APPLICATION OF 3D PRINTING IN THE STUDY OF QUADRILATERALS IN 5TH GRADE

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ПРИЛОЖЕНИЕ НА 3D ПРИНТИРАНЕТО ПРИ ИЗУЧАВАНЕТО НА ЧЕТИРИЪГЪЛНИЦИ В 5 КЛАС

Abstract

Ideas for creating jewelry with basic figures – quadrilaterals, through 3D printing are presented. Applying knowledge about the types of quadrilaterals to create authors works supports the formation of knowledge and skills about the basic characteristics of the main types of quadrilaterals. The presence of STEM centers in a number of Bulgarian schools and, accordingly, 3D printers facilitates the implementation of these ideas. The use of basic geometric figures to create unique works suitable for 3D printing supports the simultaneous development of mathematical and engineering competence.

Keywords: *3D Printing; STEAM; Quadrilaterals; Creativity; Engineering Competence.*

INTRODUCTION

For the development of STEM skills in modern schools, various steps are taken to create conditions and accessible resources for students of different educational levels [1], [2]. To consolidate students' knowledge of the basic characteristics of the types of quadrilaterals, it is appropriate to use both digital and physical models. The applications of 3D printing during the educational process can help expand knowledge related to the ways of constructing geometric figures [3], [4]. We note that the 3D pen is an accessible tool that allows for the timely creation of an author's model [5]. Studies on the use of specialized 3D printing software when working with different groups of learners also report positive results in terms of the development of creative thinking and engagement [6], [7], [8].

Here we will consider some options for using freely available online software environments of varying complexity, suitable for creating 3D models of jewelry based on geometric shapes – quadrilaterals. The studied software environments are suitable for use by students in primary and/or lower secondary school, teachers. For modeling three-dimensional objects, some drawing methods (freehand, pen) will be demonstrated; ready-made tools for construction using geometric shapes and bodies; options for using a photo, based on which to automatically generate a 3D model. The goal is to consider options for scenarios that help to simultaneously develop technical skills, creative thinking, and mathematical competence in students.

CREATING AUTHOR WORKS WITH 3D MODEL DESIGNER

The free and freely available online platform *IMAGEtoSTL* offers tools for creating, editing, resizing 3D models, converting file formats, including the ability to generate them based on a photo [9]. In the "*Image to STL*" subsection, the following image formats can be converted into 3D files – PNG to STL or OBJ; JPG to STL or OBJ; SVG to STL or BLEND. Here we will consider several examples using the PNG format. Fig. 1 shows sketches of original jewelry models and the generated 3D models after uploading the JPG photos. When using photos with filled color areas, the most common inaccuracies are: automatic generation of a base (plane) on which the figure is carved; merging of areas in the absence of sufficient distance between them; formation of holes in some areas due to different brightness and contrast of the detected colors.

