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Design and production of plastic parts for read-write didactic equipment using 3D printer

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Abstract. 3D-printing technology is part of the large group of additive manufacturing methods that present a huge potential for increase the number of new application areas in manufacturing industries. Nowadays 3D printing is only implemented in several practical applications as 3D printer farm. In all the materials applications, plastic, cellulose or metallic, using 3D-printing could enable mass customization of special products by reduction of the material consumption. In this article the authors present the design and obtaining using a 3D printer of some special parts of read-write educational equipment for preschools and school children. The plastic elements present complex details like letters and digits with a high resolution at a relative small scale. If the number of products design for fabrication is larger than 2 and smaller than 1000 the production of small complex parts can be realized using a 3D printer without involving a metallic mould which will increase the final production price. Some of the plastic materials that can be used for 3D printer present numerous advantages like weight, non-allergenic, non-corrosive, non-toxic and in various colours. 2D and 3D images of some components of the read-write equipment are design and presented.

1. Introduction
Dyslexia is a specific learning disorder of written language, in the absence of an intellectual, sensory or motor deficit. The diagnosis of dyslexia can only be done at the end of the second grade, but some elements of the symptomatology are observable, especially by a specialist, at the pre-school age of the child [1, 2]. At present, there are several equipment used for the read / write stage (RO 94948 patent), a teaching apparatus for literacy and word formation, consisting of a cassette with alveoli, in front of which are printed signs and letters. Letters can be found also written on some cards stored in the corresponding spaces of the box and a board for placing the corresponding cards for word formation [4, 5]. Other patents that refer to reading learning literacy teaching equipment are: RO 120992, RO 118684 or others. These write-read learning devices are rather difficult to handle, do not allow the word to be correlated with a visual representation of that word, while there is also the possibility of making misspelled words by misleading the letters, or the difficulty of letter combinations for pre-school children and at the same time unattractive [6, 7].
The new design proposed [1] use few complex parts that can be obtained from plastic using a metallic matrix or as a new solution the 3D printing. Worldwide are used few different 3D-printing techniques. Usually the technology uses a thermoplastic filament (for plastic parts) or metal wire which is unwound from a coil and supplying material to an extrusion nozzle which can turn the flow on and off. A thermoplastic is a plastic material, a polymer, that becomes pliable or mouldable above a specific temperature and solidifies upon cooling [8,9]. The metallic nozzle is heated (a certain temperature impose by the filament melting point) to melt the material and can be moved in both the horizontal and vertical directions by a numerically controlled mechanism. The model is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle [10-12].

The 3D printing, also known as additive manufacturing (AM), refers to processes used to synthesize a three-dimensional object in which successive layers of material are formed under computer control to create an object. Objects can have almost any shape or geometry and are produced using digital model data from a 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file [13]. The process of 3D printing consists of the next steps:
- modelling,
- printing and
- finishing a product.

Several 3D printing processes have been invented since the late 1970s. A large number of additive processes are now available. The main differences between processes are in the way layers are deposited to create parts and in the materials that are used [13-15].

In this article we present some experimental results from the design and realization of a plastic complex part using a laboratory 3D printer. The element is a part of a special dispositive for correction of reading/writing stage usually at children’s. With this complex device, it is desired to correct, through repeated exercise, the speech defect, such as stuttering.

2. Experimental details
For printing the plastic parts a Smart Rap 3D Printer was used. As active wire we use PLA - Verbatim, 1.75 mm diameter. Work temperature is 200-230 °C. The printing rate (wire alimentation) was of 2.5 mm/s. Beside the work temperature we have a table work temperature of 70 °C. The nozzle diameter was of 0.4 mm. The main active element of the final equipment proposed to be print and realized in this study is a disk with 30 letters highlighted. The final equipment contain 30 disks used to form words.

3. Experimental results
According to the invention, the apparatus for the reading-writing learning step consists of a trapezoidal prism-shaped casing, which has two viewing windows on one of the lateral surfaces which are arranged one at a different distance from one another. A continuous tape with a collinear lettering on the letters of the alphabet, signs or figures, which can be viewed through a 40x40 mm window, is drawn near the upper window.

