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3D TECHNOLOGY AS A TOOL TO IMPROVE THE WELLBEING OF CHILDREN AND ADOLESCENTS WITH AUTISM SPECTRUM DISORDER

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Summary. The arrival of new technologies has allowed us to participate in the ongoing globalization process. The need to adapt and to apprehend these new ways of life is a continual challenge. This study aims to analyse the possibilities of using 3D technology among children with Autism Syndrome Disorder (ASD) according to creativity and multiple intelligence approaches. The basis of this project is to use creativity as a way to improve children's wellbeing and their abilities to cope with developmental tasks in a 3D virtual and real environment. In this paper the theoretical psycho-didactic framework of using 3D technology in the optimisation of the development of younger generations with ASD has been presented. Based on past experience, the role of 3D technology in supporting children and adolescents was noticed (N = 40, age 5–16 Portuguese, all with ASD and one parent). This is the challenge to training new emotional and behavioural strategies undertaken by participants in coping with different tasks and improving wellbeing, satisfaction and communication in families, particularly their confidence and self-esteem, communication skills and creativity. The study had an exploratory and pilot character (first and second wave of study). The study used qualitative methodology. The preliminary results are shown on the basis of the parents' and teachers' reports. They noted the development of social skills and interests in the children with ASD. Moreover, the parents and teachers noticed the improvement if the communication after the training.
Key words: ASD-Autism Spectrum Disorder, 3D printer, creativity, development, joint involvement episodes

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Introduction

Rapid technological changes have drastically transformed the conditions of human development. Network participants can create their own worlds to suit their needs. The created worlds may be an alternative to reality, and the network user may switch back and forth between the real and the virtual domain while retaining his or her core identity. A person may not feel psychologically attached to the actual physical location where that person is staying; on the other hand, someone staying physically close to us may actually live in a world that is unattainable and distant, because it is artificially created. As life environment has been changing rapidly, recognized models of development (e.g. the adequacy of the concept of developmental tasks; Baltes, Rösler, Reuter-Lorenz, 2006; Arnett, 2007; Trempała, Cieciuch, 2016) or notions used in psychology (Sampson, 1989; Kowalik, 2015) are being questioned. Developmental psychologists are studying the problem of insufficient knowledge and a lack of efficient tools for the measurement of psychological processes connected with functioning in a world that is variable and unstable in different contexts (amusement, virtual, family life, professional life, etc. cf. Farnicka, Liberska, 2015).

The use of digital devices has not only altered the ways in which we communicate, organise information, search for knowledge and accumulate it, but it has also modified our time-spending habits. As a result, we have witnessed changes not only in the way people think about the world (content), but also in the thinking process as such. For example, it has been observed that computer games have influenced cognitive processes of their users. Peripheral vision and attention switching functions are improved, multi-tasking dominates, mental reactions and decision-making processes are speeded up (Kearney in: Small, Vorgan, 2011). Another noticeable change is a different mode of cognitive functioning in the learning process. Digital Natives (individuals born after 1999) often complain about unattractive form of traditional teaching. Single- or even dual-channel message mode employed by teachers (e.g. book or presentation) is boring and too slow for their expectations, which is connected with excitement seeking and concentration time (shorter attention span). A following example may serve as an illustration of young people's needs for content attractiveness: while watching an educational programme on TV, Digital Natives also listen to music, handle their phones and take part in an online chat, because as recipients they know that the motion picture can be stopped at any moment that is of interest to them. Those transformations, connected with new communication possibilities, have brought about changes in the frequency and forms of face-to-face social contacts and the time devoted to cultivating bonds and building social competences. A new style has been observed in interpersonal and intergenerational communication, based on texting, e-mails, sporadic necessary telephone calls to family and friends; also, certain anonymity, little activity related to social co-operation and overcoming frustration in relations with persons from the so-called 'group of friends of friends'. The possibility of instant gratification

of social needs on the Internet instead of regular social training in a given group of people in fixed time sequences (family rituals) is a threat to the development of communicative skills and emotional intelligence that is based on the recognition of multidimensional non-verbal signals, as well as self-confidence in intimate relationships. A dropping number of interactions between people, and particularly between parents and children, undermines the process of transmission of culture and prevents intergenerational support, which is detrimental for the long-term functioning of relationships, families and groups. Being in a long-term relationship requires traits such as empathy and ability to cope with emotions, frustrations and mutual interdependence. Multi-tasking, quick changes of stimuli and a high level of neural activity force our brains to adapt to this mode. Developing new connections and changing the frequency of activation of certain areas. We, as human beings, adapt and tune to the challenges faced by individuals living and working in a digital world.

