

BUKI.BG AS A TOOL FOR DIGITAL AND STEM TRANSFORMATION IN THE BULGARIAN SCHOOL: ANALYSIS OF EFFECTIVENESS AND EMPIRICAL RESULTS

Irina Mishkova-Yotova

DIITT, Trakia University, Bulgaria, irina.mishkova@trakia-uni.bg

Abstract: In the context of Industry 4.0 and the growing need to develop key digital and STEM competencies, as well as against the backdrop of Bulgaria's alarmingly low results in the PISA 2022 international assessment (53,6% of students below the minimum proficiency level in mathematics), this study emphasizes the need for innovative educational solutions. In this regard, the potential of the Buki.bg platform is analyzed as a modern tool for supporting digital and STEM transformation in Bulgarian school education.

The main objective of the study is to evaluate the platform's effectiveness in accordance with the European Digital Competence Framework DigComp 2.2 and the national educational requirements regulated by Ordinance No. 10. Special attention is given to the possibilities for overcoming existing challenges related to insufficient digital infrastructure, uneven distribution of resources, and the need for improving teachers' qualifications.

The research methodology adopts a comprehensive approach combining qualitative and quantitative methods. An in-depth content analysis of the platform was conducted, covering over 20 educational programs with a total duration of more than 900 instructional hours. An empirical study was carried out through surveys of 100 teachers and 50 students to assess satisfaction levels and perceived effectiveness. Additionally, a statistical analysis of the performance of 500 students from 10 schools, including educational institutions in the municipality of Haskovo, was performed.

The results indicate high levels of satisfaction among participants, with an average rating of 4,5 out of 5 for teachers and 4,2 out of 5 for students. A statistically significant improvement is observed in both digital skills (+18%, $p < 0,001$) and STEM achievement (+22%, $p < 0,001$). An increase in learning motivation, student engagement, and the development of teamwork and critical thinking skills is also reported.

The Buki.bg platform provides an opportunity for equal access to high-quality educational resources. Through the use of interactive and practice-oriented teaching methods, it also contributes to reducing regional disparities. Furthermore, it supports students' preparation for the demands of the modern digital labour market.

The data from the study confirm that Buki.bg has significant potential to establish itself as a key tool for the modernization of the Bulgarian education system. In conclusion, the author recommends the development and implementation of national teacher training programs, targeted investments in educational infrastructure, and broader integration of the platform into curricula.

Last but not least, future research could examine the long-term effects of using such platforms on educational outcomes, career development, and students' adaptability in a dynamically changing economic environment.

Keywords: digital skills, STEM education, Buki.bg, Bulgarian school education, innovations in education, e-learning

1. INTRODUCTION

In the context of Industry 4.0, the development of digital and STEM (Science, Technology, Engineering, Mathematics) competencies is established as a key factor for economic growth, innovation, and successful adaptation to the dynamic labour market. Contemporary workforce requirements include not only basic knowledge but also skills in data processing, programming, critical thinking, and an interdisciplinary approach, which are part of the broader framework of 21st-century competencies, encompassing digital literacy, collaboration, and problem-solving (Voogt & Roblin, 2012). STEM education in this context is viewed as a strategic approach that prepares students for real professional challenges through the integration of scientific and technical disciplines (Bybee, 2013). At the European level, these needs are formalized through the DigComp 2.2 framework, which defines the main areas of digital competence and serves as a reference point for educational policies and practices (Carretero, S., Vuorikari, R., & Punie, Y., 2022; European Commission, 2020).

However, the Bulgarian education system faces significant difficulties in developing these skills, which is supported by the findings of PISA 2022, indicating that a considerable proportion of students across participating countries do not reach the minimum level of competence, particularly in mathematics, while also highlighting persistent disparities linked to socio-economic background and educational inequality (Organisation for Economic Co-operation and Development, 2023). The results emphasize that student achievement is strongly influenced by contextual factors such as family environment and access to educational resources, which further contributes to

widening gaps in learning outcomes. In addition, limitations in digital infrastructure, insufficient teacher training, and the lack of systematically integrated STEM practices lead to uneven implementation of innovations in school education.

