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EVALUATING THE IMPACT OF 3D PRINTERS FOR CREATING INNOVATIVE POSTER DESIGNS

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ABSTRACT

The aim of the study is to substantiate the optimal choice of a software for prototyping and UI/UX design. The aim of the study is to determine the features of using 3D printing, while focusing on the creation of innovative poster designs. The research methods at the initial stage of the study were methods of comparison, calculations of the correlation coefficient, analysis of variance, t-test, calculating Pearson coefficient. It was determined that innovative approaches to creating poster designs are abstract shapes (t=1.783), the use of elements created by artificial intelligence (t=1.772). Illusionary design elements (t=1.743), combinations of mismatched parts (t=1.756), and minimalism (t=1.732) can also be taken into consideration. It was found that the 3D printer from Mcor Technologies has the greatest efficiency in CD printing. The process is related to the realism of the created drawing (93%), the quality of the color scheme (95%), and the scope of application (93%). With the help of the Anycubic Mega Pro printer, it is possible to convey the quality of the composition structure (92%) while providing multi-color printing. It was established that when developing a layout, for high-quality printing it is imperative to take into account color (t=1.783), design elements' dimensions (t=1.770) as well as the contour complexity (t=1.765). It was found that the obtained findings have a positive practical impact on prospective designers, which is due to the achievement of high results by students of Group 1 in the creation of design projects for 3D printing (92 points). The research objectives are focused on comparing the excellence of design projects when employing interactive versus traditional methods in their creation.

Keywords: *Interactive Technologies, Design Project, Three-Dimensional Elements, Abstract Shapes, Color Scheme.*

1. INTRODUCTION

Modern technologies play a pivotal role in exploring novel approaches for executing design projects. The plethora of interactive technologies available does not guarantee the attainment of high-quality outcomes; hence, it is imperative to adeptly navigate the most efficient programs and methodologies [1]. 3D printing stands out as a cutting-edge mechanism for crafting poster designs, thereby significantly influencing the pertinence of the selected topic.

3D printing is the process of creating three-dimensional elements, providing accurate reproduction of their details, focusing on the use of interactive technologies [2]. The benefits of 3D technologies lie in their capacity to produce unconventional posters, characterized not only by their dimensions but also by the utilization of diverse materials for printing. 3D technologies can be used to print on canvas, which allows printing art elements, or they can be utilized to magnify photos and images [3]. Furthermore, this approach can facilitate the use of 3D printing to create innovative poster designs. Innovative design is utilized to captivate a specific audience, which is linked to the exhibition of unconventional approaches [4]. This is due to the development of stylistic nuances, the reproduction of individual features, which affects the content and aesthetic reflection. Moreover, innovative designs influence the choice of high-quality color and graphic modelling. The efficacy of posters in captivating readers' attention should be contingent upon ensuring the overall coherence of the text and visuals that align with the intended purpose [5]. Innovative technologies also contribute to an appropriate font selection, which affects the elaboration of individual details and enhances visual perception.

Currently, it is possible to replicate the intricacies of poster designs through the utilization of 3D printing technology involving three-dimensional objects. Layer-by-layer printing of a three-dimensional object is enabled due to the availability of appropriate drawings, illustrations, choice of colors, etc. [6]. Interactive technologies provide automatic adjustment of individual design elements, which can manifest itself in changing lighting, adjusting sharpness, etc. With the help of an interactive poster, information that can be used in the educational process as well as during the creation of advertising, website development, etc., is visually perceived. An interactive poster affects the ability to access any virtual windows. For instance, services for creating interactive posters can be Genial.ly, ThingLink, Glogster, which provide a combination of creative and technological capabilities [7]. An interactive poster engages the audience by conveying information through demonstrative elements. In this light, printing interactive posters is essential for disseminating information that embodies an innovative technical and artistic concept6. Artistic means contribute to the display of an expressive visual image, which are transmitted to consumers with the help of printed graphics. Poster graphics serve as a prevalent mechanism for information perception. The alteration of the sheet plane significantly influences the modified perception of all content [8].

Based on theoretical research, it is feasible to infer that information pertaining to cutting-edge designs and CD printing is widespread individually, yet integrated methodologies for investigation are scarce. The aim of this article is to explore the intricacies of utilizing 3D printing technology in the development of innovative poster designs.

The objectives of the study were as follows:

- to ascertain the prevailing trends in poster design, with the intention of incorporating cutting-edge technologies;
- to compare the capabilities of 3D printers, taking into account the parameters of the drawing realism, the quality of the color scheme, the compositional structure as well as the scope of application;
- tp determine the criteria for preparing the layout, which have an impact on the quality of three-dimensional printing;
- to evaluate the quality of innovative poster designs created by respondents, focusing on the use of the material presented by the authors (Group 1) and drawing upon their own experience (Group 2).