Theoretical background

Link between autism and creativity. Since 2013, there has been a consolidation of autistic disorder, Asperger's syndrome, and pervasive developmental disorder into autism spectrum disorder, known as ASD. Symptoms of these disorders represent a single continuum of mild to severe impairments in the two domains of social communication and restrictive repetitive behaviours/interests rather than being distinct disorders. This change is designed to improve the sensitivity and specificity of the criteria for the diagnosis of autism spectrum disorder and to identify more focused treatment targets for the specific impairments identified (p. 42). For example, autism spectrum disorder is diagnosed only when the characteristic deficits of social communication are accompanied by excessively repetitive behaviours, restricted interests, and insistence on sameness (APA, 2013, p. 69).

Thus, Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder defined by a "spectrum condition" of behaviours that affect people in different ways and degrees (Pocinho, Caires, Rodrigues, 2015). ASD is characterized by a set of impairments in three domains: social behaviour, communication, and imagination. The deficit in imagination is manifested as restricted, repetitive patterns of behaviour, activities or interests (DSM-5; APA, 2013). ASD is often accompanied by medical and mental health issues such as attention deficit and hyperactivity (ADHD), sleep problems, anxiety and phobias, gastrointestinal disorders (Pocinho, Caires, Rodrigues, 2015). There is a single continuum of ASD severity in social communication and restrictive repetitive behaviours/interests domains: Level 1 ("Requiring support"), level 2 ("Requiring substantial support") and level 3 ("Requiring very substantial support"; APA, 2013, p. 52). The most obvious signs tend to appear between the ages of 2 and 3, but in some cases, ASD can be diagnosed as early as one year and a half. Parents should observe their children from early ages and look

at signs such as lack of or delay in spoken language;, repetitive use of language and/or motor mannerisms, little or no eye contact; lack of interest in peer relationships, persistent fixation on parts of objects, lack of spontaneous or make-believe play (see: Autism Society).

Person with ASD and creativity. There is scientific evidence that ASD individuals can generate highly original responses (Kasirer, Mashal, 2014). This finding is not in accordance with research suggesting people with high functioning ASD are impaired in the comprehension of metaphors, jokes and other non-literal language, with rigid thinking, restricted interests, and a literal interpretation of speech and behaviour (e.g. Gold, Faust, Goldstein, 2010; Rundblad, Annaz, 2010). Liu, Shih and Ma (2011) found that participants with Asperger's syndrome (ASD level 1) were superior in the elaborateness and originality of their responses on creativity tests. Thus, it may be that although there is an overall decrease in production, what is obtained may be qualitatively superior.

Creativity involves both components of 'novelty' and 'appropriateness' (Lubart, 2001; Runco, Jaeger, 2012). The capacity for producing novel ideas could be assessed through divergent thinking tasks, a cognitive component of creativity (Guilford et al., 1978; Garcês et al., 2017). For example, in the Alternate Use task (Guilford et al., 1978) participants are asked to think of alternate uses for a common object. The responses have historically been scored on one or more of the following indices – fluency, flexibility, elaboration and originality (e.g. Torrance, 1966; Garcês et al., 2017).

There is some evidence that high levels of autistic traits were significantly associated with lower fluency scores (quantity of responses), but they were associated with high numbers of unusual responses (Craig, Baron-Cohen, 1999; Turner, 1999; Kasirer, Mashal, 2014). There is also evidence of impairment from other types of creativity tests, e.g. Liu, Shih and Ma (2011) found that participants with Asperger's syndrome had significantly lower scores on openness and flexibility on a battery of creativity tests. So, if generations of novel ideas is a prerequisite for creative problem solving, it may constitute being an adaptive advantage associated with autistic traits. If we consider novelty an important component of creativity, there is, in fact, a strong link between ASD and creativity (Best et al., 2015). Apparently, people with more autistic traits, when asked to name as many uses as they can for a common object such as a paper clip, come up with fewer suggestions, but the suggestions they offer are more unusual than those of their neurotypical counterparts. They exhibit more novelty, more "divergent thinking". Best et al. (2015) show that while the results from a study of 312 people were a measure of just one aspect of the creative process, they revealed a link between autistic traits and unusual and original ideas. Thus, creativity generally involves the conception of original and valuable ideas, and it plays a key role in scientific achievement. Moreover, individuals with ASD tend to be successful in scientific fields (Takeuchi et al., 2014).

Research has confirmed that seeing the world in 'a different way' sparks unique ideas and ASD individuals can be creative. The 3D creative project is trying a new

approach, using the Gardner (1993) MI Theory that revolutionized the way educators and psychologists think about intelligence. Rather than measuring only verbal and logical-mathematical reasoning as an IQ test does, he suggests that all people possess at least eight modalities of intelligence: linguistic, logical-mathematical, natural, musical, body-kinesthetic, interpersonal, intrapersonal and existential capabilities. All people have potential intelligences in some way, and each person is a unique individual. In the same way, the intelligence (analytical, practical and creative) theory of Sternberg proposes that a child does not need reading skills or high maths grades to be smart or to have the potential for success.

