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Pedagogical Methods for Teaching the Use of Prototyping by 3D Printers

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Abstract

The paper presents the concept, design and manufacturing of an educational tool using 3D printing. This method provides valuable aid in offering the pupils and students a tactile and practical experience in their study, especially if they are visually impaired. The educational tool in the study represents the map of the counties in Romania with their names in Braille alphabet and is an example of the manner 3D printing can be used to enhance the study possibilities of pupils and students with different disabilities.

Keywords: pedagogical methods; 3D printing; visual impaired.

1. Introduction

3D printing technology provides a positive approach in education by offering pupils and students a suitable manner to improve and enhance their concepts and skills in science, technology, engineering, computer science, arts, mathematics, chemistry, biology, geography etc. [1]

3D printers and prototype design engage students in the creation and design process, improving at the same time their capacity of using creative solutions in solving problems. This process offers pupils and students a tactile and practical experience of the basic concepts presented during the lectures. [2] They will be considerably more involved

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by being allowed to turn their ideas into reality. Thus, there will be the possibility of physically examining their projects and assess the strong and the weak points of the project.

By means of 3D printing technology, students are learning to communicate more effectively using a combination between traditional tools of writing and printing and media means (websites, images, videos, CAD software, etc.)

The dedicated literature provides several examples of studies concerning the use of 3D design and printing in order to manufacture real aids for education, especially for visual impaired students to help them in almost all fields of expertise, one of the most impressive being presented in [3]. Pupils created a water molecule for chemistry study or various 3D shapes for geometry, etc. in a school in Greece with the purpose of helping persons suffering from low vision or blindness to attend classes.

Also, by using 3D printing together with CT scans of human and animal bones, new sets of bones were created to help the study of anatomy in class. [4]

Generally, visually impaired persons need more than the others a lot of tactile material such as models, maps, labels written in Braille which are often manually manufactured and are time and resources consuming and of course expensive because sometimes it is necessary to create them individually and personalized. [5]

2. Materials and methods

3D printing consists of various processes whose outcome is that a material is combined and solidified by help of a computer, in order to create a three dimensional solid object of any shape using an additive procedure. This process is characterized by the fact that for the purpose of creating a certain shape, it will add material in successive layers, following some patterns and obtain the desired project. Certain important steps have to be taken in order to print an accurate model.

Firstly, a 3D model is designed using a CAD software and then the final form is converted in a STL file, which „divides" the model in a logical series of triangles thus facilitating the „slicing" algorithm, so that subsequently the model is transformed in thin transversal layers allowing 3D printing. [6]

Then the file is sent to the 3D printer, which processes the required information during the model 3D printing. The final stage is the physical manufacturing of the model based upon the technology, materials and parameters that were previously determined.

The educational tool presented in the paper is the map of Romania, divided by counties, their names abbreviations being written in Braille alphabet. It is manufactured using a non-toxic biodegradable plastic material PLA (polylactic acid), whose properties are a good elasticity but it breaks easily. The yellow color of the filament was randomly chosen but it proves to be easily identifiable for low vision persons. The use of Braille alphabet was done in accordance with National Library Service for the Blind and Physically Handicapped standards. [7]

The final form of the prototype designed in SolidWorks is shown in fig.1. During the CAD design the prototype dimensions suffered some changes, especially in height. Unlike the prototype, the model will be filled with the abbreviated names of the counties in Braille alphabet. For the model design, Adobe Illustrator and Autodesk fusion were the used software. The chosen image was vectorized and then extruded using Adobe Illustrator and the result is shown in fig.2.