To implement a qualitative study and achieve the set goal during the study, it is necessary to pay attention to solving the following issues:

- Determine what are the most modern approaches to creating a poster design, focusing on the capabilities of available 3D printers;
- Based on the selection of available 3D printers, determine what technical advantages exist for the possibility of three-dimensional printing;
- Assess the possibility of using the analyzed 3D printers during the study;
- Determine ways for respondents to create poster designs;
- Determine approaches that can be used to evaluate poster designs that were created by respondents.

2. LITERATURE REVIEW

Three-dimensional printing is an innovative method that provides the creation of complex objects on the surface of a 3D printer using computer-aided design. In fact, three-dimensional printing is widespread in education, technology, biomedicine, which is associated with the manufacturing specialized parts compatible with physical and chemical features for possible recycling [9]. Notably, 3D printing contributes to the production of complex and simple parts that contribute to the implementation of individual projects for various fields. The use of 3D printing affects the unconventional perception of individual information, focusing on progressive approaches to its presentation. With this in mind, it is possible to show your own achievements, revealing the chosen topic, creating appropriate contrasts. Based on interactive compositional solutions, it is possible to emphasize pertinent information [10]. To cultivate graphic expertise within the contemporary educational framework, cutting-edge technologies and resources are used, among which 3D modeling, additive manufacturing, and virtual reality stand out. It was suggested to utilize Computer-Aided Design (CAD) software for the creation of educational graphic 3D designs. Students were tasked with developing two iterations of the design – one utilizing virtual reality technology and the other employing 3D modeling techniques. The process was aimed at understanding innovative graphic techniques and developing practical skills in creating designs. The above approaches impacted the ability to develop spatial thinking in students [11].

When creating advertising designs for a particular brand in the form of individual mascots

or symbols in the printing arts, the focus on cultural specifics is indispensable. First and foremost, it is imperative to comprehend the intricacies of local culture and organizational culture. When eleborating designs, the research into the features of animation, visual effects, and the software used should be taken into account. Digital Game (DG), Digital Industry Integration (DII) and Knowledge Innovation Management digital applications can be used as innovative technologies for creating designs. The utilization of digital 3D printing, based on intricately crafted designs, enables the precise visualization of the company's image [12]. Poster design based on computer-aided design promotes the use of broader approaches to create custom designs, which ensures the most accurate direction of market trends, elaborating a certain algorithm for creating designs. The process provides comparison of images, determination of the necessary materials, sizes of images. Overall, the approach influences performance optimization and the creation of effective projects [13]. Artificial intelligence (AI) has influenced the enrichment of tools for creating poster designs. For example, augmented reality technologies contribute to the search for high-quality approaches to creating designs, ensuring the purity of color, the quality of texture. Due to the combination of images and text, the interactive Gabor filter provides a high-quality combination of color and texture, which impacts the development of more captivating design projects, offering substantial communicative value [14].

One of the of graphic design tasks is to develop innovative visual solutions that can be executed using the EvoDesigner application. The application contributes to the automatic change of the layout, presenting several variants of certain pages' style. Interactive tools facilitate the accurate analysis of existing layouts to craft innovative designs, with a sharp focus on the objectives set by the designers [15]. It should be noted that 3D printing is an affordable and efficient way to create new products, focusing on the possibility of prototyping with specific customizations. The aforementioned approach serves as a versatile tool for the implementation of adaptable products across diverse industries (healthcare, automotive, medicine). High-quality 3D projects can be implemented as a result of a detailed study of designs that exclude errors in visual perception [16]. 3D printing has a major impact on the manufacturing industry and society, developing the potential to create new products. The preparation process should involve the creation of sensitive symmetrical and asymmetrical lines, take into account contrasts, certain proportions, and features of the space curvature. In this light, it is worth ensuring that designs are developed according to the scalability of printers [17].

Drawing upon the analysis of existing publications, it was discerned that research is predominantly centered on elucidating the advantages of 3D printing. However, gaps in research are related to defining the necessary criteria for the possibility of creating a high-quality poster design for 3D printing. Most of the studies have focused on analyzing the applications of 3D printing in the realms of industry and medicine, while research on poster designs has been somewhat limited. Therefore, throughout the research, it is imperative to delve deeper into the characteristics of contemporary approaches to poster designs in order to explore the potential application of three-dimensional printing. This will streamline the quest for innovative CD printers that can significantly enhance the quality of printing outcomes.