We hope this research study on 3D creativity is part of a similar transformation in the way we understand creativity. Some creative people may be able to compose fantastic tall tales. Others may be able to reshape the universe in their minds because they are not constrained by conventional wisdom. We do believe that ASD children and adolescents often have a gift of creativity that deserves celebration.

Technology. In positive psychology mental health refers to positive psychosocial factors such as resilience, optimism, wisdom, social support, purpose or meaning in life, spirituality, self-efficacy, personal mastery, and coping ability. These factors mediate the trajectory toward improved mental health outcomes including well-being, happiness, life satisfaction, low perceived stress, post traumatic growth, recovery, and prevention of psychopathology. Students with ASD learn well from visual media because pictures are their first language, while words are their second language, and therefore technology can be a valuable tool in their learning process. So, technology "just makes visual images more accessible to the individual with ASD. Computer graphics capture and maintain their attention" (Lofland, 2015). Technology can also help children with ASD to achieve emotional confidence in social situations because a "huge part of going to school is learning how to navigate social situations. Students with ASD are totally lost without a roadmap. Technology has been huge in allowing them to bridge that gap between them and the other kids" (Lofland, 2015). We are coping with Digital Technology Generation, and different processes occur. AS young people, connecting/using Digital Technology with a 3D Printer is probably a natural alternative mode of functioning that promotes positive emotions and wellbeing.

Threats. In relation to threats, researchers focus more on studying the development of those neural areas and connections that are rarely activated in cyberspace, and had earlier been developed in off line activities, mainly during social interactions and solving complicated tasks in memory. One of the problems that may serve as an example is social spontaneity and the ability to empathize. From a neurological point of view, this relates to the simulation of the activity of the amygdaloid body responsible for initiating and maintaining eye contact. Research by Ybarry also indicates that everyday social contacts are also crucial for the development of memory, not only for the elderly but also for young people (in: Small, Vorgan, 2011). Brain activity studies with the use of magnetic resonance carried

out with test participants online or using digital technology revealed the manner in which neural activity was activated and inhibited. Certain characteristic and slightly surprising results of that research are presented below. According to research carried out to date, the analysis and use of both spoken and written language activates the Broca's area in the frontal lobe. Meanwhile, writing and reading emoticons activates primarily the right inferior frontal gyrus previously associated with non-verbal communicative skills (Small, Vorgan, 2011).

Due to quick gratification of needs on the Internet and 3D technology and the possibility of providing stimuli that match expectations, the limbic system is activated. The frontal lobe and parietal cortex, the activation of which helps us plan, control and inhibit cognitive and emotional arousal, are less often activated. Questions about the consequences of the presence of young children in digital technology have resulted in the emergence of hypotheses connecting different modes of their cognitive, social and emotional functioning with changes in brain functioning. Problems so far labelled as concentration deficits or psychomotor over excitability disorders are now proposed to be treated as a new model of cognitive functioning.

Benefits. Using technology as a tool cannot be treated as a threat to development. Using technology especially for adolescents and children with AS has many benefits.

Firstly, technology can be treated as a tool for delivering instruction and presenting information. Each student has preferred styles of learning, and specific needs when receiving information. As we have said before, students with ASD are visually oriented, and technology enables teachers to choose from an increasing wide range of possibilities to present the material, to reach all students, no matter what their abilities are: interactive whiteboards to engage students presenting the information via video, slideshows or interactive games, providing tactile and kinesthetic experiences, activities on the Internet, a digital environment where the exploration of concepts and spaces is amplified because it leads to more results in less time, text-to-speech software to eliminate the barriers of traditional textbooks, voice dictation tools for writing assistance.

Secondly, a friendly robot can be used in the classroom to make students feel comfortable and experience positive emotions. Young people with ASD are often intimidated by the social aspects of classrooms. In order to help them to deal with their negative emotions and anxieties, find emotional confidence in themselves and in their classmates the Aspect Hunter School (Australia) introduced Sphero robots in the classroom (see: Autism Spectrum). Sphero is a spherical robot toy, capable of rolling around, that is controlled by a smartphone or tablet. Sphero robots encourage students to explore outside their comfort zones, and outside the classroom.

Thirdly, apps can be used to increase verbal skills and to improve social and emotional skills. As Autism Speaks organization reported, 25% of people with ASD are identified as non-verbal or low-functioning communicators (see: Autism Speaks). Special apps called "visual scene displays" can play an important role in

assisting students to struggle with verbal skills. Apps can help children and young people to develop their storytelling skills by creating their own interactive displays and stories. The Secret Agent Society (see: Autism Spectrum) is a social skills program for 8 to 12-year old children with social and emotional challenges such as high-functioning autism. This evidence-based program provides professionals with a ready-to-use curriculum and set of resources to help children improve their social and emotional skills. It comprises a range of educational activities, including a multi-level computer game, board game, walkie-talkie game, card games, and a workbook. Children are taught how to identify simple and complex emotions in themselves and others, using face, body, voice and environmental clues.

