ABSTRACT

Nowadays, creativity is a growing value due to its close relationship with problem solving and entrepreneurship. In this paper, we present the actions that are being carried out in the Children’s Education Workshop of the University of Cadiz in relation to the promotion of creativity with 3D technology. The actions are being carried out in both Higher Education and Early Childhood Education (ECE). On the one hand, we are working with the design and creation of didactic material with 3D technology with our students in initial training and future pre-school teachers, and on the other hand, with children from pre-school stage through the theory of Gardner’s multiple intelligences and 3D technology.

Key words: Creativity; Early Childhood Education; Higher Education; 3D Technology

INTRODUCTION

Childhood Education Workshop of the University of Cadiz was initially created as a space to promote the practice of our students of the Childhood Education degree. We often receive visits of pupils from pre-school stage at this workshop. The need to carry out a very close relationship with pupils from this stage is due to the fact that our students of the degree do not attend classes in the schools of Cádiz until the sixth semester (the second semester of the third
year). Therefore, we receive children in the Faculty in order to give them experience for developing professional competencies.

Today, in addition to its initial function, the Childhood Education Workshop has become an open classroom that is frequently attended by pre-schoolers and where the teaching staff with their university students, research new ways of approaching the teaching/learning processes with pre-schoolers.

Since the last academic year 2015–2016, we have been carrying out the design and creation of didactic material with BA students, as well as initiating future teachers in makerspaces\(^1\) philosophy and DIY mentality, trends which have recently gained a considerable amount of popularity.

Numerous universities are creating makerspaces as interdisciplinary centers where students can experiment and design prototypes, such as at the University of West Virginia, Houston, Arizona, etc. A similar example is a Harvard professor, Karen Brennan, who has turned her classroom into an open and welcoming environment that engages students in research and creativity. The space/laboratory of creation has replaced what used to be a traditional classroom. We agree with her in stating that “it is important for students to be creative, not just consumers of technology” (Brennan, 2014). Today, most students, including “native digital” experts, are technology consumers.

Nowadays, this technological progress is leading teachers to creating new learning spaces or adapting the existing ones. And so we do at the University of Cadiz. The aim of this work is to popularise the actions that, as teachers of the Childhood Education Degree, we are developing both in our university and in a pre-school in Cadiz.

3D PRINTING AS AN EDUCATIONAL RESOURCE

The advance of new technologies is transforming societies and, therefore, education. It is a great challenge for educators to know, understand and implement these new advances in the classroom, not only by changing the environment in which pupils learn, as it often happens, but also, in the case of the Faculty of Education, promoting the development of new learning, skills and

\(^1\) Workshops open to the community for the creation of prototypes and inventions with new technologies.
abilities in our students, providing them with new tools that in the future can be implemented in their classrooms.

3D printers are machines that allow to generate objects of different materials (plastic melt, resin, metal, powder, etc.) from digital files. This technology has also come to be called rapid prototyping (Canessa, Fonda, and Zennaro, 2013). The cheapening of this technology in recent years has allowed us to think about its use in educational contexts (Saorin, Torre Cantero, Melian, Meier and Rivero Trujillo, 2015).

Already in the 2013 annual report from NMC\(^2\) Horizon Project, it was estimated that 3D printing would be soon widely adopted in the educational field. According to this report, digital manufacturing would have an important role to play in education, science and creative research, and it ensured that 3D printing would become one of the trends in higher education within four to five years (Johnson, Adams Becker, Estrada and Freeman, 2013). The 2015 report states that the potential is even greater as this type of technology is becoming increasingly accessible:

> [...] Makerspaces advocates the benefit of students participating in solving higher order creative problems through a practical approach to design, construction, and iteration. The question of how to renovate or reuse classrooms to meet the needs of the future is being addressed through the concept of makerspaces or workshops that provide the tools and learning experiences needed to help people carry out their ideas “(Johnson, Adams Becker, Cummins, Estrada, Freeman, and Ludgate, 2015).

