

REVIEW

on a thesis for the educational and scientific degree "PhD"

Author of the thesis: MSc Eng. Borislava Lyubomirova Kostova

Topic of the thesis: Integrating 3D Printing and Robotics with Modern Technologies for Educational Purposes

Member of the scientific jury: Prof. Valentin Mateev, PhD., TU-Sofia

Order of the Director of IR-BAS No. 94 of 29.07.2026

Field 5. Technical Sciences

Professional field: 5.2. Electrical Engineering, Electronics and Automation

Scientific specialty: Application of the Principles and Methods of Cybernetics in Various Fields of Science

1. Relevance of the problem developed in the thesis in scientific and scientific-applied terms. Degree and levels of relevance of the problem and the specific tasks developed in the thesis.

The presented PhD thesis examines the possibilities and application of modern technologies for 3D printing, robotics, and artificial intelligence in three main areas of education – traditional, specialized humanitarian or artistic, including education aimed at students with special educational needs. Specifically, the aim of the PhD thesis is to develop, validate, and analyze an approach for integrating 3D modeling, 3D printing, robotics, and artificial intelligence technologies in order to increase the effectiveness of educational STEAM activities.

To achieve the set goal, the following main tasks are defined: 1) Development, validation, and analysis of a protocol for the automated development of an educational STEAM activity, including the use of artificial intelligence to assist the teacher, as well as for its conduct, applying 3D-printed educational models and scenarios with an educational robot; 2) Defining an approach for the automated creation of 3D-printed personalized models and their application for educational purposes; 3) Development and creation of a program for automated 3D modeling in the AutoCAD environment, intended for the creation of decorative elements based on the proposed approach, creating and studying 3D-printed models intended for teaching applied arts; 4) Study and application of the approach, the developed software solution, and the 3D-printed objects in the educational. Study and analysis of the effectiveness of 3D-printed writing aids for students with special educational needs. To analyze approaches for creating personalized assistive devices. This includes studying methods for adaptation, taking individual measurements, and determining basic geometric parameters; 5) Development of a program for the automated creation of a 3D model of a personalized writing device for students with fine motor difficulties.

I find the set tasks, the formulated goal of the thesis, and its technical aspects to be definitely significant and relevant in scientific-applied and applied terms.

2. Degree of knowledge of the state of the problem and creative interpretation of the literature material.

The thesis is composed of 150 pages and includes an introduction, 5 chapters for solving the formulated main tasks, a conclusion, a list of the main contributions, a list of publications on the PhD thesis, and references. A total of 140 literature sources are cited, all in Latin script. The literature review

covers a very significant selection of a wide range of publications on the topic. What stands out here is the author's ability to navigate the problem freely, classify the literature sources, identify leading directions of development in the field of the PhD thesis topic, and freely use the capabilities of modern technologies. In the following chapters, the significance and relevance of the PhD thesis topic are considered, the main goals and tasks are defined, and its structure is described. Chapter 1 is an introduction to the subject area of the research. In this chapter, a study and analysis of the literature in the field of the application of 3D printing, robotics, and artificial intelligence technologies for the purposes of general education, arts profiles, and the education of students with special educational needs, and more specifically with fine motor difficulties, is made. Chapter 2 presents the development of a protocol for conducting an educational STEAM activity, including 3D-printed educational models, scenarios with the NAO robot, and the use of artificial intelligence. The experimental study of the protocol during a physics lesson in the high school stage of a general education school in Sofia is described. The effect of the use of the technologies on the educational process was registered. Chapter 3 describes the developed approach for the automated creation of 3D-printed personalized models and their application for educational purposes. Chapter 4 presents the creation of an innovative program for automated 3D modeling of rings, following the approach from Chapter 3. The approbation of the program in a real educational environment is described, in a specialized class in Design and Construction of Clothing and Accessories at a high school in Gotse Delchev. The results of the study and the effect of including the program in the educational process on students' motivation and interest in science and technology are presented. Following the approach from Chapter 3, Chapter 5 describes the creation of an innovative program for automated 3D modeling of writing aids for persons with fine motor difficulties and atypical grip. The innovative elements in the development of these programs, compared to existing such solutions, are the increased levels of personalization of the educational process and its automation. The degree of knowledge of the state of the essence of the problem based on literature materials and the application of creative approaches to its interpretation are undoubtedly at a high level.

3. Correspondence of the chosen research methodology with the set goal and tasks of the thesis and with the achieved contributions.