Finally, achieving independence and wellbeing may now be more accessible for ASD individuals. Technologies which can support self-monitoring and can reduce the need for assistance are readily available. These technologies are socially accepted and portable and they can be used by ASD children at school or at home with family, improving social connections and communication.

Research aim

All of the above examples have shown some connection among young people with ASD and their functioning and technology. This coexistence is very important from a psychological point of view. Technology can improve not only cognitive skills but also emotional and communication skills. Using technology with satisfaction could affect the wellbeing and relationships between adolescents, children and their parents or teachers. A pilot study has been designed to show the possibility of increasing wellbeing in children and adolescents with ASD. The research models are based on Schaffer's theory of Joint Involvement Episodes, which are treated as a context for development (Smorczewska, 2013). These episodes are contacts between two people during which the participants pay close attention to a subject (Schaffer, 1994, p. 153). The relationship between the child/ adolescent, parents, technology and its product can create a specific triangle of interaction. A 3D printer could be a good subject (the subject of interest). In this common reference system the activity of an adult assumes one out of two forms: support (keeping up the child's current behaviour) or challenge (adopting the principle of "one step ahead"). One cannot underestimate the fact that the process of producing the output can be an opportunity for a direct involvement of the adult in the child's activity. This aspect is important for communication and emotional development and it can improve the level of satisfaction from a relationship. The process of real output production can develop creativity and motivation to stay on task. It needs cognitive and emotional control, respect to new rules of work and acceptance of the new social situation (cooperation with parent, teacher). The formal impact of joint involvement episodes to the development of mental functions is based on their quantity, i.e. the repetition of the situation: short but authentic engagement (Schaffer, 1986; 1994; Figure 1).

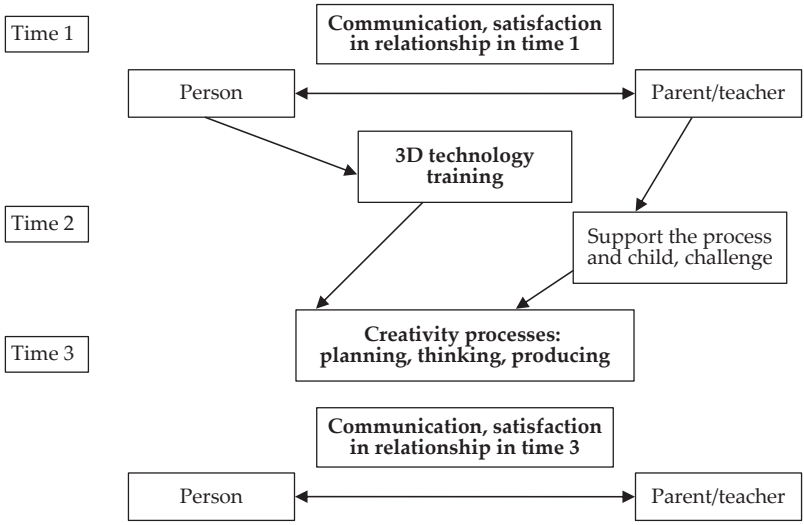

Figure 1. The episode of work with 3D printer as a joint involvement episodes

The research questions were: (1) how can the interaction of children and adolescents with ASD, when exposed to 3D activities, improve **their satisfaction and communication in relationship to their parents and** (2) **how does their engagement in producing the process improve their creativity**? During the training procedure, which was an element of the study the following hypotheses were expected to be verified:
H1. The interaction of children and adolescents with ASD, when exposed to 3D activities, improves their satisfaction and communication in relationship to their parents; and H2. Students' engagement in producing the process improves their creativity.

Method

This study is based on the authors' past experience on the European Project Dream Makers (Pocinho et al., 2017). Dream Makers is a longitudinal study that aims to help pre-school disadvantaged children develop their creative, cognitive and 3D technology skills. Creativity is an important piece for problem solving, however, it is also related to divergent thinking skills, personality, cognition, motivation, imagination, culture and much more. Gardner Multiple Intelligences (MI) theory has been a theoretical framework that has brought new ways of thinking to children's talents and abilities. The basis of the project is associating MI and creativity as a way of fostering children strength (wellbeing) and giving them the tools to cope with developmental tasks in a 3D virtual and real environment. The ultimate goal of the project is to develop a new model for curriculum education while promoting a connection between technology and the development of chil-

