REVIEW

of a dissertation submitted for the educational and scientific degree "**Doctor**"

Author of the dissertation: Borislava Lyubomirova Kostova

Title of the dissertation: "Integrating 3D printing, robotics and emerging technologies for the purposes of education"

Professional field: 5.2 Electrical Engineering, Electronics and Automation

Doctoral programme "Application of the Principles and Methods of Cybernetics in Various Fields of Science"

Reviewer: Prof. Tanio Tanev, Institute of Robotics – Bulgarian Academy of Sciences

1. General description of the dissertation

The dissertation of Borislava Lyubomirova Kostova is devoted to the integration of 3D modelling and 3D printing, educational robotics, and artificial intelligence (AI) in different educational contexts. The work is interdisciplinary and combines issues from robotics, computer-aided design, additive technologies, assistive technologies, and contemporary STEM/STEAM pedagogical approaches. The research is aimed at three groups of learners: students in general education, students in specialised arts education, and students with special educational needs and/or fine-motor difficulties.

The dissertation has a total length of 150 pages (including 4 appendices) and is organised into 5 chapters. It contains a title page, table of contents, introduction, main body, conclusion summarising the results obtained, appendices, and a bibliography of 140 cited sources, as well as a list of publications related to the dissertation (4 publications on the dissertation topic).

2. Relevance of the problem addressed in the dissertation from scientific and applied-scientific perspectives

The dissertation addresses a current and socially significant problem related to the introduction of modern digital, robotic, and assistive technologies into educational practice. The digitalisation of education, the development of STEAM approaches, and the rapid adoption of generative artificial intelligence create a need for methodologies through which new technologies can be integrated not merely for demonstration purposes, but as a sustainable component of the learning process. Particularly important is the problem of overcoming technological and cognitive barriers faced by teachers and students when using CAD systems and 3D printing. The topic is especially timely in the context of STEAM education, personalised learning, and the need for more effective inclusion of students with diverse interests and special educational needs. 3D printing enables the rapid and economical creation of individualised educational and assistive tools, while social robots and AI can increase interactivity and support teachers in developing learning content. In the dissertation, these technologies are not considered in isolation, but as mutually complementary components of a pedagogical scenario, which is an appropriate and practically significant approach. The developed solutions have potential for application in schools, STEM centres, resource-support settings, and therapeutic practice, which gives the work substantial scientific and applied significance.

3. Degree of familiarity with the state of the art

The doctoral candidate demonstrates good knowledge of the subject area and of the main directions related to STEAM education, educational robotics, artificial intelligence in education, 3D modelling and printing, and assistive technologies. Chapter One presents a review of the application of the technologies considered in general education, specialised arts education, and special education. The analysis identifies practical limitations: a lack of clear integration protocols, the substantial preparation time required for interdisciplinary lessons, the high entry barrier to mastering CAD systems, and insufficient personalisation of available assistive devices.

I positively assess the effort to link the literature review directly to the developments proposed in the dissertation. For example, the analysis of existing solutions for automated 3D modelling and of user-centred design approaches is used as a basis for the proposed iterative approach and for the "pinky" program.

The dissertation cites 140 references, a large proportion of which were published within the last ten years. In substance, they are relevant to the dissertation topic.

The presented review and bibliographic survey demonstrate that the doctoral candidate is well acquainted with the problem, as well as with the methods and techniques related to the dissertation topic, and correctly interprets the achievements in this field.

4. Consistency of the selected research methodology and the stated aim and objectives with the achieved contributions

The selected methodology is generally consistent with the stated aim and objectives. It combines engineering design, software development, 3D prototyping, pedagogical experiments, questionnaire-based methods, observations, and statistical processing. This combination is justified by the interdisciplinary nature of the research and enables assessment of both technical feasibility and educational impact.

Overall, the methodology is adequate to the stated objectives and has led to results that substantiate the formulated scientific-applied and applied contributions. Its strongest aspect is the "analysis – design – prototyping – validation – feedback" cycle, applied in different educational contexts.

5. General assessment of the dissertation

The dissertation integrates 3D printing, educational robotics, the NAO social robot, and artificial intelligence into practically applicable pedagogical scenarios. The work has a clearly interdisciplinary character and connects engineering, robotics, pedagogical, and applied-technology aspects. The developed protocols, approaches, and software tools for automated 3D modelling demonstrate an orientation toward real-world applicability in school environments, while their validation in educational contexts increases the practical value of the research.