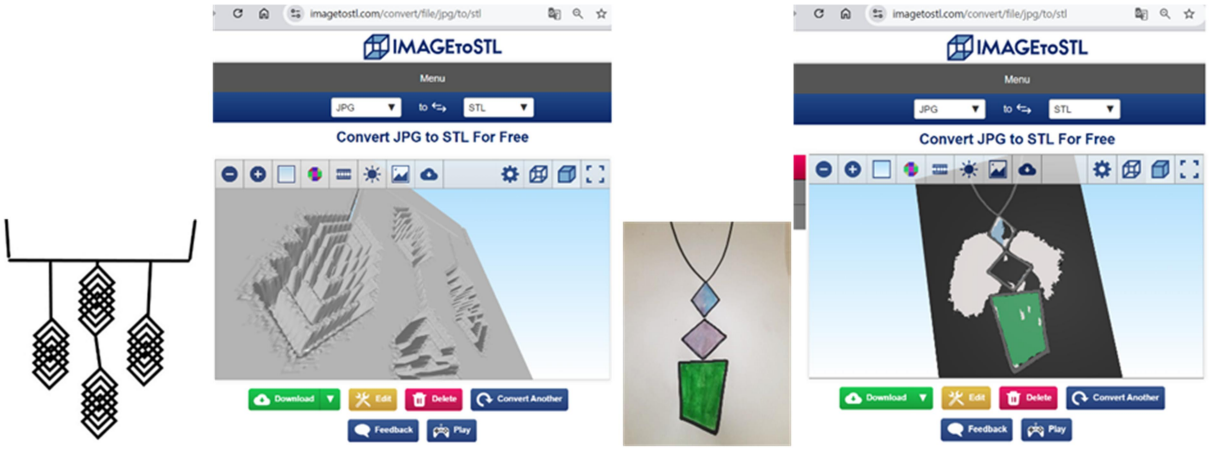

Fig. 1. Sketched jewelry models based on quadrilaterals and generated 3D models from them

To remove the base and generate only the outlined figure, you need to select "*Remove Background*" from the "*Tool*" menu on the left and set at least medium quality of the model detail (Fig. 2). The depth, thickness and unit of measurement of the layer can be changed before the generation itself, as well as after it from the yellow "*Edit*" button. The software environment allows downloading the finished 3D model in several file formats – STL, ZIP, 7Z, URL link for download.

Fig. 2. Generating a 3D model of a jewel from a digitally made file with the background removed

When working with *IMAGEtoSTL*, it is appropriate for students to go through the processing of photos of hand-sketched models on paper, as well as to use files made with software environments already used in school, such as *Paint*, *Skratch*, and others. By overlapping colors and contours, which can imitate depth, three-dimensional models are obtained during 3D generation (Fig. 3)

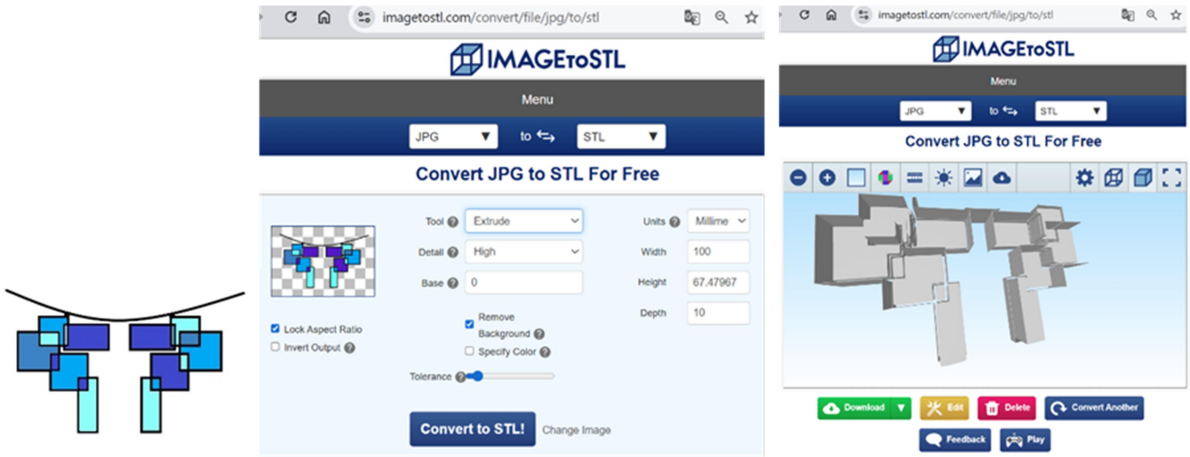

Fig. 3. 3D generation of a jewelry model from a digital file

In the "3D Model Designer" subsection of the same online software, there is an option for freehand drawing. By analogy with Paint, the thickness and color of the trace left by the pencil can be adjusted, there is an option for erasing, i.e. students can easily navigate the interface. By analogy with the 3D models made above based on a photo, the background has been removed here as well, so that only the outlines of the figure remain (Fig. 4).