dren skills. The project started in September 2016 in Madeira (Portugal), where it was originally piloted in a Portuguese private kindergarten where 3D technology was used as a daily routine to develop MI skills. This intervention was treated as an optimisation of the developmental process by using Gardner MI Theory and 3D technology. The activities of the project were based on "Creativity Days", that took place 8 times (once a month). Each time the main theme of the day was one of Gardner's MI, which means that all activities were executed and implemented and would be considered as part of that "Intelligence". Part of the "Creativity Day" was to help children in small groups to develop an idea of a product, build it in a 3D modelling software appropriate for children and then print it on a 3D printer. The activities used by the staff were to improve their working methods and to involve training to learn more about creativity and multiple intelligences and other variables that could be important through the project implementation, such as inclusion and 3D technology. The study and experience after one year of the project showed possibilities of using 3D technology not only as a tool to improve the development of different skills but also as a communication tool.

Based on the experience gained in the Dream Makers with qualitative methodology, we suggest an intervention programme using 3D technology as a tool to develop wellbeing and to improve mental health and children with ASD. The intervention programme has a clear innovation aspect. We aim to bring together a set of variables (creativity, communication and self-confidence). This is done by approaching education services in a new holistic way and by focusing on a particularly vulnerable target group such as children and adolescents with ASD and their parents.

Study group. The study group consisted of 40 children and adolescents from the CAIS (Centre of Autism and Social Inclusion; $N = 40$, N parents = 60). The study group were divided into a group of 20 children and adolescents who took part in the project, and a control group of 20 students who they were offered only care and basic activities. In Portugal, the educational system for ASD children or adolescents offers general activities to these students in classes where they are mixed with children with other disorders (they are grouped together with children with Down syndrome and brain paralysis), therefore the main aim of CAIS is to offer autistic adolescents' activities that they like and that are related to ASD (focused on communication and relation deficit). In addition, they have volunteer autism specialists, for example, psychologists, speech therapists, occupational therapists and teachers (art, ICT teachers). This organization is a Portuguese IPSS – Social Solidarity Public Institution that does not receive any financial incentives.

Instruments

During the study a variety of instruments including: **the Guilford creativity test** (divergent thinking) in written computer adaptation, a **semi-structured interview, evaluation of 3D products and observational** grids were used.

The Guilford creativity tests are popular and well standardized (for adolescents and children).

The *satisfaction questionnaires* were prepared as control questions in two versions. Adult participants gave answers on the Likert scale from 1 to 5. The noticed variables were: satisfaction, communication skills and creativity

The questions for Parents/Teacher and ASD Technicians were as follows: *What is your level of satisfaction/wellbeing connected to the participation in 3D printer training? What are your son's/daughter's/student's good emotions and social communication like after a 3D printer session?* For young people with ASD, the questions were: *Are you satisfied with your relationship with your teacher/classmates? How do you feel (in terms of wellbeing, emotions and social communication) after a 3D printer session?*

Moreover, a semi-structured interview was conducted with the adults to have a more in-depth understanding of their children's development and achievements seen from the parents' perspective.

3D printer products were evaluated by their level of 'novelty' and 'appropriateness' on the Likert scale from 0 to 3) (0 – none; 1 – medium; 2 – high or 2+1 – very high) (Pocinho et al., 2015) as an alternative and complement of the Guilford creativity test. The measurement was planned to conduct three times: at the beginning, after six months and after a year. Is planning. Naturalistic observation took place during the project with observational grids.

Intervention programme implementation

When CAIS went to a 3D Conference and knew about this Project, they asked us immediately to experiment with 3D technology (multiple intelligences and creativity) with ASD adolescents. We also did a specific seminar about 3D technology to CAIS associates in the Casa da Luz Auditorium. After these meetings, some work regarding the implementation started. A short training for parents and their children in small groups was developed about the technical guidelines for 3D modelling and 3D printing with young people with ASD. It assumed knowledge about the idea of a product, which is built it in a 3D modelling software appropriate for children and then prints it on a 3D printer. Once a week they met with a tutor and had a "Creativity Day". Training was necessary to work with 3D printers and 3D modelling software programs, which was given to the staff and researchers; an informed consent was requested from the child's legal guardian and transport was provided if needed. As a result, after the first part of the training, which consisted of 3 or 4 meetings children were able to use 3D modelling software to create their own objects. After the next 3–4 weeks they were able to create their own project and then print it.

Technical Guidelines for 3D Modelling and 3D printing with young people with ASD. The introduction of 3D technology to ASD children had to take into account a set of variables. Firstly, and foremost, the ASD level of severity, age and

cognitive development stage and secondly the most appropriate equipment to work with this specific group of young people. Considering the characteristics of the participants, the modelling and slicer software and 3D printer were carefully chosen. Next, we presented the main technical guidelines for the project implementation. These were the ones we believed vital to start working with this technology, however, a more in-depth training with professionals was advised.