Specifically, the aim of the PhD thesis is to develop, validate, and analyze an approach for integrating 3D modeling, 3D printing, robotics, and artificial intelligence technologies in order to increase the effectiveness of educational STEAM activities. The main tasks of the PhD thesis work are formed in these directions. The chosen research methodology is based on the developed approach for automated 3D modeling, in all its phases, from design, through printing, to different levels of testing, of personalized educational tools, and builds upon existing ones. A specific emphasis is placed on the universalization of design through the *used* principle of simplified and minimalist design, which allows rapid production, iterativeness, personalization, and comprehensibility of function. Standardized basic geometry is used, overcoming the limitations of 3D scanning technology, on which existing scientific developments are based. Extended adaptation to user needs, to various educational subjects, and to the level of knowledge. The approach is validated through the development of two programs for automated 3D modeling. What stands out is the striving to validate the obtained results in a relevant environment for the purpose of the PhD thesis work. I believe that the chosen research methodology corresponds to the set goal and tasks of the PhD thesis and is reflected in the achieved contributions.

4. Brief analytical characterization of the nature and assessment of the reliability of the material on which the contributions of the thesis are based.

The subject area toward which the scientific and applied activity of the PhD thesis is directed is the use of modern technologies for educational purposes. The application of 3D modeling, 3D printing, robotics, and artificial intelligence technologies in three main areas of education is considered – traditional general education, specialized in creative disciplines, and aimed at students with special educational needs.

I highlight the following more significant objective results realizing the goal and forming the contributions of the PhD thesis:

- 1) A developed approach for automated 3D modeling of objects with an educational purpose. The approach includes automated generation of 3D models in the AutoCAD environment and subsequent manufacturing with a 3D printer. The algorithm seeks optimal parameters in three directions: (1) adaptation to the user, (2) adaptation to the tool, and (3) visual effect with educational value.
- 2) A protocol for conducting an educational STEAM activity, including the use of AI to assist the teacher, 3D-printed educational models, and a scenario for the NAO robot.
- 3) A created program for automatic 3D modeling of rings in the AutoCAD environment, developed on the basis of the approach.
- 4) A created program for the automated creation of a 3D model of a personalized writing device for students with fine motor difficulties, developed on the basis of the approach.
- 5) A created and applied methodology for approbation of the models in a specific educational environment, under different learning scenarios and meeting special educational needs.

5. Scientific-applied and applied contributions of the thesis.

The contributions presented by the author of the PhD thesis correspond to the research carried out and the results obtained. With some generalization and arrangement, I believe that the contributions can be presented as follows.

Scientific-applied contributions

- 1) An approach has been developed for the automated creation of 3D-printed personalized models intended for educational purposes. The approach includes automated generation of 3D models in the AutoCAD environment and subsequent manufacturing with a 3D printer.
- 2) A protocol has been developed for conducting an educational STEAM activity, which includes the use of artificial intelligence to assist the teacher, 3D-printed educational models, and scenarios for the NAO robot.

Applied contributions

- 1) A program has been created for automatic 3D modeling of rings in the AutoCAD environment. The program allows personalization of geometric parameters and automatic placement of decorative elements selected from a library. The program works in two variants. One for generating 3D models and a second that step-by-step demonstrates the way the models are created, for educational purposes.
- 2) The properties and qualities of real 3D-printed models obtained from the proposed program were studied.
- 3) A pilot application of the developed software for the automated creation of 3D-printed rings was conducted in a real educational process. The results were analyzed and systematized.
- 4) A study was conducted on the effectiveness of 3D-printed writing aids for students with special educational needs. Various approaches for creating personalized assistive devices were analyzed.

Methods for adaptation and taking individual measurements were studied. On this basis, the main geometric parameters that have the most significant influence on ergonomics and ease of use were determined.

5) A program was developed for the automated creation of a 3D model of a personalized writing device for students with fine motor difficulties.

The scientific-applied and applied contributions belong to the creation and development of research methods, innovative designs, and technologies in the field of the PhD thesis work. The practical applicability of the considered methods will increase even more in the foreseeable future, which will increase the importance of the contributions of the doctoral student's work.

6. Assessment of the degree of personal participation of the PhD student in the contributions.

The personal participation of the doctoral student in the contributions can be assessed from the presented PhD thesis, the scientific publications made, and the presented autoreferat. From them it can be concluded that in their main part they were developed by the doctoral student and are a product of creative labor and the efforts made. Of course, the role of the scientific supervisors and co-authors of the publications should not be neglected.

Noteworthy is the completion of the PhD thesis work within the study period, before the expiry of the four-year study period on 1 July 2027. This testifies to dedication and systematic work to achieve the set tasks. During this period, six exams were taken, all with excellent grades; participation in four scientific forums with the corresponding publications is reported, including an independent report and publication, as well as the research work carried out with the approbation activities for the achieved results.