3. METHODOLOGY

3.1. Research procedure

At the first stage of the study, the existing trends in poster design were identified, whereby attention was paid to the study of poster design, which can be implemented using interactive technologies. The second stage of the study included an analysis of the capabilities of CD printers (Mcor Technologies, Anycubic Mega Pro, Super Helper 3D Printers). The evaluation of 3D printers involved considering the verisimilitude of the design, as well as the quality of the color scheme and compositional structure, the scope of application. At the third stage of the study, it was ascertained which elements should be focused on in order to ensure print quality. During the study, the features of state-of-the-art approaches to the creation of poster design were taken into account. The fourth stage of the study envisaged evaluating the innovative posters created by respondents. Group 1 was represented by respondents who took into account the features of state-of-the-art designs and principles of 3D printing established by the authors, while 2 Group focused on their own experience in creating poster designs. The study protocol is presented in Appendix 1.

3.2. Sampling

Respondents participated in the study solely during the final, fourth phase (185 individuals). The choice of respondents was made

among students of the Kyiv National University of Technologies and Design (Group 1), the Faculty of Design and among the respondents who create designs on their own (Group 2). Respondents in Group 1 were third-year students and were enrolled in the study, as they had the skills of creating poster designs and the skills of independent work (73 individuals). Respondents in Group 2 were selected from among those submitted through Facebook (112 individuals). The condition for the sample of respondents for Group 2 was that they had created ready-made poster projects, an understanding of the principles of graphic design and 3D printing. Checking the availability of the necessary knowledge of the respondents of Group 2 was implemented as a result of the ready-made projects provided by them and the implementation of the proposed tasks for the creation of individual design fragments. All participants were in identical conditions, as previously specified prior to the commencement of the research study.

3.3. Methods

The exploration of innovative approaches that contribute to the development of contemporary poster designs was conducted through the utilization of the comparative analysis method. The process involved taking into account the features of poster designs from the 2000s and modern poster designs (2022-2024 years). With the help of the comparison method, characteristic elements of modern designs that have not been used before were established. The basis for the comparison was determined by the quality of printing, features of the structure of the drawing, the specifics of the location of the text and drawings, comparison of the color scheme. Also taken into account were approaches to the use of images depending on the chosen form (abstract or concrete), and features of the combination of various details. After considering the relevant criteria, calculations of the correlation coefficient, the analysis of variance and t-test were carried out. A comparison of different statistical elements was defined in order to verify the final results, which were obtained on the basis of the definition of conditional estimates for the study, focusing on the initial definition of significant indicators.

The formula for calculating the correlation coefficient [18] is as follows:

$$r = \frac{\sum_{i=1}^{n}(p_i - p_m)^{1/2}}{m-1}, \quad (1)$$

m – the number of criteria for conducting the study;

p_i – the relative value of the criterion under study;

p_m – the arithmetic mean.

The formula for calculating the analysis of variance [19]:

$$R^2 = \frac{S_t}{pq-1}, \quad (2)$$

S_t – the total sum of square deviations;

p – the numerical indicator of observations at each level;

q – the number of levels studied.

The formula for calculating the t-test [20] is as follows:

$$t = \frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}} \quad (3)$$

M_1, M_2 – the average discrepancy between the indicators used;

m_1, m_2 – the standard deviation of the indicators for comparison.

The grades assigned by the educators facilitated the computation of the Pearson correlation coefficient [21]. The objective of the Pearson coefficient is to establish a comparative rating among various indicators. This procedure entailed allocating appropriate scores to participants based on the quality of their completed projects, thereby contributing to the determination of this coefficient. The formula for calculating the Pearson ratio is as follows:

$$r = \frac{\sum z_{x_i} z_{y_i}}{n-1}, \quad (4)$$

z_{x_i} – variable of the first indicator;

z_{y_i} – variable of the second indicator;

n – the number of indicators for comparative analysis.

3.4 Research tools

When evaluating the printing advantages of certain 3D printers over others, the focal point was on identifying printers that exhibit similar functionality (graphic extension, color set, power, print material, etc.). The sample was made from more than 50 printers that are characterized by volumetric printing capabilities. The choice of printers for the study was made based on the manufacturer's analysis of these characteristics (Figure 1). Particular attention was paid to the selection of 3D printers, which are widely used, which facilitates the possibility of creating three-dimensional poster designs.

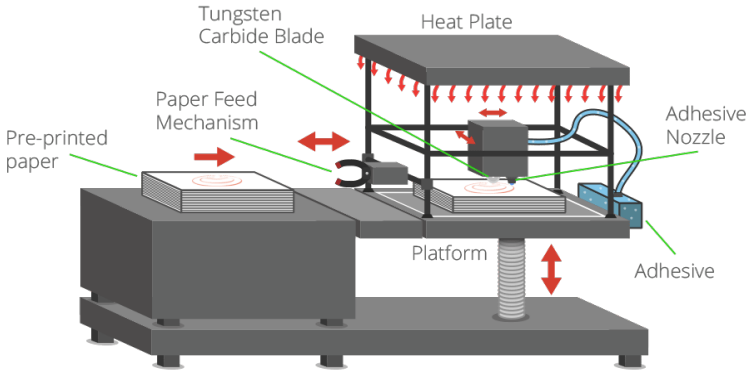

Figure 1: General Operation Principle Of 3D Printers
Resource: Elaborated By The Authors Drawing On [22]

The above analysis made it possible to choose for research a 3D printer from Mcor Technologies, Anycubic Mega Pro, Super Helper 3D Printers. The selection criteria for comparing printers involved taking into account the possibilities for publishing posters based on the created interactive designs. With the help of the established criteria (drawing realism, quality of the compositional structure and color scheme, scope of application), the advantages of some printers over others were determined.