3D Printer: the main components and materials. To understand 3D technology and how it is used in the project we believe it is important to explain the main concepts and materials that are basic to operate this technology and the ones the team deals with directly during the project implementation. The main components and materials are as follows:

A 3D Printer: It is a computer-aided manufacturing (CAM) tool that produces 3 dimensional objects.

Extruder: This is one of the central parts of the 3D printer, which is where the filament enters, melts and comes out. The extruder can reach extremely high temperatures.

Build Platform or Print Bed: This is the surface where the objects are printed. This can be made from different materials such as glass and can be heated or not.

Filament: This is the material that the printer uses to make the objects. The most commonly used is plastic, but many others exist. The filament comes in rolls, and can have two different diameters 1.75 mm or 3 mm.

User Interface: There are some 3D printers which have an LCD screen where it is possible to control the printing process. This can be used to start printing, it can give indications about the extruder and build platform temperatures, pause or cancel the printing.

SD Card Slot: There are printers which have a SD card slot; it is possible to load files from the slicer software to a SD card and directly print the object form the card.

For the implementation of projects some considerations were needed regarding the 3D non-toxic biodegradable thermoplastic, which is easy to print and durable. Usually it is made of corn starch or sugar cane, which belong to the most environmentally friendly materials. For this reason, our professional consultants suggested using biodegradable thermoplastic, Secondly, when choosing the 3D printer for the Dream Makers we had to take into consideration what we wanted to use it for and which one printer had the best characteristics for our goal. As young people with ASD were the participants of the project we had to choose a printer that was closed and not open. Numerous printers had heating elements, for example, the extruder and the printer build platform which were left open, meaning that they had no protection and were thus easy to be reached with hands. This type of printers could not be an option for ASD adolescents. We needed ones which had all the heating elements safely covered. Having consulted some experts, the Flash Forge Creator pro 2016 was selected. This printer was closed, had two extruders (this meant that it could print in two colours; it changed colours when the temperature rose; and it

also made sounds when printing started). All these aspects were considered important since they would give young people with ASD different measures of security and more awareness of safety measures when working with a 3D printer.

3D modelling software. Prior to printing any kind of 3-dimensional object it is necessary to build a 3D model with appropriate software. 3D modelling is a process of creating a 3-dimensional object with specific software. 3D modelling involves space manipulation and a greater awareness for orientation and details. Furthermore, 3D modelling is an important part of 3D technology, some of which are extremely detailed and others are very user friendly with a greater usability. For the Dream Makers project usability is a major aspect since we worked with young children so an age appropriate software was important. Tinkercad (see: Tinkercad) a free online 3D modelling software was thus chosen as the suitable one. Tinkercad has basic forms and is intuitive in its use and also allows one to import 2D and 3D objects. It is one of the best introductions to 3D modelling software, which also helps to develop basic skills and an awareness of this process. The use of Tinkercad is simple and available online. After having set up and registered an account a tutorial is presented to get the user acquainted with its multiple functions and possibilities.

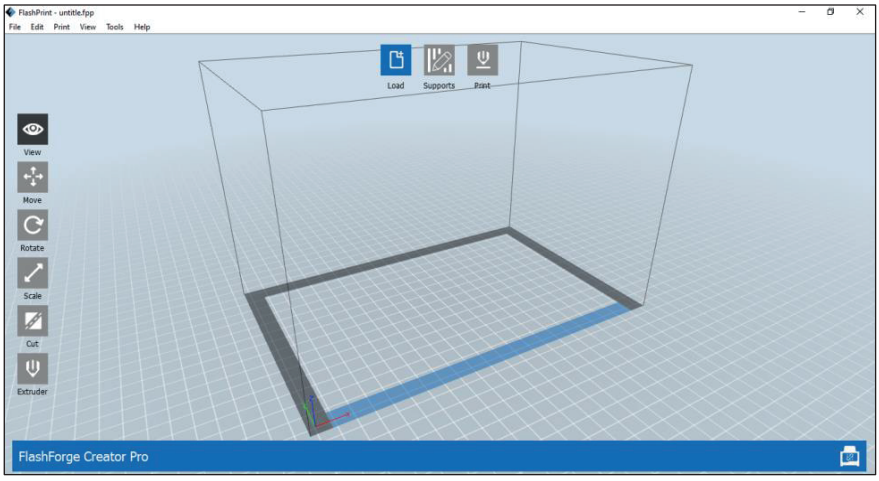

Figure 2. Flash Print Software Interface

3D slicer software. Another important software to allow 3D printing is called a slicer. After the construction of the 3D model, it must go through a slicer software which will transform the model into individual layers recognizable by the 3D printer. The software generates a "STL" format file with the sliced model. There are several slicer software programs on the market, however, the Dream Maker project used the slicer that came with the 3D printer. In this case the Flash Forge Creator Pro 2016 came with the Flash Print software (Figure 2). This software allows the

user to control many elements of the printing process, as for example, the height between layers, extruders and build platform temperatures and printing speed. It also has a basic command mode where the more complex 3D printing definitions are already set up, which means it is more user-friendly for small children to work with.