Letters, words, and graphical representations are grouped, collinear and correlated with the letter represented on the bandwidth. The band is endless and can be rolled inside the casing on two rolls at the top of the winding and deployment equipment, having its own support and tension system consisting of supporting rollers, the arrangement of these rollers being after system itself known.

Each mobile disk, figure 1 a), engraved, on the circumference, the letters of the alphabet, the punctuation marks and a free space. The disc was designed in Catia software in 3D version. The 3D representations were also assembled to work together. The details of the element are presented in 2D scheme from figure 1 b).
Figure 1 Active elements designed for plastic parts for words formation 3D project in a) and technical draw b)
We prepare few version of the disc with different dimensions of the discs or of the letters in order to obtain the best practical solution. Instead of the pins proposed in the patent of the disc rotation equipment, it was chosen to emboss these elements (letters, numbers and punctuation marks - figure 2) to allow very easy rotation of the discs, while also allowing the selected letter to be placed in the window viewing.

![Figure 2](image)

**Figure 2** Active elements with letters for a) -c) various dimensional variants

For learning the small or large letters of the alphabet, the discs may have the desired letter size. Changing, depending on the destination or desire, of the tape or discs on the horizontal axis is possible due to the side cover of the case. The letters that are inscribed on the discs and which from the phonetic point of view are consonants are written in a colour, and the letters representing the vocals are inscribed in a colour different from the first. The colour difference between different elements of the final element can be obtained straight from the layer by layer production using a 3D printer with 2 nozzles, one for each filament colour or type. In table 1 are presented the parameters for the plastic parts that made the final assembly.

| No | Element | Pieces | Time/element[h] | Layer [mm] | Shell [mm] | Bottom [mm] | Infill [%] | Support [tip] | Adhesion [tip] |
|----|---------|--------|----------------|------------|------------|------------|------------|---------------|---------------|
| 1  | Lateral board | 2*1/2 | 2* 7.5 | 0.2 | 0.8 | 0.6 | 30 | touching | none |
| 2  | Back cover with handle | 2*1/2 | 2*5 | 0.2 | 0.8 | 0.6 | 30 | none | none |
| 3  | Board | 2*1/2 | 6.75 | 0.2 | 0.8 | 0.6 | 30 | everywhere | raft |
| 4  | Front board with drawer | 2*1/2 | 2*16.5 | 0.2 | 0.4 | 0.6 | 20 | none | none |
| 5  | Discs with letters | 27 | 27*2.25 | 0.2 | **1.2** | 0.6 | 20 | everywhere | None |
| 6  | Lateral board right/left | 4*1/2 | 2*6.5 | 0.2 | 0.4 | 0.6 | 25 | everywhere | None |
| 7  | Writing board | 2*1/2 | 2*8 | 0.2 | 0.4 | 0.6 | 25 | everywhere | raft |
The discs are the main active elements and the production of one element is 2.25 hours. The obtaining of a final element using 3D printing suppose three main stages: a) design of the element, b) printing the element and c) surface final preparation by eliminating the plastic casting network. An important characteristic of the plastic elements made by 3D printing is the filling percentage. This is a characteristic specific for 3D elements growth layer by layer. For practical applications is very important if the same element can be heavier or not modifying his internal structure like filling degree. In this case we use a 20% filling degree maintaining the element integrity and also keep the element easy enough for final application.

Analysing the time to obtain the main elements of the final equipment some of the elements (like front board) can be obtain through different methods like plastic injection because the production time is high (16.5 hours). In the same time because the disks have a complicated geometry can be properly obtained using 3D printing but for a higher production of final elements a farm of 3D printers (ten or more).

4. Conclusions

We use 3D printing to obtain plastic pieces with complicated geometries and with very good final result concerning the accuracy of the details. The advantages of 3D printing in this case are represented by the flexibility of changing details in the production of the final element based on 2D and 3D model. Based on the elements complexity big parts with no special geometry can be cut from a bigger piece (using laser cut for example), or by plastic injection, 3D printing is not quite the best choice because of the very big time production. The elements with complex geometries are easier to be obtained through 3D printing and don’t need special production stages. Mechanical resistance can be improved by modifying the filling degree or even the plastic material.

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