To practically confirm the quality of the established features of 3D printing and the features of poster designs, respondents were involved. Respondents were required to create their own poster designs that would meet the capabilities of 3D printing. Group No. 1 took into account the results of the study to create designs, focusing on the specified criteria. Group No. 2 used their own experience in creating poster designs. To ensure an innovative approach to creating designs, the digital application Meshy was used. During the study, respondents created posters for a month. The quality of the created designs was assessed by teachers who had more than 5 years of experience teaching designers. When assessing the created posters, teachers took into account the features of the color combination, the quality of the combination of individual design elements, which had an impact on the consistency of individual elements. The assessment included the complexity of the contour, the depth of space. The assessments given by teachers allowed for calculations of the Pearson coefficient [21]. The process involved assigning respondents appropriate scores for the quality of completed projects, which further contributed to the calculations of the Pearson coefficient. The Pearson coefficient is aimed at providing a comparative assessment between indicators, which is associated with the definition of a linear relationship.

3.5. Data analysis

The analysis of the obtained results involved the use of calculations of the correlation coefficient, analysis of variance and t-test. Based on their calculations, the authors obtained specific statistical results. However, to identify possible deviations and anomalies, additional calculations of the possible error were used.

$$\bar{x} - t_a \frac{s}{\sqrt{n}} \leq a \geq \bar{x} + t_a \frac{s}{\sqrt{n}}, \quad (5)$$

X – average value;

t_α- coefficient that affects the distribution of the Student's t-test;

a- set of average values;

s –standard deviation coefficient;

n- number of indicators studied.

The absence of errors (and anomalies) in the calculations will be excluded if the calculation error is not more than 95%. Calculations within the framework of this study showed the presence of values of more than 10%, which excludes the possibility of errors in the study and possible anomalies.

4. RESULTS

The diversity of consumer demands necessitates the exploration of novel approaches in crafting poster designs. In light of this, the authors delineated the prevailing trends in poster design. Hence emphasis was placed on captivating readers and discerning the most cutting-edge methodologies. Calculations of the significance of the criteria were carried out using the correlation coefficient, analysis of variance and t-test. (Table 1).

Table 1: Poster Design Trends Implemented On The Basis Of Innovative Approaches

Established criteria	r	R^2	t-test
Abstract shapes	0.82	0.73	1.783
Using AI-generated elements	0.76	0.70	1.772
Illusionary design elements	0.71	0.65	1.743
Combining mismatched parts	0.73	0.68	1.756
Minimalism	0.69	0.63	1.732

Source: Elaborated By The Authors

State-of-the-art poster designs are associated with the use of interactive technologies that provide automation of the creative process. One common form of modern design is *Abstract shapes*, which provide a non-standard approach to materials perception. In modern posters, abstract rounded shapes are used when creating a design, which affects visual perception. The utilization of abstract shapes is linked with an array of vibrant hues, which helps to enhance the weight of individual elements. Such design elements of expression influence the artistic comprehension of the composition and establish the foundation for project endeavors. *Using AI-generated elements* Contributes to the creation of custom images or text. Focusing on virtual experiences helps expand design possibilities. The process is all about setting a specific task and selecting interactive options based on high-quality results. An automated approach avoids streaming drawings and ensures the presence of bright virtual elements. The implementation of creative ideas is facilitated by artificial intelligence.

Combining mismatched parts is also aimed at a new design perception of posters. This may involve experimenting with fonts, color schemes, text sizes, and images. The process may be associated with the creation of deformation of geometric shapes, which allows adjusting human consciousness to perceive information. The combination of different shapes influences the creation of more evocative posters and this is attributed to the intricacy of the project itself, necessitating consideration of juxtaposing elements and varied hues, which in turn enhances the overall expressiveness of the visuals. *Illusionary design elements* contribute to the expansion of the conventional approaches to posters creation by combining non-standard multimedia images. The process may involve comparing multidimensional items. The said approach affects the discrepancy in perceiving information, lines, individual figures. While creating illusions, the processes of variation with light, texture, color, shape, etc., are essential. Illusion posters exhibit a profound quality that engenders a modified perception. Through the utilization of illusions, one can facilitate the processes of contraction or expansion of individual elements, thus creating a captivating visual experience. In modern designs currently *minimalism* is increasingly preferred, which ensures the reproduction of the most important elements and the necessary information. The process is aimed at ensuring the most effective combination of elements, which affects their functionality. Minimalism aims to provide heightened aesthetics and ingenuity, influencing the seamless perception of information. However, it is imperative to ensure harmony in the amalgamation of details, which will be manifested in perception.