7. Assessment of the publications on the thesis.

Main achievements and results of the PhD thesis were published in the period 2024–2025, i.e., during the period of preparation of the PhD thesis work. The results in the PhD thesis were published in 4 articles, which were presented at international conferences and published in the proceedings of these conferences. One of them has SJR, Q3; two more were published in Scopus-indexed editions; and one in ISSN/ISBN-indexed proceedings. In these publications, there is 1 sole-authored, in 2 she is first co-author, and in 1 she is second co-author. As of August 2026, 5 citations of these articles have been noticed, which are expected to grow. In Scopus and Google Scholar, other author publications and citations are also visible, which testify to the continuing development and work of the doctoral student.

In my assessment, the publications made cover the main results shown in the PhD thesis work and create sufficient visibility for the research carried out and the output data obtained from them. The prepared autoreferat reflects key moments of the PhD thesis; the requirements for structuring and formatting have been observed. The number of publications corresponds to the requirements of the law and the regulations of BAS.

8. Usage of the results in scientific and social practice.

A strong aspect of the research carried out is the documented approbation in a relevant environment. Two official notes are attached from Dimitar Talev National Vocational High School, Gotse Delchev, and 19th Primary School Elin Pelin in Sofia. Accordingly, a study conducted on the effect of using a program for automated 3D modeling in the education of students from a specialized class at Dimitar Talev National Vocational High School, in Gotse Delchev city, has been certified. The study was carried out in connection with the PhD thesis. The experimental study was conducted as part of the research on the

application of 3D printing technology in education; it contributes to the development of effective approaches for increasing students' interest in modern technologies, including among those studying in creative specialties. Unlike most existing studies aimed at students specializing in STEM fields, the present study examines the impact of 3D printing technology on students with a non-technical profile. A protocol for a lesson was also provided, demonstrating the use of 3D-printed models and scenarios with the NAO robot for conducting an experimental physics lesson at 19th Primary School Elin Pelin in Sofia. The study was carried out in connection with the PhD thesis. The experimental study, conducted as part of the research on 3D printing technology for educational purposes, contributes to the development of a practical, easily applicable, and methodologically structured protocol facilitating the development of STEAM lessons and increasing student engagement. According to the text of the PhD thesis, additional approbations, attempts to test the achieved results, and surveys with target groups were also considered, documented by protocols of the Ethics Committee for Scientific Research (ECSR) at the Institute of Robotics – BAS with Protocols 1, 8, 10, and 16 with corresponding dates in 2025 and 2026.

Results of the PhD thesis were published mainly in 4 articles, which were presented at scientific conferences and published in the proceedings of these conferences. All four registered conference participations were at international forums. As of August 2026, 5 citations have been noticed. This certifies approbation in an international environment and the usability of these results by other researchers. Such feedback regarding the usability of the results is fully commensurate with the short period from obtaining the results of the PhD thesis work, their approbation in practice, and monitoring their effectiveness.

9. Opinions, recommendations, and remarks.

The PhD thesis is a current scientific-applied study meeting the requirements of the law for obtaining the educational and scientific degree "PhD".

I have no serious critical remarks, but the following can be noted:

Some minor inaccuracies could be observed:

- Formatting issues, such as large tables without paragraph lines, partially remaining English text and in some of the figures, statistical formulas not shown in Chapter 2, etc. The terms "3D printing" and "3D plotting" are used in parallel; it would be desirable to unify their use.
- Some of the results in Chapter 5 suggest additional statistical evaluation and expanded test groups.
- At each of the technical stages of the research and work, it is desirable to expand the use of open-source software and non-commercial licenses.
- In some places, a certain opposition between STEM and STEAM education is hinted at, which is unnecessary; the two merge naturally and provide a more complete toolkit for self-expression; in essence, they are a progressive development of one educational concept.

My recommendation for the author is to continue the research and improve the methodologies, which should lead to broader applicability of the results. The popularization of the results of all these activities should actively continue.

10. Conclusion with a clear positive or negative assessment of the PhD thesis.

The PhD thesis under review represents a comprehensive work; the results achieved by the author are important, are characterized to a certain degree by significant innovativeness, expanded applied scope, and significant potential for the use of new additive technologies, robotics, and artificial intelligence in the educational process.

Based on the foregoing, I give a positive assessment of the presented PhD thesis on the topic "Integrating 3D Printing and Robotics with Modern Technologies for Educational Purposes" and confidently recommend to the respected scientific jury to award to MSc Eng. Borislava Lyubomirova Kostova the educational and scientific degree "PhD" in Field 5. Technical Sciences, Professional field: 5.2. Electrical Engineering, Electronics and Automation, Scientific specialty: Application of the Principles and Methods of Cybernetics in Various Fields of Science.

15.09.2026

Reviewer:

/Prof. V. Mateev, PhD/