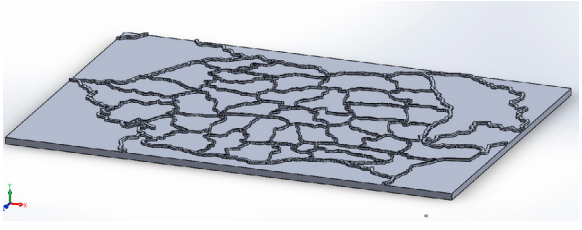

Fig.1. SolidWorks prototype

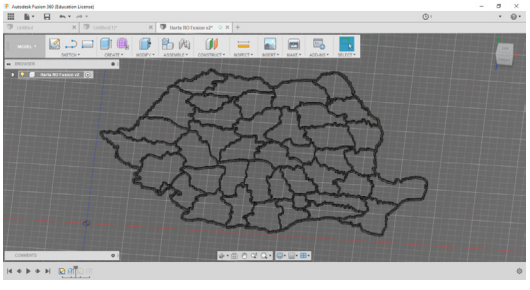

Fig.2 Extruded sketch in Adobe Illustrator

An svg. file containing the abbreviated names of the counties was inserted in Adobe Fusion and the new form is shown in fig.3. Then the file was converted in a stl. file and prepared for 3D printing, the result is shown in fig.4. The more this step results in a simple and "clean" format, the less errors may occur in the stl file. and further, in the final 3D print model.

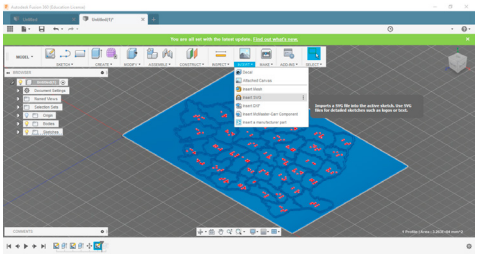

Fig.3. File with abbreviated names in Braille

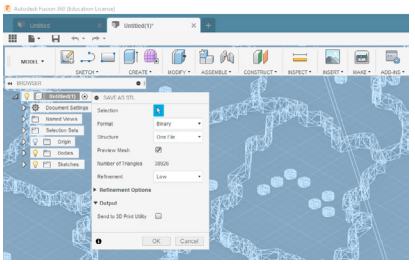

Fig.4. Final stl. file

3. Results and Discussions

First the prototype was printed in order to analyze and inspect the possible errors and correct them before manufacturing the model. The final form of the prototype is presented in Fig. 5. The obtained prototype was analyzed and evaluated and certain errors were noticed, like the south-eastern boundary of the country did not have the height and thickness which were established by the SolidWorks sketch, also some color defects were spotted and some inaccuracies in respecting the counties boundaries. These errors are the result of poor vectorization of the initial image in SolidWorks, which was manually created but also of converting the sketch into an stl. file.

3D printing of the model was done using the same 3D printer as for the prototype, same technology and material. But due to the fact that the sketch, image vectorization, 3D model and converting in stl. file was done by help of Adobe Illustrator and Autodesk Fusion, within the final model no more surface, colour, accuracy errors occur. (fig.6)

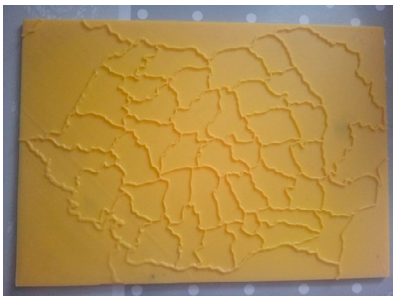

Fig.5. Final form of the prototype

Fig.6 Final form of the model

The final model also includes the abbreviated names of the counties written in Braille alphabet.

This educational tool can be made in several copies and distributed within the schools attended by children with visual impairments. By getting a feedback from the users, changes can be made regarding the size of the map, of the Braille characters, texture, roughness, material, etc. The methodology can be extended of course for the maps of other countries or of the entire world according to requirements.

4. Conclusions

The method of creating an object by 3D printing is a great opportunity for visual impaired pupils and students because it brings objects, phenomena and virtual concepts into their hands providing the possibility of using another sense, the tactile one to analyze them.

The reasons for which a 3D printer is useful and necessary in a lecture room or in a laboratory are some of following: selection of a nontoxic, biodegradable material for the models, manufacturing the object in the desired shape and texture and the short time of manufacturing.

Education plays a key role in building creative minds, in developing senses, curiosity by stimulating experiences. Currently the educational system in the entire world follows the approach DIY (Do It Yourself), allowing the students (even if they have certain impairments) to explore and develop their innovative skills by creating and working based upon their own imagination, being encouraged by modern technologies.

Basically, 3D printing at a larger scale may be used to create for educators, teachers, pupils an students a favourable environment for applying more effective ways of teaching, learning and understanding of various concepts expressed by help of 3D models.

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