A substantial advantage is the attempt to analyse not only knowledge acquisition but also student engagement, considering indicators such as positive emotion, effort in answering questions, verbal participation, attention, and following the teacher's presentation. The dissertation reports statistically significant differences for some of these indicators across the different stages of the lesson. This is appropriate for a topic related to educational robotics and STEAM learning, because the effect of such technologies often manifests precisely through motivation, attention, and participation.

Another positive aspect is that, in the statistical analysis, the author does not limit the presentation to descriptive results, but also uses quantitative indicators such as mean values, standard deviations, and p-values. This demonstrates an effort to support the results not only qualitatively but also quantitatively.

The approach for creating and applying 3D-printed devices intended for educational purposes can be used to introduce automated 3D modelling at different stages of school education—from primary to upper-secondary level—and in different educational settings, including general education, specialised education, and education for students with special educational needs.

An original AutoCAD-based program for automated and personalised 3D modelling of rings has been developed, with the possibility of direct preparation for 3D printing, thereby reducing the cognitive barrier to learning complex CAD systems.

6. Contributions of the dissertation

Two scientific-applied and five applied contributions are formulated.

I consider the contributions formulated in the dissertation to correspond, for the most part, to the work performed. The developed and validated protocol for a STEAM lesson integrating AI, 3D-printed educational models, and the NAO robot has a scientific-applied character. The contribution lies in the methodological structuring of the process and its validation in a real school environment, with results supporting a positive effect on student engagement.

A second significant scientific-applied contribution is the proposed general approach for the automated creation of personalised 3D-printed models for educational purposes. It combines parametric modelling, adaptation to the user and the tool, educational visualisation, co-design, and iterative evaluation. The approach has the potential to be transferred to other CAD environments and to other classes of educational and assistive products.

Among the applied contributions, I include the developed "rings/steprings" program for automated and instructional 3D modelling of rings, the investigation of the parameters of the printed models and their pilot application in an educational setting, the systematisation of requirements for 3D-printed writing-assist devices, and the development of the "pinky" program for automated creation of personalised models.

The achieved scientific-applied and applied contributions are useful and have practical relevance. They demonstrate that the doctoral candidate is capable of conducting research and applying the results in concrete practical developments.

7. Assessment of the publications related to the dissertation

Results from the dissertation are presented in 4 publications—3 co-authored and one single-authored. In 2 of the co-authored publications, the doctoral candidate is the first author. Two papers are published in indexed and referenced in internationally recognised scientific databases, Scopus/Web of Science. The four publications presented satisfy the minimum requirement of 30 points for Area 5, Technical Sciences. Citations of some of the publications are also reported.

The publications demonstrate that the dissertation results have been communicated to a broad segment of the scientific community and satisfy the requirements associated with the defence of a doctoral dissertation.

8. Dissertation abstract

The dissertation abstract is 45 pages long and presents each chapter of the dissertation briefly and accurately. The main contributions of the dissertation are included. The abstract is provided in Bulgarian and English. A minor discrepancy has been noted in the number of publications: the Bulgarian version of the abstract lists 5 publications,

whereas the English version and the dissertation list 4. This is most likely a technical error.

9. Critical comments and recommendations

I have no substantial critical remarks.

Some recommendations:

- I recommend a subsequent multicentre study using larger samples, with an a priori determined sample size and stricter randomisation or group matching. A similar recommendation is also made in the dissertation in the section "Perspectives for Future Research".
- I also recommend future publications in scientific journals with an impact factor.

10. Conclusion

In conclusion, the dissertation constitutes a complete, relevant, and practically oriented study that contributes to the application of robotics and 3D technologies in education. The topic is significant, the results are applicable, and the developed solutions have potential for further development and use in real educational environments. On the basis of the submitted dissertation, the achieved results, the formulated contributions, and the publication record, I give a POSITIVE ASSESSMENT and recommend that the esteemed Scientific Jury award **Borislava Lyubomirova Kostova** the educational and scientific degree "**Doctor**" in professional field 5.2 "Electrical Engineering, Electronics and Automation".

14 September, 2026

Reviewer:

/Prof. Tanio Tanev/