

Review of Online Tools for Introducing Robotics in Schools

1. Introduction

Objectives of the review

- The relevance of robotics in school education (STEM education, 21st-century skills, computational thinking).
 - The role of **online tools** (platforms, simulators, courses, virtual environments).
 - Highlight the skills that they foster.
 - Highlight their strengths and limitations.
 - Identify (if there are) gaps in existing literature (e.g., fragmentation of tools, hardware-centered approaches, lack of systematic frameworks, etc.).
 - Provide the results of the research to teachers and educators in an accessible and easy to use way (e.g. web repository, an e-book, etc.)
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2. Review Methodology

2.1 Inclusion and Exclusion Criteria

- Target age groups and school levels → secondary school (12-18).
- Online accessibility (web-based platforms, cloud tools, MOOCs).
- Language availability (English, national languages).
- Educational focus (excluding tools designed exclusively for industrial or university use).

2.2 Sources

- Scientific literature (reviews, empirical studies, case studies).
- Official websites of educational platforms.
- Institutional and educational projects.
- Open-source communities and repositories.
- Questionnaire within the consortium (to be defined).

2.3 Classification and Analysis Method

- Qualitative thematic analysis.
 - Taxonomy based on functional (and pedagogical?) criteria.
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3. Pedagogical and Theoretical Framework

- Constructivist and constructionist learning theories.
 - Learning by doing.
 - Computational thinking.
 - Problem-Based Learning (PBL).
 - STEAM education.
 - Inclusive education and accessibility principles.
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4. Categories of Online Tools for Educational Robotics

4.1 Robotics Simulators

- Virtual environments for programming and testing robots.
- Advantages: no physical hardware required.
- Limitations: reduced physical interaction.

Key analysis dimensions

- Supported programming languages (block-based, Python, C++).
- Simulation realism.
- Complexity and scalability.

Resources

Tselegkaridis, S., & Sapounidis, T. (2021). Simulators in educational robotics: A review. *Education Sciences*, 11(1), 11.

Zhan, Z., Zhong, B., Shi, X., Si, Q., & Zheng, J. (2022). The design and application of IRobotQ3D for simulating robotics experiments in K-12 education. *Computer applications in engineering education*, 30(2), 532-549.

Karaman, S., Anders, A., Boulet, M., Connor, J., Gregson, K., Guerra, W., ... & Vivilecchia, J. (2017, March). Project-based, collaborative, algorithmic robotics for high school students: Programming self-

driving race cars at MIT. In *2017 IEEE integrated STEM education conference (ISEC)* (pp. 195-203). IEEE.

Hughes, J., Shimizu, M., & Visser, A. (2019). A review of robot rescue simulation platforms for robotics education. *Robot world cup*, 86-98.

4.2 Visual Programming Platforms

- Block-based programming environments oriented toward robotics.
- Support for transitioning to text-based programming.

Key aspects

- Target age group.
- Support for creativity and experimentation.

Resources

Yadagiri, R. G., Krishnamoorthy, S. P., & Kapila, V. (2015, June). A blocks-based visual environment to teach robot-programming to K-12 students. In *2015 ASEE Annual Conference & Exposition* (pp. 26-17).

Coşkunserçe, O. (2023). Comparing the use of block-based and robot programming in introductory programming education: Effects on perceptions of programming self-efficacy. *Computer Applications in Engineering Education*, 31(5), 1234-1255.

4.3 Integrated Learning Platforms (LMS for Robotics)

- Structured learning paths including lessons, exercises, and assessments.
- Often aligned with school curricula.

Analysis dimensions

- Self-assessment and feedback mechanisms.
 - Teacher support tools.
 - Progress tracking and analytics.
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4.4 Online Courses, MOOCs, and Open Educational Resources

- Video lessons, courses, tutorials, and modular teaching units.

- Open versus proprietary resources.

Evaluation criteria

- Pedagogical guidance.
- Quality of instructional materials.
- Reusability in classroom contexts.

Resources

Pozzi, M., Prattichizzo, D., & Malvezzi, M. (2024, August). Educational Resources for Robotics: Accessible Lectures and Toolboxes. In *The International Conference of IFToMM ITALY* (pp. 528-535). Cham: Springer Nature Switzerland.

Pozzi, M., Prattichizzo, D., & Malvezzi, M. (2021). Accessible educational resources for teaching and learning robotics. *Robotics*, 10(1), 38.

4.5 Online Communities and Collaborative Platforms

- Forums, repositories, and challenge-based environments.
 - Informal learning and peer-to-peer knowledge exchange.
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5. Comparative Analysis of Tools

5.1 Comparison by School Level

- Lower secondary education.
- Upper secondary education.

5.2 Comparison by Skills Developed

- Programming skills.
- Robotics and automation concepts.
- Problem solving.
- Collaboration and teamwork.
- Creativity.

5.3 Comparison by Technical Requirements

- Hardware requirements.
 - Browser-based versus locally installed tools.
 - Cost models and licensing.
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6. Accessibility, Inclusion, and Sustainability

- Economic accessibility.
 - Support for students with special educational needs.
 - Multilingual availability.
 - Continuity between formal and informal learning.
 - Long-term sustainability for schools.
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- Support for instructional design.
 - Teacher communities of practice.
 - Ready-to-use materials versus pedagogical flexibility.
 - Need for specific teacher training.
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7. Discussion

- Support for instructional design.
 - Teacher communities of practice.
 - Ready-to-use materials versus pedagogical flexibility.
 - Need for specific teacher training.
 - Emerging trends (virtual robotics, AI integration, digital twins).
 - Limitations of online-only approaches.
 - Integration with physical robotic systems.
 - Differences between commercial and open-source approaches.
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8. Practical Recommendations

- Guidelines for selecting appropriate tools.
 - Strategies for curriculum integration.
 - Usage scenarios (classroom activities, laboratories, distance learning).
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9. Conclusions and Future Perspectives

- Summary of findings.
- Implications for school education.
- Future research directions (impact assessment, longitudinal studies).