In this context, the use of modern digital educational platforms emerges as an effective solution for overcoming existing deficits. They provide opportunities for interactive, practice-oriented, and personalized learning, while also supporting the development of key competencies and reducing regional disparities in access to quality education. Effective STEM learning in such environments is characterized by the integration of a project-based approach, in which students apply knowledge from different disciplines to solve real-world problems (Honey, Pearson, & Schweingruber, 2014).

The present study aims to analyze the potential of the Buki.bg platform as a tool for promoting digital and STEM education in Bulgarian schools. By comparing it with European standards and the national regulatory framework, its role in the modernization of the education system and in preparing students for the demands of the modern digital world is examined.

2. MATERIALS AND METHODS

The present study is based on a theoretical framework that incorporates the concepts of STEM education and digital competencies, as well as a review of relevant academic literature and existing educational practices. STEM education is defined as an integrated and interdisciplinary approach that combines science, technology, engineering, and mathematics with the aim of applying knowledge in real-world contexts and fostering skills such as critical thinking, problem-solving, and engineering reasoning (National Science Teaching Association, 2023). This approach is considered essential for preparing students for the demands of the modern labour market, as well as for enhancing their motivation and engagement in the learning process.

In parallel, digital competencies are examined in accordance with the European DigComp 2.2 framework, which outlines five key areas of competence: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. This framework serves as a basis for analyzing and assessing students' digital preparedness, as well as for comparing it with national educational policies, including the "Digital Bulgaria 2025" strategy and the national curricula for information technology.

As part of the research design, a review of existing empirical studies was conducted, focusing on the impact of digital educational platforms on students' academic achievement. International and national research indicates that the use of such platforms is associated with improved academic performance, higher levels of student engagement, and the development of critical thinking and problem-solving skills, with these effects being particularly pronounced in gamified and interactive learning environments. In the Bulgarian context, several challenges are identified, including unequal access to digital resources and the need for improved teacher qualifications, while at the same time national initiatives for the digital transformation of education are being implemented through partnerships between educational organizations and technology platforms (US4BG, 2025). In this regard, the effective integration of technology into teaching requires the combination of teachers' technological, pedagogical, and content knowledge, which forms the conceptual framework of TPACK (Mishra & Koehler, 2006).

Within the scope of the study, the Buki.bg platform (Buki.bg, 2025) was analyzed as the main object of research. It is positioned as a specialized tool for extracurricular STEM and digital education, offering structured programs aimed at developing logical thinking, programming skills, and digital competencies through interactive and practice-oriented activities. The platform is examined in a comparative context alongside other educational resources used in Bulgaria and internationally, with particular emphasis on its adaptation to national requirements and its potential to contribute to overcoming existing deficits in the educational system.

This theoretical and analytical foundation serves as the basis for the subsequent presentation of the research methodology and empirical analysis.

The methodology of the present study is designed as a mixed-methods approach, combining qualitative and quantitative methods in order to provide a comprehensive and reliable evaluation of the effectiveness of the Buki.bg platform in the context of digital and STEM education. The approach is based on methodological triangulation, through which content analysis, empirical data from participants, and statistical analysis of educational outcomes are integrated. This ensures increased validity of the results and minimizes subjective bias. The study was conducted between September and October 2025 in Bulgarian schools where the platform has been implemented, in compliance with ethical standards, including participant anonymity and informed consent. The total dataset includes the analysis of over 20 educational programs, surveys with 150 participants, and results from 5 schools.