The quality of posters is contingent upon the printing capabilities, which are intricately linked to the functionality of various printers. As such, the research scrutinized a range of printers that offer CD printing services. The final results were obtained using percentage values. (Figure 2).

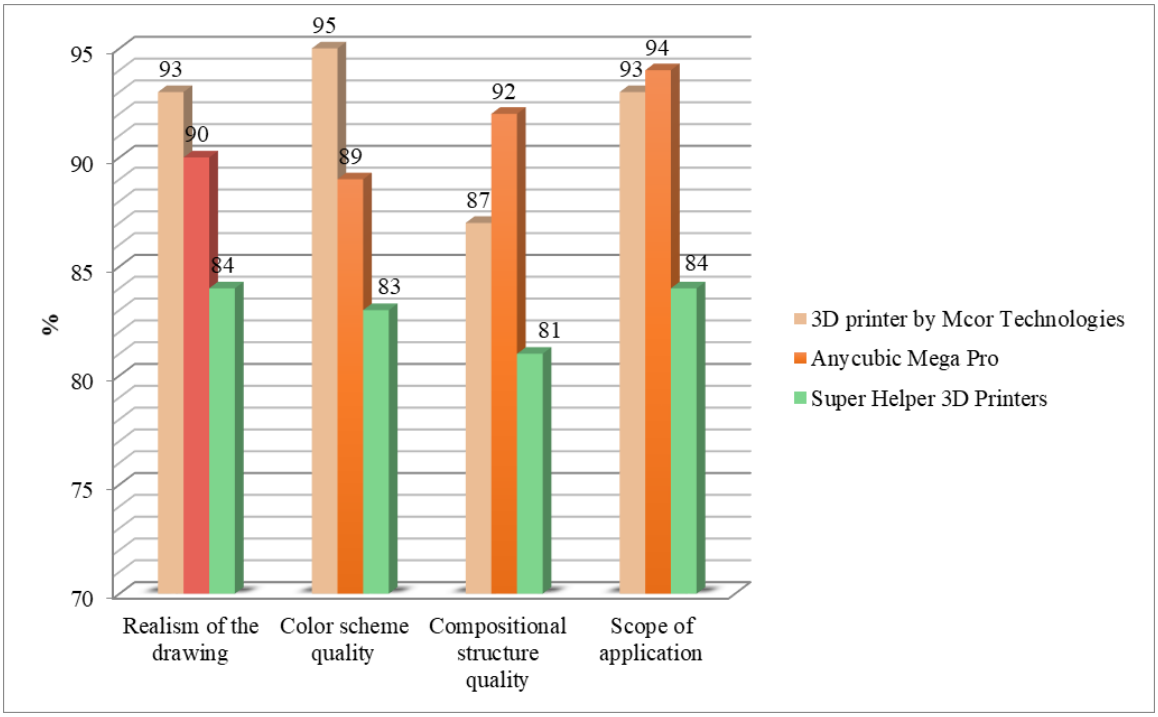

Figure 2: Comparison Of 3D Printers For The Implementation Of 3D Printing
Source: Elaborated By The Authors Drawing On The Technical Parameters Of 3D-Printers

An examination of the characteristics of the 3D printer developed by Mcor Technologies revealed the presence of favorable prospects for volumetric printing. The principle of operation is to ensure that pieces of paper are connected to each other. The cutter helps to cut the paper and then glue them together. When gluing paper, individual paper elements are painted. This affects the creation of a realistic drawing, maintaining a high-quality color scheme. The printer's functionality helps to save ink by painting over only individual details necessary for the design, rather than painting over the entire sheet. With the help of a printer, it is possible to convey the required color scheme, since its functionality provides for the use of more than a million colors. The development of a professional layout ensures a high level of printing by cutting the paper along the contour, producing photographic quality. Additionally, it is characterized by a wide range of applications that can be used in the educational process (visual models), medicine (visual organs), art (three-dimensional paintings), industry (mechanisms), etc. (Figure 3).

