the beginning of children's 3D printing education in China. As China's first simple tutorial to 3D printing, this book, together with the innovative commercial practice, reinvigorates science education in primary schools [6]. In this very year, a 3D printer for children named Printeer was also available on crowd funding website Kickstarter. The printer was targeted to secondary and primary students and can printout the components and parts to clone itself. As such, children can fabricate the components and then assemble an identical printer by themselves (See Fig. 1). In this way, children get to know the 3D printer by firstly understanding how it is made [7].

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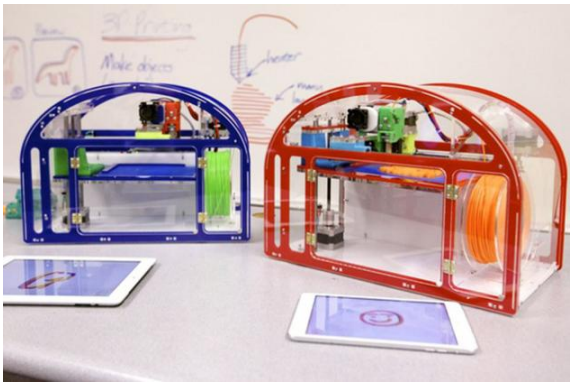

Figure 1: "Printeer" 3D printer

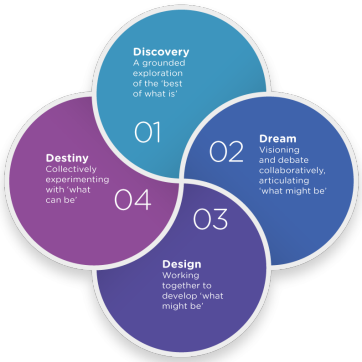

Figure 2: The 4D Action research cycles

THE INTRODUCTION OF 3D PRINTING IN BEIJING PRIMARY SCHOOLS

With 3D printing and rapid prototyping techniques shifting from designers' studios to the classroom, a mature and robust digital fabrication educational system is gradually formed. "An important production tool for the third industrial revolution", 3D printing is recognized in the NMC Horizon Report, 2013, and listed by NMC for the first time as a creative technology, which will be popularized and applied in educational field in the next 4 to 5 years [8]. An increasing number of broadcasts show that 3D printing education is starting to step into science centers, museums and schools [9]. In 2014, American company 3D System carried out a MAKE DIGITAL plan, which supplies an integrated system with various resources such as tools, software and tutorials. Thus, a mature and sound 3D printing educational system is gradually formed [10]. Such kind of teaching resources and products introduce 3D printing to primary school classes in a simple and interesting way.

In order to understand the evolution of this system, a research methodology needs to be employed. In the examples presented in this paper, the group of teachers and researchers involved in the development of the pedagogical content, decided to apply which allows the hybrid role of practicing design educators and researchers [11] [12] and stresses out the importance of the social interaction between all the participants: educators, children, their parents and other partners [13]. Moreover, as Kemmis suggests the action research methods allow the educators to "interpret current culture within a historical context as well as through the immediate process of action and reflection" [14].

3D Printing Technology as Part of Extracurricular Programs

Given the speed of the rapid prototyping techniques the dynamic structure of the educational action research methodology is particularly relevant because it allows the ongoing adjustment to the incoming circumstances (See Fig. 2).

The positive results of experiential knowledge have been shown in several literatures [15] [16] [17]. More recently it has been demonstrated that the introduction of 3D printing in primary school programs has many advantages over traditional ones. First of all, the old knowledge is taught in novel ways, moreover, it's also good to knowledge integration of different disciplines [18]. Most importantly, 3D printing helps cultivate students' all-around quality, such as design and problem-solving capability, critical thinking etc., and gradually, helps train students to think abstractly. In the following parts we will explain how the action research methods have been applied in three different 3D printing classes helping the improvement of the course content and refining the quality of the interaction experience.

What does 3D Printing Technology Do in Beijing's Primary Schools?

With the plan of 3D Printer Promotion Campaign, carried out by Beijing Municipality in 2015, many primary schools have chosen to introduce 3D printing classes. Currently dozens of primary schools have already been equipped with 3D printers [19] and are on the way to develop educational programs based on digital fabrication techniques. This initiative is supported by the Committee of 3D Innovation Education through a pilot project in which 100,000 printers will be donated to schools in Beijing. The campaign will then be expanded gradually nationwide [20]. In addition, private training institutions, such as Supiller and High House, have also developed to a certain level. With promotion of their commercial courses in primary schools, they have become pioneers in 3D printing education. This encourages not only the introduction of a brand new educational content but also its integration with the existing extracurricular activities.

