INCREASING SCIENCE AND TECHNOLOGY MOTIVATION IN FASHION STUDENTS THROUGH EDUCATIONAL ACTIVITIES WITH 3D PRINTING

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ПОВИШАВАНЕ НА НАУЧНО-ТЕХНОЛОГИЧНАТА МОТИВАЦИЯ НА УЧЕНИЦИ ПО МОДА ЧРЕЗ УЧЕБНИ ЗАНИМАНИЯ С 3D ПРИНТИРАНЕ

Abstract

The aim of this paper is to test the hypothesis that educational activities with 3D printing can increase the motivation for science and technology of students without pre-existent interest in STEM disciplines. Such students were recruited from the specialized class in garment construction in "Dimitar Talev" professional high school in Gotse Delchev, Bulgaria. The effect of the intervention with 3D printing on the construct named "science and technology motivation" is measured through a five – point Likert scale survey – the pre-existent "Science Motivation Questionnaire". The analysis of the data shows an increase in the construct. The themes where the most significant effect is observed are analyszed in order to give insights for future research and STEAM lesson design.

Keywords: *3D Printing; STEAM; Science Motivation; Technology Motivation.*

INTRODUCTION

Existing scientific literature finds a relationship between lack of interest and motivation for learning science subjects in school and low academic results, low scientific literacy and scientific reasoning and inquiry skills, necessary for responsible decision-making, development of technological skills as well as low interest in career development in the fields of science and technologies [1]. To a large extent, dropping out of technology–oriented academic and career development concerns women [1] and students with humanities and arts orientation. This trend is reflected in the technological labor market where only 1/3 of employees are female [2]. Since STEM disciplines have entered every sphere of everyday life and work processes of all professions, this is a problem of essential importance for the labor market [3], innovation and economic growth [2]. While qualified professionals with STEM profile are increasingly required, a significant part of high school students drops out of this specialization. According to Prof. Jacqueline S. Eccles [4], in a study on the role of women in education and society, women feel more comfortable in professions that by nature are considered feminine than in typically male professions. They perform better, are more effective and realize their potential more fully in these roles. Personalizing lessons according to the preferred roles of the individuals or the different groups of students, as well careful consideration of their specific motivation [5] can increase interest in scientific–technological knowledge and skills and minimize the above-mentioned negative effects. The research of Wajngurt, C. and Sloan, P. J., 2019 [6] shows the positive relationship between participation of female students in such targeted educational activities using the STEAM methodology and their desire to develop academically and career-wise in STEM direction.

3D printing offers a number of benefits in preparing educational activities with such specific objectives. The technology allows rapid prototyping of personalized learning aids, provides a premise for learning by doing, project-based and step-by-step learning, individual and personalized design or decorative options and additional resources [7]. In this way, 3D printing technology is applicable in every industry including art, fashion and music and can become an introductory technology. Technologies with broad applicability play a key role in STEAM education by enabling the integration of multiple disciplines [8] and domains of interest. By applying the unfamiliar technology in fields of existing interest, 3D printing can increase motivation toward science and technologies of students who are not STEM-oriented.

In order to empirically test this hypothesis, a scientific experiment was conducted in "Dimitar Talev" professional high-school in Gotse Delchev, Bulgaria in March 2025 by a team from the Institute of Robotics – Bulgarian Academy of Science. The experimental and control groups consisted of students from 11th and 12th grade students enrolled in the class "Garment construction, pattern making and technology", who have practical experience in making jewelry with different techniques. During a previous visit by the research team to the school, a presentation on 3D printing technology was delivered, and through classroom observation and teacher feedback, a general student interest in applying the technology within their field of study was identified. This is a main prerequisite for a successful educational activity. The goal of the conducted experiment is to register the impact of an educational activity with 3D printing on students' interest in science. One research question is defined: Can 3D printing technology increase students' interest in science and technology among learners who demonstrate low academic achievement in STEM subjects?