3D technology offers teachers new ways to approach the teaching/learning process. From this perspective, the 3D printer opens up a range of possibilities for teachers that until now were difficult to cover, using this tool for the development of entrepreneurship and creativity in their pupils, as well as when creating new didactic materials. As Zabalza and Zabalza (2011) point out, the challenge facing contemporary early childhood teachers is to link their training with the acquisition of competencies that are effective in improving the quality of education. Assuming this premise, our students learn the handling and design of 3D technology, taking into account the double function of educa-

\(^{2}\) A research project designed to identify and describe emerging technologies that can have an impact on learning, teaching and creative research in Higher Education.
tional achievement that we give to this technology. Therefore, the learning objectives of curricula are, as we have already pointed out, specified in two main areas:

1. On the one hand, this tool becomes an educational resource of Higher Education as it has the possibility of developing didactic materials. For the design and creation of didactic material, they learn how to use and manage 3D design program Sketchup.
2. On the other hand, it is the type of learning which will serve as a resource in the performance of their future work as teachers by providing the opportunity to know and learn this new technology, which you can use with pupils in the classroom. In particular, they work with an adapted design program called Tinkercad.

3D AS AN EDUCATIONAL RESOURCE IN HIGHER EDUCATION

3D modeling and design was a technology reserved for experts and required long and expensive learning as well as advanced technical equipment. The price of the programs was very high and only accessible to large centres, companies or universities (Caño, de la Cruz, and Solano, 2007). This scenario has changed since 2006 with Google’s free access to the Sketchup design program. Sketchup is a multiplatform program (PC and Mac) with a free version, which offers us the possibility of introducing ourselves in 3D modeling with little knowledge and in a very short time. It has a friendly interface, with a small number of intuitive commands that allows fast learning. Due to these characteristics, this program has been used in educational environments in subjects related to drawing and for the improvement of spatial vision (cf. De la Torre, Saorín, Carbonell, Del Castillo Cossío, Contero, 2012).

Thanks to the acquisition of four 3D printers, the Early Childhood Education Workshop has become a space to create and invent prototypes with this new technology (makerspaces) where our students acquire autonomy and confidence in making the materials themselves (The Do It Yourself mentality).

As objectives of this activity, we suggest:
1. to provide students with the possibility of learning in this new technology for the development of ECE materials by themselves,
2. to promote the development of creativity,
3. to promote the use of this technology with ECE students, once the teaching staff in training develop their expertise,
4. to provide students with spaces and tools that favour the development of activities that demand teamwork and collaborative work.

With the Sketchup program, our students learn to design new didactic prototypes that are necessary for their daily work in the classroom as future pre-school teachers. The students work in groups to design and develop prototypes that are not on the market or difficult to acquire, designed for a specific activity, thus becoming a tool that promotes professional development. With this printer, one may improve the complexity in design, originality, shapes and textures without limits.

Its potentialities in the creation of teaching materials in ECE are multiplied by the possibility of creating specific didactic material adapted to the specific needs of pupils of different abilities, thus facilitating their teaching/learning process and, in turn, favouring and improving attention to the diversity of the classroom. Finally, the use of the material designed is tested with pupils of a particular stage relevant to the ECE workshop. It is evaluated and tested in order to take into account other variables of use such as: attractiveness, user-friendliness, safety, etc. and that it fulfills the educational purpose for which it has been developed. Although these aspects are taken into account from the beginning of the design, pupils tested to suggest possible improvements.

Among the materials that have already been created we have “The Labyrinth of the Return to Calm”, i.e. games and machines for adding and subtracting based on the ABN method of learning mathematics (Algorithm Based on Numbers).