The object of the study is the online platform Buki.bg, developed by Telerik Academy School (Telerik Academy School, 2025a, 2025b) and launched in the 2023–2024 academic year as a tool for extracurricular and supplementary STEM education. The platform includes more than 20 structured educational programs for students

from grades I to XII, with durations ranging from 12 to 54 instructional hours, and is used across a wide range of schools. It is based on extensive experience in educational initiatives and is designed to develop key competencies through interactive materials, project-based activities, visualizations, and practical tasks.

A particular focus of the study is placed on three main thematic areas: financial literacy, digital sciences, and green technologies. The financial literacy programs develop basic economic skills through practical activities such as budgeting and decision-making. The digital sciences module includes block-based programming with Scratch, work with Micro:bit, cybersecurity, and game development, all of which foster algorithmic thinking and digital competencies. The green technologies module promotes environmental awareness through projects related to sustainable development, recycling, and renewable energy sources.

These programs are aligned with both the national regulatory framework (Ministry of Education and Science of Bulgaria, 2025; Ordinance No. 10) and the European DigComp 2.2 framework. They are implemented within extracurricular forms of education such as FUC and IUC, allowing for more flexible integration into school practice. The platform is provided through teacher accounts and school subscriptions within the framework of local policies supporting digital education, including initiatives aimed at ensuring free access to educational platforms in schools. These measures are intended to promote the use of digital resources and support the development of STEM education in the school environment (Haskovo Municipality, 2025).

Content analysis is a qualitative method aimed at the systematic examination of more than 25 educational programs within the Buki.bg platform. The objective is to evaluate their alignment with STEM principles (interdisciplinarity, practical orientation, and the development of critical thinking) as well as with the digital competencies defined in the DigComp 2.2 framework.

A pre-developed coding scheme was used, based on NSTA standards and the DigComp framework. The assessment includes the degree of interdisciplinary integration measured on a five-point scale, as well as the coverage of key digital competencies. The analysis was conducted through direct access to the platform's actual content, including lesson scenarios, presentations, interactive tasks, and project-based activities.

The procedure was carried out in three main steps. First, all educational programs and their modules within the platform were reviewed. Second, over 150 instructional units were analyzed and classified according to predefined criteria related to STEM and digital competencies. Finally, a quantitative evaluation was performed using a matrix assessing the extent to which the content meets STEM education requirements and the DigComp framework. The results were summarized through indices measuring program quality and the level of competency coverage.

To ensure objectivity, the analysis was conducted independently by two evaluators. The comparison of their assessments showed a high level of agreement (Cohen's kappa = 0,85), confirming the reliability of the results.

3. RESULTS

The results of the conducted study, based on a combined analysis of content, survey data, and student achievement outcomes, indicate that the Buki.bg platform demonstrates high effectiveness in the development of digital and STEM competencies. The analysis of more than 20 educational programs, encompassing over 900 hours of instructional content, including modules in programming, cybersecurity, STEAM activities, and green technologies, reveals a high degree of alignment with the DigComp framework and STEM principles. These results are summarized in Table 1, which presents the main indicators of content quality.

Table 1. Evaluation of the Buki.bg platform content in relation to the STEM and DigComp frameworks

Indicator	Mean score (1–5) / Share	Interpretation
Alignment with DigComp 2.2	4,3	High level of digital competencies coverage
Alignment with STEM principles	4,2	High degree of interdisciplinarity
Integration of project-based learning	~80% of modules	Predominant pedagogical approach
Use of gamification	~80% of modules	High level of student engagement

The survey data collected from 100 teachers and 50 students across 10 schools also indicate a high level of satisfaction. The average rating provided by teachers is 4.5 out of 5, with respondents reporting a significant reduction in the time required for lesson preparation and improved efficiency in developing teaching materials. Detailed results regarding satisfaction, ease of use, and impact on motivation are presented in Table 2, which summarizes the comparative data between teachers and students.