EXPOSITION

The purpose of the presented experiment is to register the influence of the independent variable – innovative educational activity with 3D printing on the dependent variable: the averaged value of students' answers on the topic "interest in science", on the five-point Likert scale, using the existing questionnaire "Science Motivation Questionnaire" [9].

The participating students from 11th (N = 21) and 12th grade (N = 22) are divided into control and experimental group. The control group consists of 19 students from 11th grade and 2 from 12th grade. The experimental group consists of 21 students from 12th grade. The distribution of students in the two groups is carried out through statistical analysis of t-test, where the latest semester grades of students in STEM subjects are analyzed. The average grade of each student represents the average value of the latest grades of the student in mathematics, biology, physics, chemistry and informatics, based on data provided by the students themselves through an online questionnaire. Two 12th-grade students were assigned to the control group because their average grades in STEM subjects were significantly higher than those of the other participants in the experimental group, and including them alongside their classmates would have compromised the homogeneity between the two groups. The average grades in scientific–technological subjects of the experimental group is 3.68, and of the control — 3.87. In an independent t-test, the value of t is 0.9268, and the p-value is 0.3600, which shows that the difference is not statistically significant ($p > 0.05$). In conclusion, the statistical analysis does not establish significant differences between the control and experimental group.

The control group was shown a short film made by the team of IR-BAS, which depicts a jewelry technique called "lost wax casting". The experimental group was shown the same film, but extended with content on the role of 3D printing in the same technique, which significantly facilitates the production process, makes it more efficient and allows different application of artistic talent through digital and technological skills in 3D modeling and 3D printing. After the screening, the experimental group was showed a presentation on the use of 3D printing in fashion and production of shoes and accessories. The relatively long and detailed introduction to integrated traditional craftsmanship and digital jewelry technologies as well as presentation of real practical projects from the fashion industry (more than 20 minutes) aims to establish a base for long-term motivation and understanding of the application of science and technologies in the field of interest [7]. Bonorden, M. and Papenbrock, J., 2022 [7] conclude that in order to achieve the desired lasting increase of scientific interest, it is necessary in the educational activity with a 3D printer to allocate sufficient time for detailed explanation of the basic functions for working with 3D printing software. In our case more than 60 minutes were allocated for introduction to working with AutoCAD and practical work with the VisualLisp program created by the research team [10]. The program "rings" allows automated combination of different 3D elements, whose dimensions are adapted to the created creative object (in this case – rings) and 3D printing technology. The program has an option for customized production of parts of the elements. The option for step-by-step implementation of the program shows the modeling process and is suitable for both beginners and advanced, interested in the programming language. Through interaction with the program, beginner students can quickly get acquainted with the possibilities of AutoCAD and get inspired by its applications in typically non-technological fields, such as jewelry making [10].

Research question: Can 3D printing technology increase the interest in science and technologies of students who register low academic results in STEM subjects?

The shifts of the construct "interest in science and technologies" in students with this profile are studied through descriptive statistical analysis of the questionnaire "Science Motivation Questionnaire" [9]. before and after the educational activity with 3D printing, personalized to the interests of the class (in this case – construction and modeling of accessories). Table 1 shows the averaged values that the two groups gave to each element of the variable "interest in science", shown in the first column of the table:

Table 1. Values of the different elements composing the variable "interest in science" before and after the innovative lesson with 3D printing, as well as their differences.