3D AS AN EDUCATIONAL RESOURCE IN EARLY CHILDHOOD EDUCATION

Helping children to develop their full potential is essential educators as they are developing their inherent skills (Diniz, Pocinho and Almeida, 2011). Intelligence, creativity and entrepreneurship are fundamental skills in contemporary societies to create a new perspective and improve future life. The importance of creativity for education is evident, so Skinner (2007) states that giving children the opportunity to experience creativity will allow them to: make
connections, express and challenge ideas, solve problems, develop self-esteem, etc. In a more global perspective, Dino (2015, p. 139) states that “the ability to produce and implement useful new ideas is rapidly becoming a fundamental attribute for harnessing knowledge and increasing the quality of life”.

In our opinion, the use of these printers from the first years of schooling is very favourable. Today, all children from a very early age are related to their technological environment, in part promoted by parents, who do not want their children to be left behind, and in part because of the fun and attraction that mobile phones, tablets and computers provide for them. It is all about creating an accessible technological environment that from the first years of schooling allows children to physically create toys, letters, puzzles, etc. 3D printers allow them to learn in a different way, to create real things, to bring ideas from imagination into physical and real world, thus, connecting the virtual and tangible worlds. The new emerging technologies, such as 3D printing are an intrinsic part of contemporary life. 3D printing promotes motivation in pupils and allows them to go beyond theoretical concepts to practical products, which has an extraordinary impact on children’s imagination, because their ideas can be transformed into real-life objects (Szulzyk-Cieplak, Duda, and Sidor, 2014).

It is common for 3D design programs to be directed at engineers or specialists, i.e. adult recipients. In recent years, software adapted to young people and teenagers who do not need too much training has been developed, which makes it easier to use it in the classroom. In addition, more recently, free programs have appeared that can be used by children. One example is Tinkercad, which is simple to use, attractive in appearance and, with a few hours of training, the youngest children can acquire a lot of dexterity in its use. The designs are very basic and are based on direct design options (geometric shapes, letters, symbols …) that appear in a series of drop-down menus in the right area. With them, pupils can create simple objects to make toys, prototypes, home or classroom decoration, jewelry and an infinite list of possibilities. Thanks to the different 3D design programs adapted for the different educational stages, we can initiate ECE stage pupils in 3D design.

With the little ones, the learning objectives should be:

1. to promote the development of creativity,
2. to provide children with autonomy and self-confidence,
3. to promote problem-solving skills,
4. to promote self-esteem,
5. to develop outstanding intelligences of each pupil.
With this proposal, we have participated in a European competitive call, more specifically in the K2\textsuperscript{3} call which has been highly valued. It aims to promote creativity through Gardner’s multiple intelligences with 3D printers in pupils with economic difficulties, promote equity and inclusion by promoting new learning and opportunities for pupils from disadvantaged situations. Through concrete activities, 8 multiple intelligences will be elaborated (linguistic, kinesthetic, musical, spatial, logical-mathematical, intra- and interpersonal, natural and scientific intelligence). Activities with children will include “Creativity Day”, where children will develop their creative skills and the 8 intelligences emphasised by Gardner’s theory.

This project is currently in its initial phase and will be implemented in schools in Poland, Portugal and Spain. A teaching manual or guide will be published shortly, so that any teacher interested in using this new technology can do so in their classrooms.

CONCLUSIONS

The advancement of new technologies offers teachers new tools and new ways to approach the teaching and learning processes. From this perspective, 3D printers offer the possibility of creating the material we need in the classroom and promoting creativity and entrepreneurship among our learners, values that are on the rise in contemporary societies. We understand that it is our duty as trainers to keep abreast of the latest technological advances and to investigate their possible applications in the classroom.

It is for this reason that our Early Childhood Education Workshop is understood as a space that must be adapted, reinvented and open to educational research with the maxim of trying to adapt to pupils of the future. For this purpose, we have made four 3D printers and training courses available to ECE degree students at the University of Cadiz, providing them with the possibility of acquiring new skills that contribute to promoting their use in ordinary classrooms.

\textsuperscript{3} Dream Makers K2 Project: 2016–1-PT01-KA201–023005
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