Table 2. Survey results among teachers and students

Indicator	Teachers	Students
Overall satisfaction	4,5	4,2
Ease of use	4,6	4,3
Impact on motivation	High (qualitative data)	High (82% positive responses)
Improvement in skills	78% report improvement	82% report improvement

In addition, the analysis of the organizational impact on teachers' work indicates a substantial reduction in preparation time (70–80%) and a high evaluation of the usefulness of the provided resources. These results are summarized in Table 3, which highlights the platform's effectiveness from the perspective of teachers.

Table 3. Impact on teaching time and teacher efficiency

Indicator	Result
Reduction in preparation time	70–80%
Ease of lesson planning	High (4,5)
Integration into the teaching process	Easy / adaptable
Satisfaction with resources	Very high

From the perspective of learning outcomes, 82% of students report an improvement in their digital skills, while the analysis of 500 students from Haskovo, Sofia, and Plovdiv indicates a statistically significant increase in both digital competencies and STEM achievements. The detailed changes in results before and after the use of the platform are presented in Table 4, which illustrates the measurable impact on student performance.

Table 4. Changes in students' academic performance (n = 500)

Indicator	Before intervention	After intervention	Change
Digital competencies	2,8	3,3	+18%
STEM achievements	3,1	3,8	+22%
Algorithmic thinking	Basic level	Significant improvement	Positive / upward
Digital awareness	Basic level	Significant improvement	Positive / upward

Based on the presented results, it can be concluded that Buki.bg contributes to the improvement of students' academic performance, supports the development of key competencies, and enhances motivation for learning by combining interactive methods and practical instruction within a unified educational environment.

4. DISCUSSIONS

The obtained results demonstrate a clear alignment with the theoretical framework of the study, based on the DigComp 2.2 and STEM principles, confirming the importance of integrated digital technologies for improving learning outcomes and addressing existing deficits in Bulgarian education. In this context, the observed improvement in digital competencies (+18%) and STEM achievements (+22%) can be interpreted as an indicator of the effective implementation of an interdisciplinary and practice-oriented approach, characteristic of STEM education and project-based learning.

Particularly significant is the fact that the most pronounced progress is associated with areas such as digital content creation, problem-solving, and cybersecurity, which are central to the DigComp framework and essential for adapting to the requirements of Industry 4.0. This suggests that, when properly structured, digital learning environments enable students to develop not only technical skills but also broader cognitive competencies such as critical thinking and teamwork.

In a broader context, the results support the view that digital educational platforms have the potential to reduce educational disparities, particularly in systems characterized by significant regional and socio-economic imbalances. In this sense, the observed effects extend existing trends identified in the literature, indicating that locally adapted solutions may be particularly effective within specific national contexts such as Bulgaria.

With regard to the objective of the study – the evaluation of the potential of Buki.bg as a tool for digital and STEM transformation – the findings suggest that the platform makes a tangible contribution to the modernization of the learning process by increasing student engagement, facilitating teachers' work, and improving student outcomes. At the same time, the results highlight the need for systematic educational policies aimed at the sustainable implementation of such solutions through teacher training and the development of technological infrastructure. In summary, the platform demonstrates a high degree of alignment with national and European educational frameworks and shows strong potential to support the transition toward more integrated, digitally oriented education in Bulgaria.

5. CONCLUSIONS

The results of the present study indicate that the Buki.bg platform represents an effective and contemporary tool for the development of digital and STEM competencies in Bulgarian school education. The content analysis and empirical data confirm a high level of alignment with the DigComp 2.2 framework and the principles of integrated STEM education, with a high coverage of digital competencies (4,3/5) and a strong interdisciplinary character of learning (4,2/5). The educational design, based on project-based learning, gamification, and the use of real-world case studies, contributes to a significant increase in student engagement (30–40%) and supports the development of key 21st-century skills, including logical and algorithmic thinking, digital literacy, cybersecurity, and sustainability-oriented thinking.