3D printing process. One important aspect regarding the use of 3D technology is that it is not an instantaneous process: it takes time. The following diagram shows the main steps, from conceptualization to the printing of an object (Figure 3).

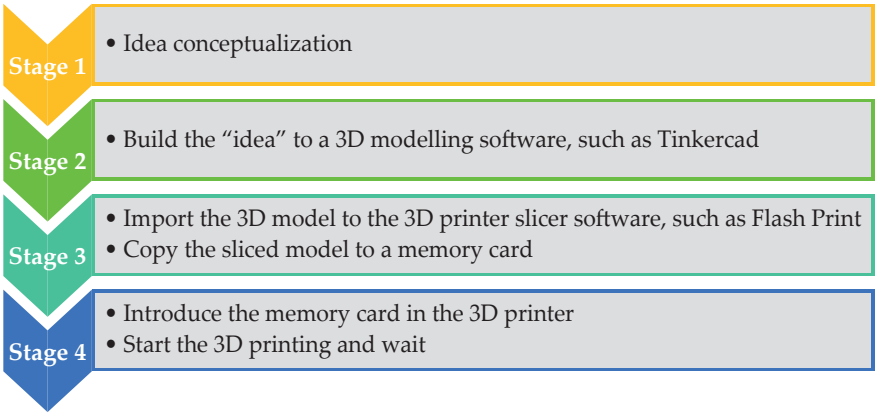

Figure 3. The 3D printing process

Results

Because this is the first communication of the project the first results show the aspirations from both mothers and fathers. They reported higher levels of changes in their life and a more positive level of communication with their children after first and second wave of study. Now we have to wait for third set of results. Thus, the H1 hypothesis was initially confirmed. We do not have the results related to the H2 hypothesis yet. therefore, there a connection between the training, activity in a 3D environment and creativity cannot be confirmed.

It turned out that the measurement with the Guilford test could not be verified in this group of respondents. The obtained results were not statistically verifiable, which requires changes in the research plan and evaluation of the results by competent judges. Below is an example of qualitative results related to communication. Separate cases are presented below. Two boys (aged 7) imagined a *"dream house"*. One of them imagined a house with a tree and a swimming pool and the other thought of the house with a swimming pool and garage (Figure 4). Then, they created a model in the modelling software – Thinkercad and with (if needed) adults' help. They together sliced it, copied the sliced model into a memory card and printed it using the 3D Flash Forge Creator Pro 2016.

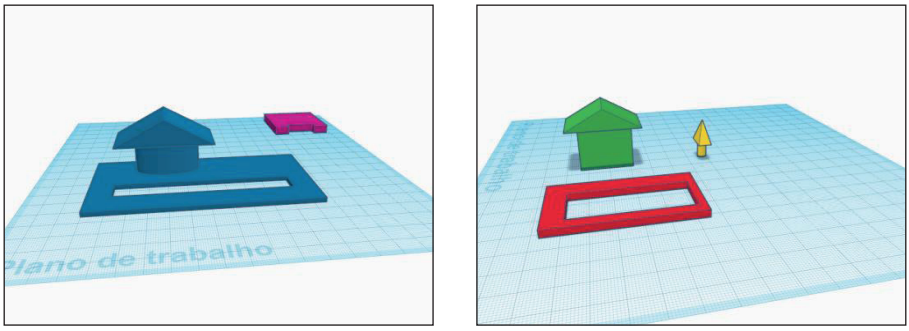

Figure 4. 3D Printer creative products

From the children and adults perspective

During the project the children and adolescents developed their creativity and 3D technological knowledge and because of specific joint involvement episodes (communication skills). They said that their communication and satisfaction improved in any relationship which was the ultimate expected impact on the participants. Overall the project gave the parents and teachers a new insight into a new, open and innovative educational approach, focusing on autistic children with different abilities and helping them to achieve their full potential. The parents and teachers were aware that it was a new approach to creativity and satisfaction among adolescents with ASD. At the end of the project it is expected that the development of a new curricular methodology will bring a new set of core concepts to the educational practice with young people who have ASD.

Conclusions

We have presented the theoretical psycho-didactic framework to using 3D technology as a tool to develop he wellbeing and mental health of young people. It was based on the authors' past experience on the Dream Makers European Project. We believe that 3D technology is the challenge to train new emotional and behavioural strategies undertaken by ASD participants in coping with different tasks and improving satisfaction, wellbeing and communication with families. The preliminary results are shown in the parents and teachers reports. They noted that their autistic children had developed their social and communication skills. These results are in accordance with the suggestions of Karim, Ali and O'Reilly (2013) on ASD mental health improvement.

