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3D printing in the education of graphic engineering and design students

Bojan Banjanin, Magdolna Pál, Vladimir Dimovski, Savka Adamović, Ana Lilić
University of Novi Sad, Faculty of Technical Sciences,
Department of Graphic Engineering and Design, Novi Sad, Serbia

Introduction

Additive manufacturing, commonly known as 3D printing, is taking its constantly growing part in a lot of different manufacturing industries, educational institutions and a lot of entrepreneurship and home businesses. One of the most commonly used and certainly most available and affordable 3D printing technique is Fused Deposition Modelling (FDM). Parameters such as printing temperature, layer height, percentage of infill, printing speed etc. are to be taken into consideration when starting a print job. So, it is essential to get familiar with them. Every slicer program comes with different capabilities of setting up a print job, and many parameters which can be modified, but some basic knowledge is necessary to begin with printing.

There is an increasing number of educational materials, tutorials, tips and tricks, reviews and projects that are available online. For beginners and, in the case of this research paper, undergraduate students, catalogue of models with the variation of basic printing parameters are printed using FDM 3D printing technique, as an introduction to the understanding of 3D printing process. These printing parameters are essential for designing and modifying different 3D models and prepare them for printing.

Methods

At the Department of Graphic Engineering and Design students are introduced to fundamentals of 3D modelling in the second year of undergraduate academic studies when they learn to work in 3D CAD software, by getting familiar with virtual 3D space and basics of designing graphic products. Further on, they continue to foster their 3D modelling skills in the third year in the two subjects: Fundamentals of spatial design and Industrial design. In the third year of undergraduate academic studies, they begin to learn about the fundamentals of 3D printing within the Industrial design course. A detailed explanation of 3D printing techniques and their specificity is covered at master academic studies in the 3D printing course.

3D printing filament made from Polylactic Acid (PLA) was used in this research. The diameter of the filament used was 1.75 mm. Artefacts were printed at room temperature of 23 ±2°C using Creality CR10S Pro FDM 3D printer. The temperature of the printing bed was set to 50 °C, and the temperature of the printing nozzle was 200 °C (except for the temperature test). Printing speed was set to 50 mm/s with enabled retraction (Retraction distance: 6 mm; Retraction speed: 45 mm/s).

After setting the list of desired 3D printing parameters, 3D models are created using Autodesk Fusion 360 CAD software, which is simplified version of Autodesk Inventor, and which is broadly used in makers' circles due to its' simplicity and fast learning curve. Each model has created bearing in mind which 3D printing parameter it needs to emphasize. Some of the models are downloaded from Thingiverse web site to show particular slicing mode (e.g. Vase (JJ76, 2018), Mold (Erickson (2017)), stringing effect using different temperatures or overhang angles (Stainhausler, 2017).

Results

Figures 1-8 showcase 3D printed artefacts using different printing parameters, mods, or some specific attribute. These are only images with some of the parameters visible. However, more detailed experience using a combination of visual and haptic senses can convey texture, structure, size and all the other attributes necessary for the more in-depth understanding of fundamentals of 3D printing.

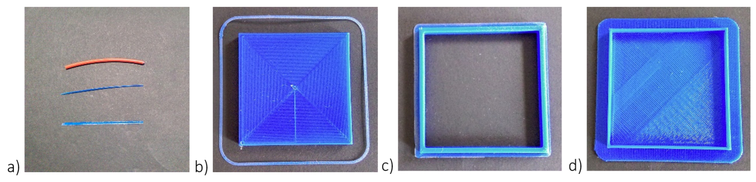

Figure 1: *a) unextruded (1.75 mm), extruded (0.4 mm) and printing filament adhered on build plate (Line width); b) part with a skirt; c) with brim; and d) with raft*