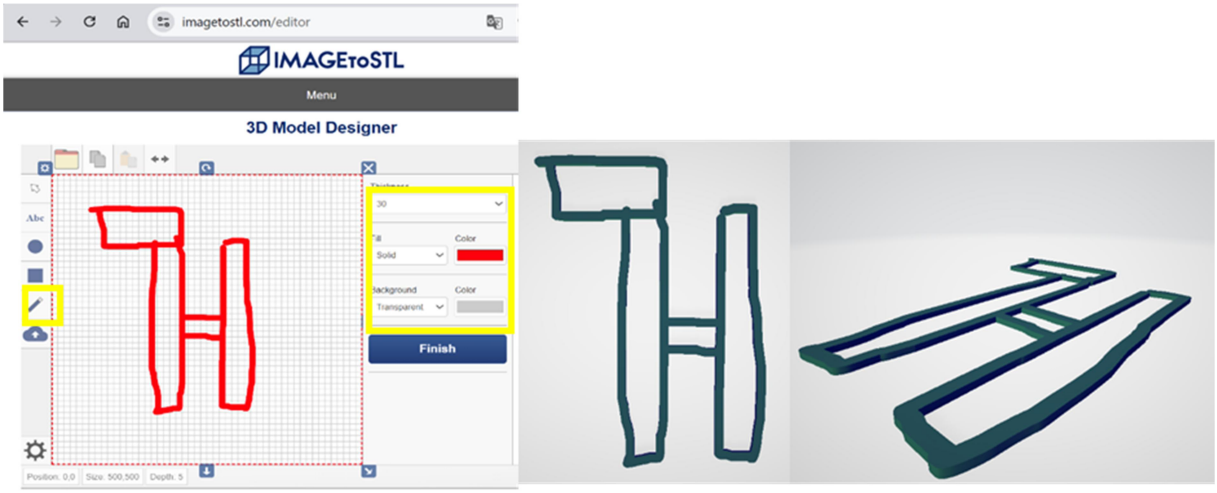

Fig. 4. Creating a jewelry initial "H" by freehand drawing and the exported 3D model

CREATING AUTHOR WORKS IN MAKERWORLD

One of the most active manufacturers of 3D printers in the world, BambuLab, maintains the online site *MakerWorld*, where it is possible to create a free user profile [10], [11]. Through it, there is access to hundreds of ready-made 3D models shared by other users, as well as an online space *MakerLab* with ready-made modeling tools. In the subsection "*Make My Desk Organizer*" there are ready-made shapes available - square, circle, hexagon, triangle, arc, line; specialized shapes - outer circle inner square, outer square inner circle and rect with rounded interior. It is appropriate to give the students the opportunity to build several models

with the ready-made shapes, and then move on to independently building the quadrilaterals. Here we will consider a variant for creating original 3D models using "*Pen*" and "*Line*" tools (Fig. 5).