Figure 3: General View Of The 3D Printer Developed By Mcor Technologies
Source: [23]

Similarly, the Anycubic Mega Pro printer provides 3D printing based on kinematic approaches that adjust the print speed (from 10 to 100 mm/s). Not only does the printer have a fast print speed, but it also has a flat size (210 × 210 × 205 mm), which allows printing large posters. Given the said approach, high print quality and printing versatility are guaranteed. The process entails utilizing a laser module to facilitate the etching of intricate designs onto leather, paper or wood. With the Anycubic Mega Pro printer, it is possible to adjust the print quality due to the presence of a sensor for automatic calibration and the multi-color printing function. However, the engraving speed is not high, which hinders the ability to produce posters with a multitude of intricate graphic elements (Figure 4).

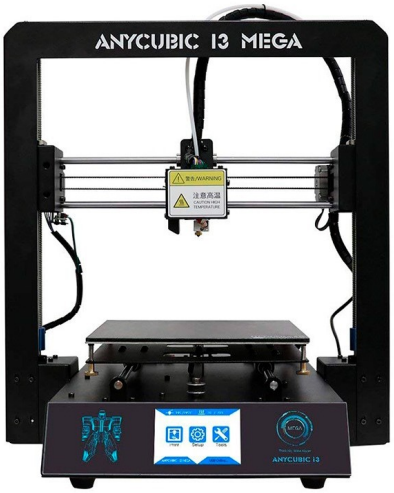

Figure 4: General View Of The Anycubic Mega Pro 3D Printer
Source: 3Dprintstore, Anycubic Mega Pro [24]

Super Helper 3D Printers have a wide potential to be used on the basis of layer-by-layer printing of a single design project. The above printer facilitates the printing of large posters, which is related to the size of the printer itself (258 x 326 x 375 mm). The print speed is medium (50 – 100 mm/s), which requires adjustment of design layouts to avoid a large number of details since printing bulky designs can affect the overall quality of the image, its structure. The convenience of using the above printer is due to the ability to upload graphic layouts using common programs such as Adobe Illustrator, Adobe Photoshop, CorelDraw, etc. Printing intricate designs ensures precision, which captivates consumers. Printed elements can be utilized to craft models for diverse artistic circles, printing establishments, and beyond (Figure 5).

Figure 5: General View Of Super Helper 3D Printers
Source: Winbo.Top, Super Helper 3D Printers [25]

Ensuring high-quality printing depends on the level of layout preparation. Therefore, the authors determined which elements are crucial during printing. The results were obtained on the basis of the following factors: calculations of the correlation coefficient, analysis of variance and t-test (Table 2).

Table 2: The Factors That Should Be Taken Into Account When Preparing A Layout For 3D Printing

Established criteria	r	R^2	t-test
Color	0,81	0,72	1,783
Dimensions of design elements	0,76	0,68	1,770
Visual consistency of the text with the latest design elements	0,71	0,62	1,760
Contour complexity	0,74	0,65	1,765
Depth of space	0,70	0,60	1,759

Source: Elaborated By The Authors

It is possible to achieve high quality of the created poster during printing by adjusting the printers capabilities to created designs. It should be noted that one of the important features is color adjustment. When using a rare color palette, it is necessary to take into account the peculiarities of the color reproduction of the selected printer, in particular the presence of the necessary gradients. Color display algorithms will be the most accurate due to adjusting the accuracy of inclusions and the ability to transfer them to the corresponding print material. When considering the print material, it is expedient to focus on the surface characteristics of the reflective light, which allows adjusting light reflectivity and absorption to color. It is essential

that during 3D printing, the designer's concept is effectively communicated through the conveyance of the necessary shades.

Furthermore, design elements should be proportioned to align with the overall printing capabilities of printers. Small details should be clear and efficiently distributed throughout the poster space, which will eliminate visual chaos during printing. It is of note that small design elements should match the texture and volume of the overall design, but at the same time provide emphasis on other details. When choosing large design elements, it is imperative to ensure the selection of the appropriate color scheme, texture, which will contribute to their high quality during printing. When creating an illusion of deformation of design elements, it is expedient to consider the intricacies of line curvature methodologies, which can be implemented using 3D printing in order to maintain the required depth. It also affects the quality of the three-dimensional shape, texture, etc. The above indicator is related to the path complexity during the printing process. The images silhouette should be clear, which will not only reflect the developer's creative idea, but also ensure the quality of volumetric printing. The presence of a fuzzy contour can affect the transfer of the necessary depth, expressiveness of the design, so for high-quality 3D printing, a clear images silhouette should be ensured.

Further, the text's visual consistency with the latest design elements also has an impact on print quality since it reflects the cohesion of all the details. Based on the visual coherence of all the details, a cohesive perception of the entire poster is elaborated, yet considering the intricacies of printing will elevate the quality of the design and the conveyed information.

The specifics of crafting the letters of each typeface should be harmonized with font sizes, additional intricacies, and hues. It is imperative to consider the alignment with the line length, spacing from other design elements, all of which will enhance the clarity of the output when printed. Furthermore, the characteristics of contrast, coordination, and readability must be taken into consideration.