	Control group			Experimental group		
	Before	After	Change	Before	After	Change
Averaged overall data	3.28	3.45	0.18	2.88	3.33	0.46
I can master knowledge and skills in STEM disciplines.	3.71	3.44	-0.27	3.14	3.47	0.33
To get a good grade in STEM subjects.	3.90	3.67	-0.24	3.36	3.45	0.09
Strategies to master STEM knowledge.	3.29	3.06	-0.23	2.64	2.95	0.31
Knowledge in STEM will give me advantage in career.	3.95	3.72	-0.23	2.77	3.35	0.58
I am confident that I can master STEM knowledge.	3.71	3.50	-0.21	2.82	3.75	0.93
STEM is related to my life.	3.48	3.28	-0.20	4.05	3.30	-0.75
I am curious about STEM discoveries.	3.48	3.33	-0.14	2.82	3.75	0.93
Understanding STEM will be useful in my career.	3.71	3.61	-0.10	2.68	3.10	0.42

	Control group			Experimental group		
I put effort in STEM subjects.	3.43	3.44	0.02	2.91	3.10	0.19
Studying STEM will help me find a good job.	3.85	4.00	0.15	3.23	3.50	0.27
To get an excellent grade in STEM.	3.55	3.72	0.17	3.10	3.60	0.50
I think I will use skills to solve STEM problems in my career.	3.10	3.28	0.18	2.41	2.90	0.49
I like doing better than others in STEM tests.	3.86	4.06	0.20	3.27	3.25	-0.02
I enjoy studying STEM.	3.19	3.39	0.20	2.82	3.90	1.08
Studying STEM is interesting.	3.67	3.89	0.22	3.41	3.75	0.34
I prepare well for STEM tests and lab exercises.	2.95	3.22	0.27	2.45	3.05	0.60
I think my career will be somehow related to STEM.	2.95	3.22	0.27	2.41	3.00	0.59
It is important to achieve high results in STEM tests and lab exercises.	3.10	3.44	0.35	3.05	3.55	0.50
I devote much time to studying STEM.	2.29	2.72	0.44	2.23	3.00	0.77
I will do well in STEM tests.	2.71	3.22	0.51	2.59	3.20	0.61
I will do well in STEM lab exercises and projects.	2.48	3.00	0.52	2.43	3.25	0.82
I study hard to master STEM knowledge.	2.52	3.11	0.59	2.32	3.15	0.83
Acquiring STEM knowledge makes my life more meaningful.	3.05	3.67	0.62	2.82	3.05	0.23
I believe I can get grade "Excellent (6)" in STEM.	2.86	3.50	0.64	3.00	3.40	0.40
I think about the grade I will get in STEM.	3.14	3.83	0.69	3.18	3.50	0.32

The following elements stand out:

- "I am confident that I can master STEM knowledge.". The value of this item decreases in the control group. This is expected since in this group no activity is included that increases knowledge and skills in STEM fields. In the experimental group, the value increases as students recognize the benefits that technology brings to the jewelry-making process and have the opportunity to practice with 3D modeling software [10]. In this way they build motivation and positive self-confidence for future academic success in the field. The experimental group reports a change after the experiment of 0.93, while the control group decreases its positive outlook by -0.21 points.
- The elements "I will do well in STEM laboratory exercises and projects" and "I study hard to master STEM knowledge" are also related to positive projection for future academic success. The experimental group registers an increase of respectively 0.82 and 0.83 points. An increase of these values is also observed in the control group – 0.52 and 0.59 points, showing general interest in such exercises, projects and laboratories among all participating students.
- The element "I enjoy studying STEM" is related to positive emotions in the learning process. The registered increase in the experimental group is 1.08, and in the control – 0.20. Positive emotions are a prerequisite for long-term interest and improvement of academic results in STEM disciplines [7].
- In the element "I am curious about STEM discoveries" a decrease of the average value is observed in the control group, and in the experimental – an increase of almost 1 unit. "I am confident that I can master STEM knowledge".