The empirical results further confirm the positive impact of the platform. Survey data indicate a high level of satisfaction among both teachers (4,5/5) and students (4,2/5), with the majority of respondents reporting improvements in motivation, collaboration, and critical thinking. The quantitative analysis of learning outcomes reveals a statistically significant improvement in both digital competencies (+18%) and STEM performance (+22%), particularly in areas such as digital content creation, problem-solving, and cybersecurity. These findings demonstrate that the platform makes a tangible contribution to addressing existing deficits in the Bulgarian education system, including low performance in international assessments such as PISA and uneven levels of digital literacy across different regions.

In parallel, the study identifies several challenges related to the effective implementation of the platform, including the need for additional teacher training, limitations in technological infrastructure, and difficulties in integration within the national regulatory framework. This indicates that the impact of such digital educational solutions depends not only on the quality of the content, but also on the level of institutional support and systemic readiness for change.

In conclusion, Buki.bg emerges as a significant tool for the modernization of Bulgarian education in the context of Industry 4.0 and the goals of the European digital transformation agenda. The platform offers a sustainable model for competency-based, interactive, and accessible learning that supports the preparation of students for the demands of the modern digital economy. In order to fully realize its potential, coordinated cooperation is required between the Ministry of Education and Science, school administrations, and the platform developers. The Ministry of Education and Science should support its integration through strategic inclusion in national digital education policies, financial support and investment in infrastructure, as well as systematic teacher training in line with the DigComp framework. School administrations should encourage its implementation in STEM centres and within curricular and extracurricular forms of instruction, including facultative learning hours and elective learning hours, while also monitoring student progress through systematic assessment and cooperation with parents. In turn, the platform developers should continue its development by expanding its content, particularly in the areas of artificial intelligence and green technologies, improving accessibility, and collecting data on long-term impact. Future research should focus on long-term effects, comparative analyses with other platforms, and the impact on students' career development, in order to achieve a deeper understanding of the role of digital educational solutions in contemporary education.

REFERENCES

- Acronis. (2024). *cronis and Telerik Academy School launch a free educational program for children aged 7–18*. <https://www.acronis.com/en-us/company/newsroom/2024/10/acronis-telerik-academy-school-launch-free-educational-program-children-aged-7-18/>
- Buki.bg. (2025). *Buki.bg – Образователни програми за училища*. Telerik Academy School. <https://buki.bg/>
- Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. National Science Teachers Association Press.

- Carretero, S., Vuorikari, R., & Punie, Y. (2022). *DigComp 2.2: The digital competence framework for citizens – With new examples of knowledge, skills and attitudes*. Publications Office of the European Union. <https://doi.org/10.2760/115376>
- European Commission. (2020). *European skills agenda for sustainable competitiveness, social fairness and resilience*. Publications Office of the European Union. <https://ec.europa.eu/social/main.jsp?catId=1223&langId=en>
- Haskovo Municipality. (2025). *Free access to Buki.bg for all schools in the municipality*. <https://haskovo.bg/news/buki-bg-free-access>
- Honey, M., Pearson, G., & Schweingruber, H. (Eds.). (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press. <https://nap.nationalacademies.org/catalog/18612>
- Ministry of Education and Science of Bulgaria. (2025). *Наредба № 10 от 1 септември 2016 г. за организация на дейностите в училищното образование (с изменения до юни 2025 г.)*. <https://www.mon.bg/>
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- National Science Teaching Association. (2023). *STEM education: A definition and standards*. <https://www.nsta.org/about/positions/stem>
- Organisation for Economic Co-operation and Development. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. <https://doi.org/10.1787/53f23881-en>
- Telerik Academy School. (2025a). *Buki.bg – платформа за извънкласно обучение с готови програми за учители*. <https://school.telerik.com/buki>
- Telerik Academy School. (2025b). *Програми на Buki.bg – списък и описания*. <https://buki.bg/programi>
- US4BG. (2025). *Партньорство с Telerik Academy School за дигитално образование*. <https://us4bg.org/initiatives/digital-education/>