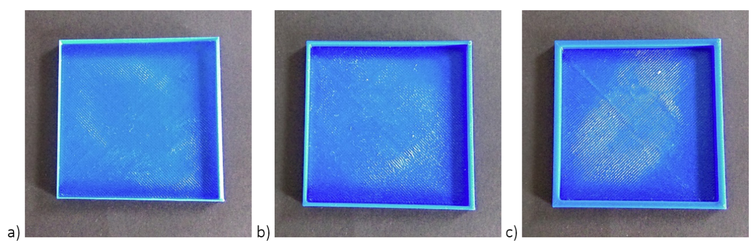

Figure 2: *Wall line count. a) one, b) three and c) six walls. Printed with bottom layers and without top layers*

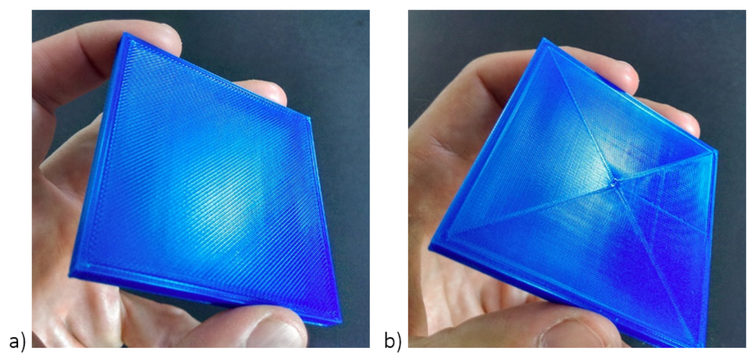

Figure 3: *Top layers printed with different patterns. a) Lines and b) Concentric pattern*

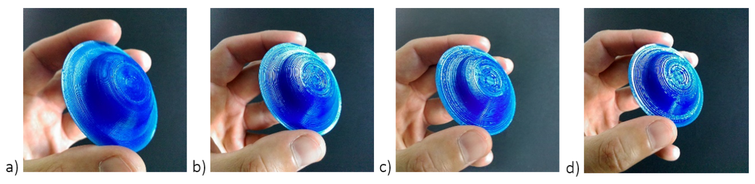

Figure 4: *Models with varied layer height. a) 0.1 mm, b) 0.2 mm, c) 0.3 mm, and d) 0.4 mm*

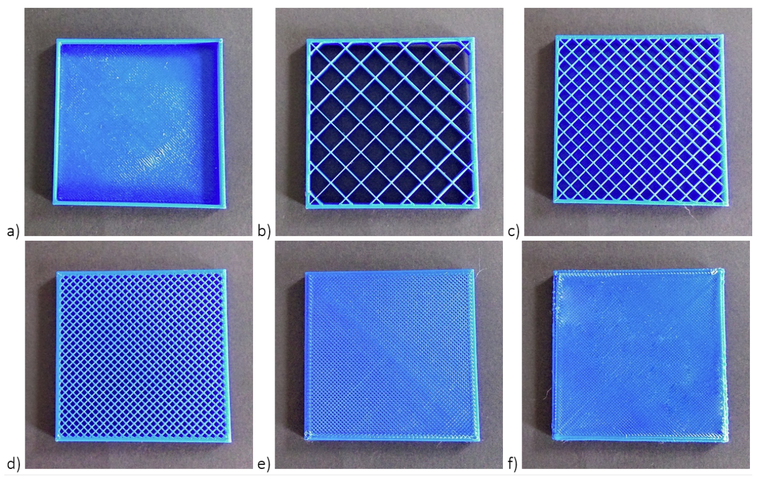

Figure 5: *Models with varied percentage of infill. a) 0%, b) 20%, c) 40%, d) 60%, e) 80%, and f) 100% infill*