In conclusion, the project can help children and young people with ASD to develop and maintain their mental wellbeing by discovering and developing their creative potential and bring this potential to reality by using a 3D printer. Those with ASD can pay closer attention to their interest object (3D printed product) and

build a relationship with, not only 3D technology and its product, but with the ones who observe their creation.

The basis of this intervention programme is to associate 3D technology to creativity as a way of building children and adolescents' strength (wellbeing) and giving them the tools to cope with developmental tasks in a virtual and real environment. The prevalent view is that creativity and imaginative thoughts are extremely difficult or impossible for individuals with ASD. There is substantial research evidence that almost all forms of imagination are impaired in autism including a lack of pretend play, pragmatic language, comprehension and construction of narrative, theory of mind and experimental tests of creativity. A significant challenge to this perceived lack of creativity is the enormous achievements that some people with ASD show in creative and scientific fields (Lyons, Fitzgerald, 2013). As impaired imagination is a core feature of autism, it seems paradoxical that there are high profile cases of people with autism who exhibit creative flair in their fields of special interest (Fitzgerald, 2004). These expert abilities occur far more frequently among people with ASD than in those with other developmental disabilities (Treffert, 2009). Therefore, it has been posited that ASD cannot be explained by a deficit-only model and the islets of preserved or even superior ability need to be explained (Happé, Brownell, Winner, 1999). Creativity is an important piece for problem solving, however, it is also related to divergent thinking skills, personality, cognition, motivation, imagination, culture and much more.

New technologies allow us to participate in the globalization process that takes place every day. The need to adapt and to apprehend these new ways of life is a daily challenge. In this study we analysed the possibilities of using 3D technology among ASD children and adolescents. Here we presented only an overall introduction to start working with 3D technology and particularly the main tools that enable anyone to implement the ASD intervention programme. The software and hardware mentioned were the ones chosen to implement the project due to the participants' characteristics, and the possibility to use free online software and open source software. Obviously, other tools are also available and may be used as well. Books, tutorials and articles can provide a more in-depth understanding of these tools. 3D technology is in constant evolution so updates are common in its community and tools.

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TECHNOLOGIA 3D JAKO NARZĘDZIE DO PODNIESIENIA POCZUCIA DOBROSTANU DZIECI I MŁODZIEŻY Z ZABURZENIAMI ZE SPEKTRUM AUTYZMU

Streszczenie. Pojawienie się nowych technologii pozwoliło nam uczestniczyć w trwającym procesie globalizacji. Potrzeba przystosowania się i zrozumienia nowych sposobów życia związanego z wykorzystywaniem technologii jest wyzwaniem. Niniejsze opracowanie ma na celu analizę możliwości wykorzystania technologii 3D wśród dzieci z zaburzeniami ze spektrum autyzmu (ASD). Podstawą tego projektu było wykorzystanie kreatywności jako sposobu na poprawę samopoczucia dzieci i młodzieży. Starano się zatem przyjrzeć ich umiejętnościom radzenia sobie z zadaniami rozwojowymi zarówno w środowisku 3D, jak i naturalnym (np. w zakresie komunikacji twarzą w twarz). W artykule przywołano teoretyczne psycho-dydaktyczne ramy wykorzystania technologii 3D w optymalizacji rozwoju młodszych pokoleń z ASD. Na podstawie wcześniejszych badań można podejrzewać istnienie pozytywnego związku między korzystaniem z technologii 3D a rozwojem dzieci z ASD. **Grupa badana**: Dzieci i młodzież ze stwierdzonym zaburzeniem z kręgu autyzmu (N = 40) w wieku między 5. a 16. rokiem życia oraz minimum jeden rodzic (N = 40), a także nauczyciele pracujący w projekcie (N = 16). Badanie miało charakter eksploracyjny i pilotażowy. Przeprowadzono trening pracy z drukarką 3D. W treningu uczestniczyła młodzież wraz z rodzicem. W badaniu wykorzystano metodologię jakościową. Wstępne wyniki przedstawiane są na podstawie raportów rodziców i nauczycieli. Wskazywali oni na rozwój umiejętności społecznych i zainteresowań dzieci z ASD. Co więcej, rodzice i nauczyciele zauważyli poprawę komunikacji z dziećmi i młodzieżą po przeprowadzonym oddziaływaniu. Oczywiście można postawić pytanie, czy był to efekt specyficznej technologii 3D, czy raczej trening był tylko pretekstem do nawiązania komunikacji zgodnie z koncepcją epizodów wspólnego zaangażowania.
Słowa kluczowe: ASD – zaburzenie spektrum autyzmu, drukarka 3D, kreatywność, rozwój, epizody wspólnego zaangażowania

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