The space depth affects the ability to convey the complex and unconventional images, which is implemented through the adjustment of light and shadow. The creation of contrasts affects the evocative design that emphasizes individual nuances. When conceptualizing a design, it is imperative to consider the capacity to convey profound intricacy within a three-dimensional illustration. The level of intricacy that is opted for when printing will determine the necessary level of detail.

Among the students, careful consideration was given to how they could ensure the development of cutting-edge poster designs. The findings were shared with students who were instructed on the intricacies of 3D printing as outlined in the research study (Group 1). The other group of students (Group 2) was guided by their own experience in creating poster designs (Table 3).

Table 3: Quality Of Poster Designs Made By Respondents For The Implementation Of 3D Printing

Study Group Number	Average score*	Mean	SD	Pearson's criterion	Confidence interval (at 95%)	*p*
Group 1	92	0.37	0.32	2.49	0.102	0.09
Group 2	76	0.12	0.23			

** A high level of points is equal to 90 to 100 points, a sufficient level is from 75 to 89; medium – from 60 to 74; low – less than 60.*
Source: Elaborated By The Authors

Evaluating the created posters, the advantages of the projects were established by Group 1, which ensured not only a harmonious combination of design elements, but also took into consideration the 3D printing features. Thus, the students of Group 1 noted a combination of color schemes in accordance with the requirements of the 3D printer and created additional shades to reflect the design depth. The students were able to achieve the necessary balance between the clarity of the written information, visual expressiveness and printing capabilities. Students of Group 2 made mistakes in maintaining the required spacing between letters, which would have entailed the printing deterioration. When it comes to the illusion elements, they were not consistent with the other design elements.

5. DISCUSSION

The complexity of utilizing 3D technologies for printing is intertwined with the

necessity of furnishing extensive methodological and modeling approaches. In German schools, 3D printing is a common training tool contributing to the openness of education forms that appear to be more student-centered. The number of 3D printers is related to the training concepts used, which provides visual perception of individual models [26]. For the students, 3D printing is an effective learning mechanism, allowing for improved visualization in technology and engineering education. It allows for hands-on classes in science, technology, engineering, and mathematics. Furthermore, 3D printing allows reducing pragmatic interaction among students, decreasing interest in conducting practical classes. It is feasible to mitigate potential knowledge deficiencies by incorporating additional STEM technologies, which ensures the use of repetition for modeling and generates interest in students [27]. 3D printing technology helps to improve the training skills of teachers and students, focusing on previously gained practical experience. Conducting seminars with the help of three-dimensional objects made it possible to increase students' academic performance and avoid misconceptions. The development of the concept of a course in Mathematics using 3D technologies influenced the improvement of students' performance at the classes [19]. Based on the analysis of the published works, it was found that they focus on the possibility of using 3D printing for the implementation of the educational process. The current study reflects the possibilities of implementing high-quality 3D printing based on the developed design designs. Therefore, the educational process was considered only from a practical point of view, which made it possible to assess the correctness of the established criteria that contribute to the creation of high-quality project designs.

It is common knowledge that production processes are focused on the wishes of customers, which involves taking into account the capabilities of Industry 4.0. Accordingly, this involves navigating the creation of projects with smart thinking, providing a new level of organization and control, focusing on complex designs and mass customization. This, based on 3D printing, it is feasible to elaborate guidelines that could contribute to a detailed examination of individual objects, developing visual perception [20]. Three-dimensional printing is an effective mechanism for improving engineering technologies, which can be applied not only in the engineering industry, but also in construction and medicine. It should be noted that one of the simple technologies of three-dimensional printing is FDM (Fused Deposition Modeling), which involves applying a thin layer of molten filament to the printing surface, which contributes to the creation of the required model. Additionally, the technology is characterized by the breadth of use of materials (ABS, PLA, HIPS, PET-G, copper, wood), which expands the possibilities of printing [18]. 3D printing is grounded on the ability to automatically adjust the entire process. On the basis of touch electrodes, the electrochemical properties of printing can be emhanced, which affects the image quality. In this linght, the fast and lightweight materials can be used to store energy, which affects the manufacturing quality of the required objects within given projects [28]. Accordingly, 3D printing technology can be applied in medicine, engineering, sports, fashion, education, art education, graphic design, etc. However, the major obstacle to utilizing 3D printing is the low technological education to implement the technology. Notably, the application of 3D printers in the educational process can affect the consolidation of the subject matter, the increse in students' motivation, the search for approaches to the development of educational and methodological materials [29]. The published articles indicate the features of three-dimensional printing and the scope of its use. What is more, in the presented study, the emphasis was placed on determining these parameters, but specifically as a result of focusing on the certain models of 3D printers (3D printers from Mcor Technologies, Anycubic Mega Pro, Super Helper 3D Printers).