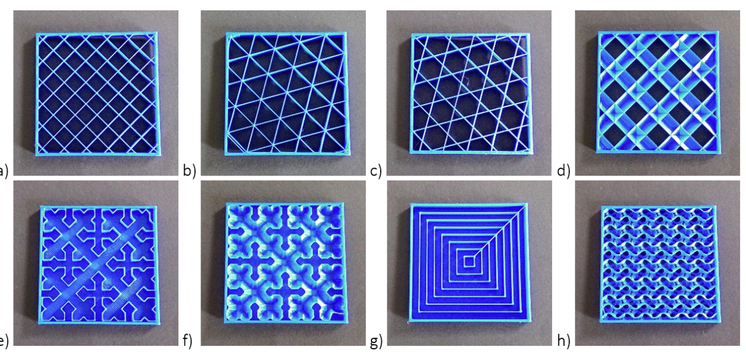

Figure 6: *Models with varied infill pattern. a) grid, b) triangles, c) Octet, d) Tri-Hexagon, e) Cross, f) Cross 3D, g) Concentric, and h) Gyroid infill pattern*

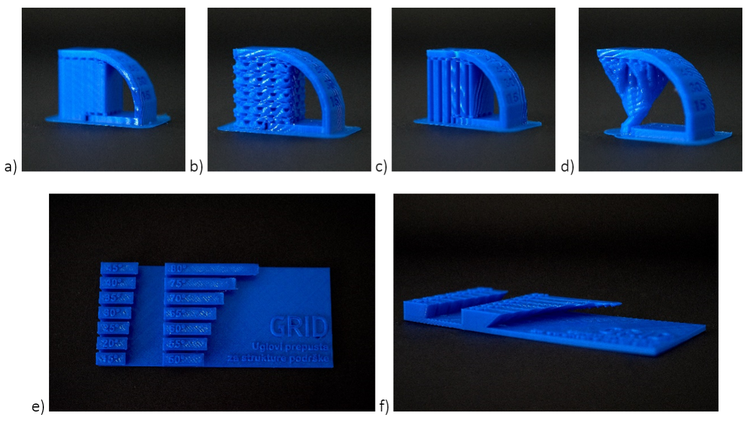

Figure 7: *Models with different support pattern. a) Zig Zag, b) Gyroid, c) Triangles, and d) tree support structure. e) i f) represent model with different overhang values and no support structures*

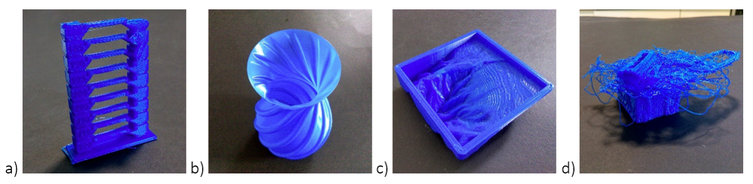

Figure 8: *Different artifacts. a) "temperature tower" for testing influence of different nozzle temperatures on stringing and bridges, b) part printed with only one wall – Vase mode, c) 3D printed mold, d) example of failed print*

Conclusion

In this research paper, different ways of using 3D printing in interdisciplinary industries such as graphic engineering and design are discussed, and some practices of integrating 3D printing in education process are reviewed. Implementing of 3D printing in the curriculum for undergraduate students of Department of graphic engineering and design, after reviewing scientific literature, can definitively have a tremendous positive impact on students' and teachers' engagement improving both the learning and the teaching experience. The first step in this implementation process is getting familiar with the fundamentals of 3D printing process parameters and then finding a novel and creative ways of using this technology as an aiding tool in the graphic industry. The haptic experience involved with 3D printing, based on the reviewed literature, generally helps in better understanding of observed parts and in case of 3D printed artefacts done in this research paper it definitively can improve students' learning process.
Further research can be done by interviewing students about 3D printing fundamentals using physically 3D printed parts and comparing those results with a group of students who only used visual apparatus throughout the learning process. Also, the collection of printing parameters presented in this paper can be further on expanded in order to cover some of the advanced printing parameters and problems which can be solved by thoroughly understanding of these parameters.

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Stainhausler: "Better temperature tower 240-180", URL: https://www.thingiverse.com/thing:2625999 (last request: 2020-08-15).

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