The analysis of the values and their change before and after the integrated lesson in jewelry making and design technologies shows that students' interest in science and STEM disciplines increases under the influence of this educational activity. In the third row of Table 1, the change of the average value of the construct "interest in science" before and after the educational activity with 3D printing is shown. In the experimental group, interest in science increases by 0.46 points compared to 0.18 for the control group. The construct values are obtained as the sum of the arithmetic mean values of the elements presented in Table 1. The change of these values is shown in the third row of Table 1 and graphically illustrated in Figure 1. The control group registers higher interest in science and technologies, since it is composed of older students (12th grade), while the experimental – of 11th grade. This trend is preserved after the experiment, but the greater increase of interest is observed in the experimental group, which indicates that targeted educational activity with 3D printing can increase the values of this construct even for groups with low STEM orientation.

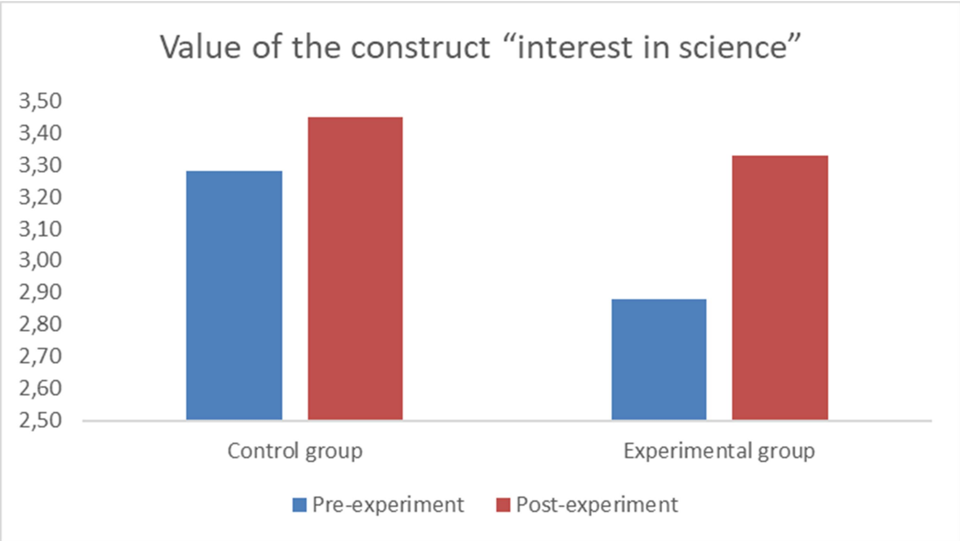

Fig. 1. Value of the variable – the construct "interest in science", before and after the experiment in the control and experimental groups.

LIMITATION OF THE STUDY

The present study defines only one research question. The experimental work can be expanded with other aspects that influence the construct "interest in science". The questionnaire does not register the change of interest specifically directed toward 3D printing before and after the educational activity. Since the experiment is part of a long-term process of investigating the interaction between science, technology and art in NPG "Dimitar Talev", these limitations can be overcome in the next stage of the research.

CONCLUSION

The present study shows that interaction with 3D printing technology increases the construct "interest in science" in the participants. The study confirms the hypothesis that 3D printing can successfully be applied as an introductory technology for students who do not have an existing interest in STEM disciplines. It can be concluded that the used program for automatic 3D modeling of rings is a useful educational resource for an integrated artistic–technological lesson.

The following areas for future scientific investigation stand out: (1) Long-term quantitative and qualitative observations can register whether and how the acquired interest and motivation for working with technology and science changes over time, as well as (2) whether an unfolding of new artistic and educational opportunities through application of technology and scientific principles is observed. Other possible goals of future experiments are investigation of (3) challenges arising in integrating 3D printing technology in the education of students with learning difficulties and/or special needs, (4) elements in the design of the integrated lesson that support the increase of interest and motivation toward science in children with humanities–artistic predispositions. (5) The focus of the present study is on quantitative measurements and does not cover qualitative observations of manifestations of creative thinking related to 3D printing technology in participating students. Specifics of the creative process could be registered, such as overcoming difficulties in working with technologies, as described in [8]. There is also an opportunity to document students' desire to use accompanying technologies such as 3D pens.

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