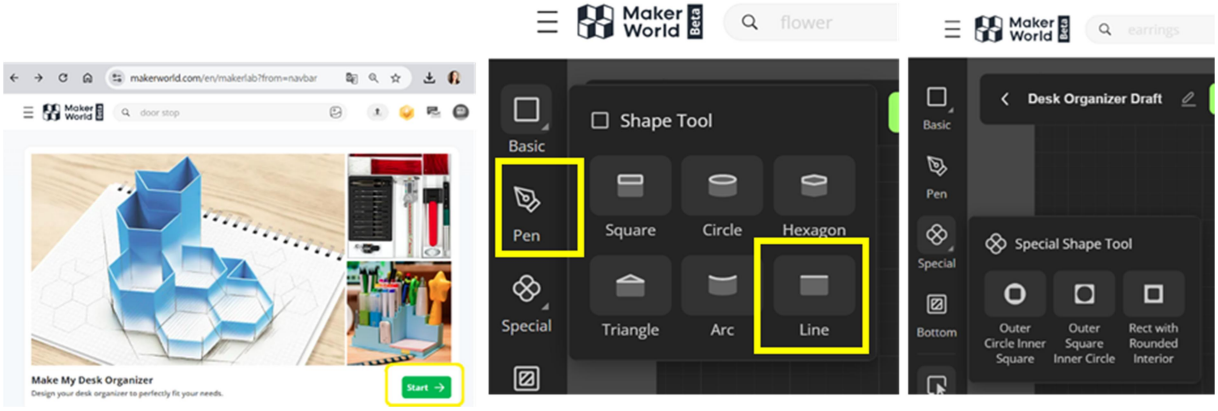

Fig. 5. 3D modeling tools in the "Make My Desk Organizer" subsection of the MakerWorld website

When working with the "*Pen*" tool, it is appropriate to use the ready-made grid on the drawing surface. By sequentially applying points, an arbitrary quadrangle is created. When working with students, it is good to show that in addition to manually creating each subsequent geometric figure, multiplication of an already created module can be used. For example, with the right button, the ready-made geometric figure can be copied and duplicated, i.e. in the context of the task of creating a piece of jewelry - a chain of identical consecutive links can be created. This can be done both by using the first base figure and by selecting an increasingly larger composition to be superimposed on the previous one (Fig. 6). To facilitate working with fine and small 3D models, there is an active "3D preview" field in the upper right, where three-dimensional objects are visualized (Fig. 6).

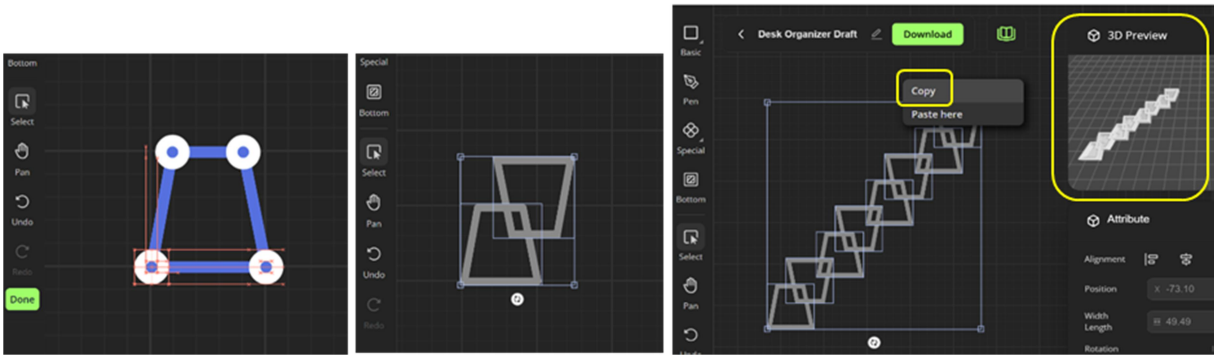

Fig. 6. Multiplying an entire 3D model to create a piece of jewelry using the "Pen" tool

When working with the "*Line*" tool, each added line has an automatic length (20 *mm*) and thickness (1 *mm*), but they can be adjusted at any stage of the work from the "*Attribute*" field on the right. The slope of each marked line can be adjusted by the button below it, or an exact degree of rotation with accuracy to the hundredth of a decimal point can be entered in the "*Rotation*" field on the right. (Fig. 7).

