

## R E V I E W

on a dissertation for the acquisition of the educational and scientific degree  
"Doctor" (PhD)

**Author of the dissertation:** Maya Stefanova Staykova

**Dissertation Topic:** Information and Communication Technologies in STEM Education

**Reviewer:** Assoc. Prof. Stanislav Dimitrov Gyoshev, PhD, Eng. – Institute of Information and Communication Technologies – Bulgarian Academy of Sciences (BAS)

**Scientific Field:** 5. Technical Sciences

**Professional Field:** 5.2. "Electrical Engineering, Electronics, and Automation"

**Doctoral Program:** "Application of the Principles and Methods of Cybernetics in Various Fields of Science"

### 1. General Characteristics and Relevance of the Topic

Maya Staykova's dissertation is dedicated to an extremely relevant and significant topic – the integration of information and communication technologies (ICT), and specifically robotics, into STEM education. In the introduction, the author correctly identifies the critical gap between the rapid development of technology (Industry 4.0 and 5.0) and the lagging behind of traditional educational systems. Against the backdrop of the described "stalemate" and "collapse" of state education in Bulgaria, the dissertation positions STEM education and ICT as key tools for modernization and overcoming this deficit.

The work is well-structured, consisting of 159 pages of main content divided into an introduction, three chapters, a conclusion, a list of contributions, approbation, a bibliography with 126 sources, and two appendices.

### 2. Analysis of Content and Structure

The dissertation follows a clear logical sequence – from the theoretical definition of the problem to its practical development and experimental validation.

- **Introduction:** Successfully defends the relevance of the problem. It introduces key concepts such as Industry 4.0, generational theory (Z and Alpha), and defines STEM. The goal—to show how robots can support technological STEM training—and the resulting tasks are clearly formulated. The object (educational robots) and the subject (their cyber-physical environments and suitability for STEM) are correctly defined.
- **Chapter 1: "STEM Education"** Provides a thorough theoretical review. It traces the origin of the term (from SMET to STEM) and its founders (Yakman and Ramaley). The concept of STEM is viewed as an interdisciplinary, project-based, and student-centered approach. A relevant

retrospective analysis of STEM globally and in Bulgaria is provided, noting the important historical precedent of the "Sendov System".

- **Chapter 2: "Technologies in STEM"** Narrows the focus by defining ICT and robotics. This chapter successfully links the theoretical foundations from Chapter 1 with the practical tools (robots) investigated in Chapter 3. Robotics is correctly positioned as a multidisciplinary field and a key technology for preparing students for Industry 5.0.
- **Chapter 3: "Development, Research, and Integration of Educational Robots in STEM Education"** This is the core of the dissertation and contains the main scientific and applied contributions. It is divided into two main parts:
  - **Artificial Intelligence (AI) in STEM:** Presents an original qualitative and quantitative study conducted by the author regarding the understanding of AI (specifically ChatGPT) among 130 students (ages 6-18) at a private school in Sofia. The methodology included Kahoot surveys and practical tasks. Results show that while students use AI, they do not fully understand the technology and encounter inaccuracies, especially when working in Bulgarian. This research itself is a valuable contribution to pedagogical science in Bulgaria.
  - **Research of Robotic STEM Solutions:** The author demonstrates deep engineering and software skills. Instead of just describing existing robots, Maya Staykova performs original developments and tests:
    - **Ozobot EVO:** Developed new Python source code using asynchronous programming to simultaneously perform two tasks – moving in a star shape (simulating a folk dance) and playing music ("Svornato horo").
    - **ArtieMax:** Performed "reverse engineering" (re-engineering) of the hardware, identifying components like the ESP32 microcontroller. Developed new source code (Blockly) for writing words ("LONDON"). Hardware defects (e.g., tilt sensitivity) were critically investigated, and a software correction was presented.
    - **Cody Rocky:** Developed new source code for maze navigation with obstacle avoidance, analyzing the debugging process.
    - **XGO-mini 2 Dog:** Developed new QR codes and corresponding Python source code allowing the robot to

recognize them and perform coded movements (circle, square, rectangle).

- **Intelligent Mobile Robots:** Presents the most significant scientific contribution – a new model for a distributed system for 3D measurement. The model uses a Raspberry Pi 5 with a 3D camera (Orbbec Petrel A) on the robot for data collection and a remote computer station for heavy calculations (analysis of objects, color, distance, and physical dimensions). The system achieved very low relative measurement errors (e.g., up to 5.71% for size and 2.12% for distance).

### 3. Scientific and Applied Contributions

The dissertation contains numerous original scientific and scientific-applied contributions:

- **Scientific-Applied:** Developed new source codes for several popular educational robots (Ozobot EVO, ArtieMax, Cody Rocky, XGO-mini 2 Dog) that expand their standard functionality.
- **Scientific-Applied:** Performed reverse engineering of the ArtieMax hardware and proposed a software method to correct hardware inaccuracies.
- **Scientific:** Developed and experimentally validated a new model of a distributed system for 3D visual measurement based on Raspberry Pi 5 and a 3D camera.
- **Scientific-Applied:** Conducted an original study on AI understanding among Bulgarian students.

### 4. Strengths and Remarks

- **Practical Applicability:** This is the greatest strength. The dissertation is a practical guide full of developed and tested source codes and lesson plans ready for STEM application.
- **Originality and Depth:** The author demonstrates a rare set of competencies combining pedagogical vision with serious engineering and software skills.
- **Critical Analysis:** The author does not accept robots as a "panacea" but performs a critical analysis of their real capabilities and limitations (e.g., ArtieMax calibration issues, light influence on sensors).
- **Approbation:** Results were presented at several authoritative international scientific conferences (TechSys, ICAI, TECIS, etc.).

- **Notes:** The AI study was conducted in one private school; therefore, results cannot be fully extrapolated to the entire educational system, particularly state schools. The author correctly notes this as a direction for future work.

## 5. Evaluation of the Abstract

The abstract accurately and fully reflects the main content, tasks, results, and original contributions of the dissertation.

## 6. Conclusion

The dissertation work of Maya Stefanova Staykova represents a complete, in-depth and original scientific research. It successfully meets the set goal and tasks, providing significant scientific and scientific-applied contributions in the field of cybernetics and its application in STEM education.

The author demonstrates that he masters both the theoretical apparatus and the necessary engineering and software skills to conduct independent research. The practical value of the developed software codes, lessons and system models is undeniable.

The work fully meets the requirements for awarding the educational and scientific degree "doctor" in a professional field

I propose to the esteemed Scientific Jury to positively evaluate the dissertation work of the doctoral student mag. Maya Stefanova Staykova, by making a decision to acquire the educational and scientific degree "doctor" in professional field 5.2. "Electrical engineering, electronics and automation".

Sofia, 04.03.2026

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