Introduce 3D Printing to Extracurricular Culinary Activities

Similar to 3D Printing Class, Food DIY cooking class is another type of extracurricular activity that shares a same goal in education. In these classes, students learn about food culture, cooking methods from raw materials, nutrition facts etc. In first-tier cities like Beijing, there are culinary classes offered by commercial institutions like KindyROO,

Beidaxueyuan Kindergarten, and Family Box (See Fig. 3). Aiming at enhancing parent-child relationship, Family Box tries to cultivate children's independency and practical abilities. Parents are encouraged to participate to make sandwiches, cookies, tarts or ice creams with their kids in this way training them to play the same role at home.

Figure 3: Students in the culinary class at the Family Box in Beijing

Nevertheless, usual Food DIY classes in China focus more on traditional food making without using 3D printing as a new teaching method. In America, although 3D printing in Food DIY is not widely used, some individuals have already tried in informal settings. For instance, Barnacules Nerdgasm, a video blogger devoted to innovative 3D printing, recorded series of 3D printing Food DIY videos showing how 3D printing moulds can be created with simple apps, and animal-like cookies can be casted and then baked in the moulds [21].

DING DING PRINT IN BEIJING'S PRIMARY SCHOOLS

As part of the BIFT Project of Extracurricular Programs for the Primary Schools, Ding Ding Print project (See Fig.4), is an extracurricular class designed by faculties from Beijing Institute of Fashion Technology. The main focus and objective of the Ding Ding Print is bringing an innovative content to Food DIY by introducing 3D printing to the existing culinary courses. During the class, students are taught the rapid prototyping techniques by first creating food moulds and tableware with 3D printers and then baking cookies in their own moulds. This well combines children's interests and creativity, inspiring more of their leaning enthusiasm.

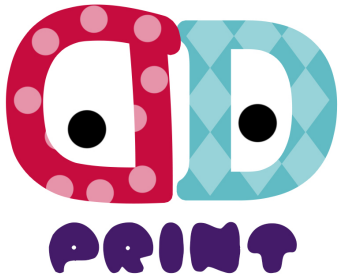

Figure 4: Logo of DingDing Print

Principles in Designing the Class

By analyzing the relationship between food and life, Ding Ding Print combines in an innovative way the advanced 3D printing technology and practical activities. For this reason, the class offers an enhanced interactive experiential learning highly welcomed by the students and parents. The knowledge offered in the class, structured on Food Storage, Food Production, Food Design and Food Consumption, was predefined and organized by teachers of the courses (See Fig. 5) in order to make sure that children master the whole process of cooking upon finishing the class. Compared with generic 3D printing classes available in Beijing, this class shows more concern for culinary arts rather than printing as a way to emphasis on 'creation' rather than 'building' or with 3D printers.

Figure 5: The course Roadmap

To "Create" But Not "Build"

Before Ding Ding Print was available, we have tried designing the class with 3D App Paintshop as a teaching tool but finally the result proved that it's not the best choice. (See Fig. 6) The Paintshop helps printing small objects like rings, necklaces, characters but these types of objects are to some extent out of touch with our goal, which is to convey food culture to students. Similar to the modeling software 3D Max, Paintshop is with less connection to food while in use

and serves only as a tool to "build" models with little thematic linkage.

Figure 6: **The Interface of App Paintshop**

In contrast, the class in Ding Ding Print emphasizes more on "create". One of the inspirations for designing the class content was the work of Milan designer Astrid Luglioz who published series of 3D dinning wares in CASAfacile, among which the Appetizer Holder stands out with exquisite and simple design style [22] (See Fig. 7). Much as in Luglioz projects, the core concept of Ding Ding Print explores the relationship between food and life.

Figure 7: Objects designed by Astrid Luglioz

The Printing Classes

Until now, Ding Ding Print has been designed three courses to grade five primary school students. From a research point of view, the course sequences have allowed the educators to compare the results and adjust the educational content according to the feedback received from the participants. In the class, students together with their parents designed and printed out Chinese food moulds to produce their foods and to share their creativity by decorating them. Throughout the whole designing, production and serving experience, students' social abilities were visibly improved and team spirit enhanced. This was confirmed by the enthusiasm showed by both students and parents when the final results were displayed and tasted.