The use of 3D prints is a new element of the educational process, which contributes to a better understanding of modern technologies. Creating printed objects in GeoGebra allows the educationalists to grasp approaches to the modeling process and also develops independence in students [22]. When choosing printers for 3D printing, one needs to focus on adaptive layering processes that help optimize print quality and efficiency. From this perspective, print optimization depends on the height of the print layer, the slope, and the curvature of the model. Consideration of threshold parameters is possible due to the combination of the Newtonian method and the gradient method. Drawing on the aforementioned, the study findings showed that this method is an effective tool for working with three-dimensional models [30].

Based on the study of the features of the published works, the general advantages of three-dimensional printing, which are not tied to a separate field of activity, were established. In the presented study, attention was paid to the creation

of poster designs and the features of their 3D printing, which corresponded to the objectives of the study. To do this, the authors focused on the study of the most important elements of modern poster design, the features of existing 3D printers, and important elements of printing.

5.1. Restriction

The article is devoted to examining the features of 3D printing of poster designs, but the approaches of 3D printing for different fields of activity are not defined separately. In the future, it is planned to identify what characteristics of creating interactive designs are provided for the creation of advertising posters and the posters to be used in the educational process.

5.2. Recommendations

Poster designs captivate consumers through their originality and superior quality. Hence, when crafting them, it is expedient to consider the nuances of innovative approaches in their development. Additionally, focusing on the specific requirements of individual printers is essential in order to attain a superior end product.

6. CONCLUSIONS

The results acquired validate the significance of the topic under study. The authors identified the characteristic features of prevalent 3D printers and the criteria for pioneering design development, serving as the foundation for tangible projects. To facilitate a comprehensive exploration of the subject matter, the distinctive qualities of innovative poster designs were distinguished. Based on the capabilities of 3D printers, it was established which elements should be primarily paid attention to when creating a design for printing. The weight of the established indicators was determined by calculating the correlation coefficient and analysis of variance and t-test. It was ascertained that abstract forms (t=1.783) are used to implement modern poster designs, which affect the change in visual perception. A prevalent strategy involves utilizing components generated by artificial intelligence (t=1.772), thereby influencing the development of unconventional designs. The combination of mismatched details (t=1.756) and illusionary design elements (t=1.743) serves to captivate consumers through the employment of unconventional methodologies. Minimalism is also important when creating poster designs (t=1.732), which contributes to empasizing the most salient details.

During the study, the advantages of certain 3D printers over others became apparent. It was discerned that the 3D printer developed by Mcor Technologies stands out for a number of its advantages, particularly in its capacity to ensure precise color reproduction, thereby significantly enhancing the realism of the printed images. Furthermore, this printer boasts a diverse array of applications, making it a versatile and invaluable tool in various industries, which allows printing a variety of elements for the educational process, medicine as well as various industries. The Anycubic Mega Pro printer affects the quality assurance of the composite structure, which is associated with taking into consideration small details during printing. Nevertheless, the speed of engraving and the number of colors are not significant, which does not favor its use for bulkier projects. It was found that the quality of printing depends on the developed layouts, depending on the color scheme as well as the size of the design elements. Hence, the visual consistency of the text with additional design elements, the complexity of the outline, and the depth of space also have an impact.

It was found that students who were guided by the established results of the study (Group 1) were able to achieve high results in creating design designs for 3D printing (92 points). Respondents who were guided by their own experience (Group 2) were able to achieve lower results, which is due to the lack of the necessary intervals as well as the selection of colors. The results demonstrate the benefits of scrutinizing the features of innovative poster designs to create the highest quality projects.

The practical significance of the study is aimed at determining the features of interactive design that should be taken into account during 3D printing. The obtained findings could benefit the prospective esigners as well as enrich the expertise of the practicing designers. The prospects of the study include determining the effectiveness of specific 3D printing devices depending on the manufacturing country, focusing on the technical capabilities depending on the parts utilized.

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Appendix 1

Research protocol:

1. To ensure the need to identify poster design trends in accordance with the following criteria:

- abstract forms
- use of elements created by artificial intelligence
- illusory design elements
- combination of unrelated parts
- minimalism

2. To provide a comparison of 3D printers (Mcor Technologies, Anycubic Mega Pro, Super Helper 3D Printers) in accordance with the criteria:

- realism of the drawing
- quality of the color scheme
- quality of the compositional structure
- scope of application

3. To determine the most influential elements of the layout for 3D printing:

- color
- dimensions of design elements
- visual consistency of the text with the latest design elements
- complexity of the contour
- depth of space

4. To assess the quality of the poster designs created by the respondents in accordance with the indicators of different groups of respondents:

- group No. 1
- group No. 2