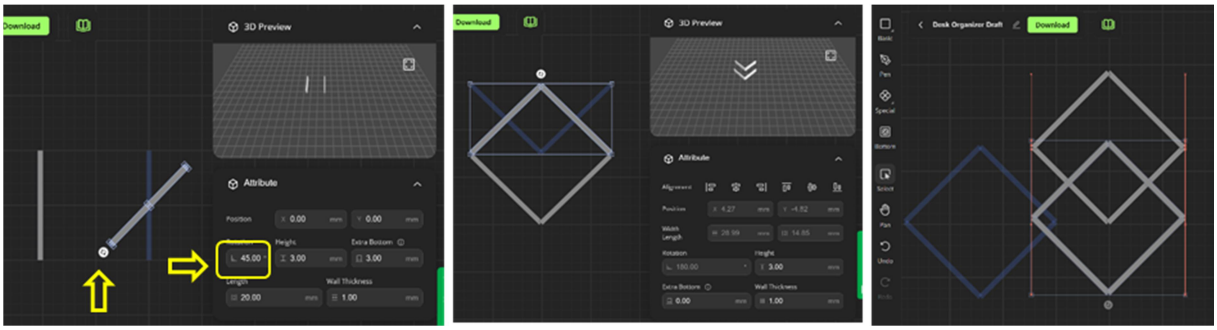

Fig. 7. Creating a quadrilateral in 3D model designer using the "Line" tool

By analogy with the work with the "*Pen*" tool, here too, by marking, copying and pasting a selected figure, the time for creating the final model can be reduced. The software also allows partial copying of a figure without destroying its integrity, as shown in Fig. 8.

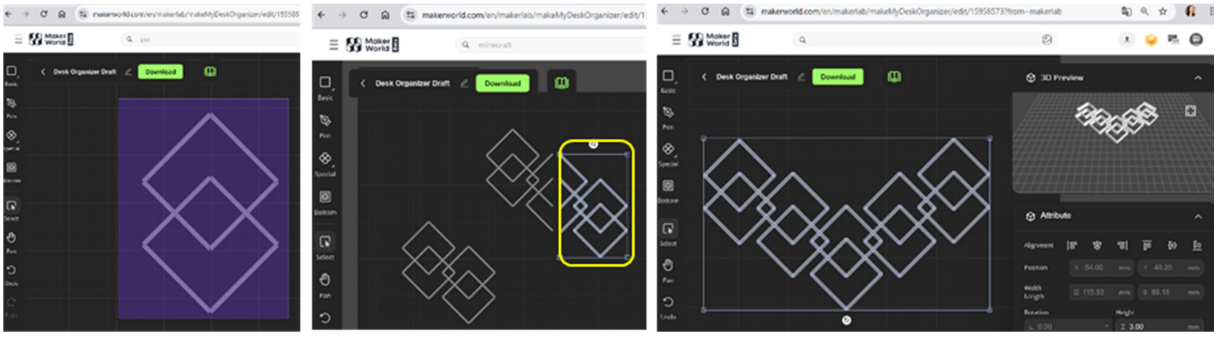

Fig. 8. Copying parts of a 3D model to create a necklace

From the green "*Download*" button above the drawing field, you can download the finished 3D model in STL or 3MF format. The 3MF format allows other registered users of the site to download it from the author's personal profile, edit it, supplement it and re-attach it, citing the original source. This contributes to the distribution and work with ready-made resources on a global scale, understanding the ways of using ready-made resources and their copyright.

CONCLUSION

The examined software environments allow the creation of original 3D models using quadrilaterals. The studied software products are free and available online. Working with them does not require prior technical training. An online platform requiring free user profile creation was used, as well as software that does not require system registration. The online platform allows access to users from all over the world and their 3D works. A positive step for educating the rules of copyright is the ability to edit a 3D model and re-upload it with a citation of the original source, offered on the same platform. The user interface of the examined online environments includes a small number of settings familiar from working with Paint and Scratch at school. The proposed guidelines for organizing scenarios are suitable for use in Information Technology, Computer Modeling, Entrepreneurship classes, when working in STEM centers, during extracurricular activities.

It is appropriate for students to go through several methods for creating three-dimensional objects - sketching a figure on paper, based on whose photo to generate its 3D version; creating a digital drawing that can be used to generate a similar 3D model; drawing using a "pen" tool, which has different trace accuracy (freehand, point-to-point, etc.) depending on the software used; creating geometric shapes using basic "Line" tools. In

addition to using a 3D printer to print the author's models, if possible, a 3D pen can also be used for comparison with other working methods.

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