Compared with other 3D printing courses available in Beijing, "Ding Ding Print" stands out in four innovative aspects:

1. 3D Printing As Part of Life Style
2. Introducing Chinese Food Culture
3. Encouraging Full Parental Engagement
4. Replacing Technology with Entertaining and Fun

Making Mooncakes (the First Class)

Combined with traditional Mid-Autumn Festival, the course encouraged students to make and bake their favorite mooncakes. The innovative point of this class is that students can choose moulds according to their own will from various existing ones printed by 3D printers, not being confined to traditional commercial moulds. Under the guidance of a pastry teacher, they made and baked mooncakes of different tastes. At the end of the class the kids shared their achievements with their parents, who were deeply moved (See Fig. 8).

Figure 8: The results of the Mooncakes class

Making Rice Cakes (the Second Class)

Combined with Chinese New Year ritual, this class aimed to help students understand Chinese New Year in relation with the traditional dessert. The innovative point of this class is that students can conduct different food designs freely with 3D printed moulds and fruits. This class, was more flexible in terms of the combination of 3D printed models, and therefore left more space for students' creativity (See Fig. 9).

Figure 9: The results of the Chinese New Year cooking class

Making Cakes (the Third Class)

In the third class the students had a more complex task combining 3d printing with fondant cakes technique. In the first step the teacher explains in detail the 3D printing technology and then encourages students to pick up their favorite moulds. Using the printed food moulds, students decorated the base, creating colorful and sophisticated cakes for the Christmas party. In this third class the parental involvement was essential and brought a higher degree of entertainment spicing up the entire learning experience in the class (See Fig. 10).

Figure 10: The results of the Christmas cake class

Feedbacks

According to feedback from teachers and over 70 students, we find out that: More than 80% of students like the format of Ding Ding Print; over 90% of students were satisfied with the classes; More than 60% of students like making food more than 3D printing; and up to 40% of students like the Q&A sessions (See Fig. 11). We summarize up from feedbacks the following key points.

1. These classes are well considered by both teachers and students.
2. Students quite enjoyed to design tools and moulds by themselves.
3. Students found particularly interesting the social interaction, especially when the teaching method involved telling stories.
4. The way of introducing 3D principles in videos is favorably reviewed.
5. The class reached beyond the targeted students stirring the interest of the students from other classes, such as the ones from Robot Club.
6. Part of the student wanted to reiterate the experience and the whole process of 3D printing so as to become able to develop more complicated moulds.

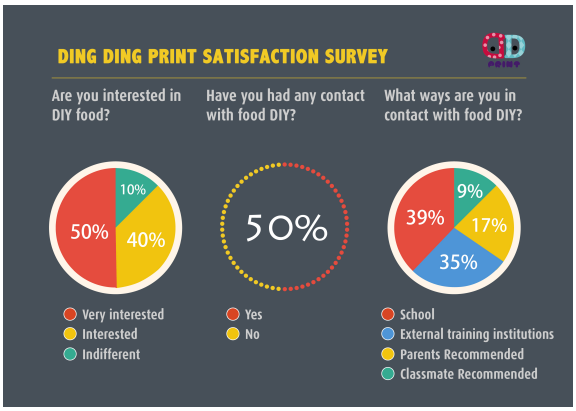

Figure 11: Ding Ding Print satisfactory survey

CONCLUSION

Taking Food DIY as a medium of introducing 3D Printing knowledge, the classes combine very well food and design, two essential parts in our life. What's more, another main purpose of the classes is to draw attention to the variety of food culture throughout China. Such classes not only aim at preserving these cultural heritages for future generations, but also giving them a reinterpretation within the context of today's growing technology.

The action research methodology applied in the innovative and hybrid setting of 3D printing and culinary classes enabled the educators to reflect on the actions taken and their results and gradually improve the educational content making it more challenging from technical point of view but also more rewarding in terms of acquired experiential knowledge.

Next step of Ding Ding Print is to develop an App that is going to help design printable 3D storages, food moulds, dinning ware, and dinning decorations on mobile devices such as smart phones or PADs.

By acknowledging the quality of the results of the classes, the educational project presented in the paper helped to advance the creation of a new educational system based on digital fabrication techniques and focused on 3D printing. It

is our hope that the 3D printing education in China's primary schools will be flourishing in no time.

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