



Integration of Innovative Learning Strategies into Science Technology Engineering Arts and Mathematics (STEAM) Education

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Abstract

STEAM education is a method of teaching that equips students with the abilities and understanding necessary to succeed in a constantly evolving global economy. Even with significant attempts to improve STEAM education, teachers encounter considerable challenges in identifying appropriate instructional approaches. A lot of educators not only lack expertise in particular subjects but are also unfamiliar with effective teaching methods that can boost student learning and involvement through STEAM. Hence, this calls for this study which investigates the integration of innovative strategies into STEAM education, highlighting its significance in the 21st century economy. The importance and need for innovative strategies in STEAM education are discussed, emphasizing the role of teachers' qualifications in delivering effective STEAM education. The use and applications of Artificial Intelligence (AI) in STEAM education are also examined, showcasing its potentials to enhance student learning outcomes. Furthermore, the classification and distribution of STEAM education are analyzed, providing insights into its various forms and delivering methods. This study ultimately highlights STEAM education's significance in nurturing critical thinking, creativity, and problem-solving skills, and its function in equipping students for a progressively intricate and interconnected world.

Keywords: Integration, Innovative Strategies, STEAM Education

Introduction

STEAM is an educational framework for learning and growth, blending Science, Technology, Engineering, Arts, and Mathematics into a complete educational journey. STEAM education proves crucial in equipping students for the intricate demands of the 21st-century workforce. As Karampelas (2020) notes, STEAM education emphasizes combining these subjects to boost students' interdisciplinary knowledge, comprehension, higher-order thinking, and problem-solving skills. The author further stressed that STEAM education is an essential component of technological development and needs to be continually promoted through effective innovative strategies. Hence, STEAM education foster creativity and critical thinking to students. Hew et al. (2019) and Radianti et al. (2020) presented a thorough framework, providing a complete overview of the landscape. It identifies broad trends, frequent difficulties, and effective strategies evident across various STEAM subjects and educational stages. The authors further opted that STEAM education provides learners with knowledge and skill needed to

adapt favourably in the modern and technological society. STEAM integration can be taught as a single discipline or delivered independently. For successfully implement integrative STEAM education in schools, efforts should be made to restructure the existing curriculum system to be in line with the new teaching strategies. Beyond the curriculum, STEAM educators require strong teaching knowledge and skills. That is why it is necessary that the teachers who are saddled with the responsibility of facilitating the learning process especially in STEAM education, be well grounded with the task ahead of them so that they can approach it using the most appropriate innovative strategies and methods.

The teaching of STEAM demands the adoption of the best innovative strategies and teaching methods. Innovation is a vital component of STEAM education. Hence, effective integration of innovative strategies/methods into teaching and learning of STEAM will enable students to be creative and also become critical thinkers who will be able to analyze



information to know what skills they need and when to apply it. The end product will improve students' performance and increased interest in STEAM subjects. Thus, this paper is organized under the headings:

- Need for Innovative Strategies in STEAM education
- The importance and Role of STEAM Education
- The role of teachers' qualifications in STEAM Education
- The uses and application of AI in STEAM Education
- STEAM Education
- Classification and Distribution of STEAM Education
- Suggestion
- Conclusion

Need for effective Innovative Strategies/Methods

Integrating innovative strategies into STEAM (Science, Technology, Engineering, Arts, and Mathematics) education is vital for readying students for the 21st-century economy's complexities. Traditional teaching often emphasizes rote memorization and standardized testing, which can result in disengagement, limited creativity, and reduced critical thinking. However, innovative approaches, like project-based learning and gamification, can significantly boost student engagement and motivation. A study carried out by Thomas, (2000); Dichev and Dicheva, (2017) emphasizes the important of awareness and utilization of strategies in STEAM education, highlighting their potentials to enhance teaching and learning outcomes. People have different views of the nature of STEAM education and how learning takes place. These different views have resulted in different propositions on what strategy STEAM teachers should use to facilitate learning. This has equally given rise to the different teaching strategies in STEAM Education. Hence, there are many innovative strategies in STEAM education. Dewey, (1916); Dichev and Dicheva, (2017); Sutherland (1965); Caudell (1992); Johnson and Johnson (2009); Bergmann and Sams (2012); Dewey (1916) and Bybee and Powell (2001) enumerated many innovative strategies in STEAM education. These include: Project-based learning, gamification, virtual reality and augmented reality, collaboration, flipped learning, enquiry-based learning, and 5E learning.

Project-based learning, students tackle real-world projects that blend STEAM subjects, fostering critical thinking, creativity, and problem-solving. For

successful implementation within STEAM education, the teacher serves as a guide, advisor, or coordinator, adhering to general project-based learning stages: sparking student interest, designing project activities, enabling student execution, and finally evaluating their project's outcome. This aligns with Thomas's (2000) inference that project-based learning enhances critical thinking and problem-solving.

Gamification is the one of the effective innovative strategies in STEAM education. Students are encouraging to use educational games and simulation to make learning interesting and attractive. STEAM concepts are thought through game design, development, and play, increasing student engagement, motivation, creativity, and innovation. According to Jantakoon et al (2024), gamification in STEAM education attracts students interest, making learning more interactive and engaging. The authors further stressed that gamification in STEAM education promote students' creativity, problem-solving, and interdisciplinary collaboration. Students have access to hands-on, project-based learning experiences that foster creativity, innovative, and entrepreneurship.

Virtual Reality and Augmented Reality are potent instruments in STEAM education. Virtual Reality is a computer-created simulation featuring a three-dimensional environment that can be physically experienced and interacted with. It boosts student interest and participation in STEAM education. Virtual reality improves student learning outcomes and promote scientific literacy (Liu, & Hou, 2023). Augmented reality is a technology that uses a device's camera and display to overlaps digital information and images onto the real world. It engages student in hands-on activities and experiments that combine physical and digital elements. Augmented reality according to Chen and Liu (2024) improves student understanding and motivation. The technology equips student with skills and knowledge needed for careers in STEAM fields. By integrating these innovative strategies into STEAM education, educators can foster engaging and effective learning experiences. This prepares students for success in the 21st-century economy.

Collaborative learning is a method where students get the chance to discuss topics in groups. Hornby (2015) defines it as the art of working with another person or group to create or produce something. Through this learning approach, topics to be taught are thrown open for systematic class discussion. The outcome of the discussion will be actualize in their minds and students will be able to apply them in their



daily life experiences. If adequate teaching aids are introduced and used well in STEAM education, the usefulness and effectiveness of the collaborative learning will be greatly enhanced. The STEAM teacher will only be expected to perform the function of a moderator, a helper, a guide, a facilitator, and as well as a contributor in the group process. This type of learning helps the students in developing communication skills, overcome shyness and has more comportment and confidence in the classroom discussion. Everyone succeed when the group succeeds (Bishop & Verleger, 2013; Capar & Tarim, 2015).

Flipped learning is a blended approach in STEAM education where direct instruction shifts from group settings to individual study. It inverts traditional methods, boosting student engagement, collaboration, and time for hands-on STEAM activities. In flipped learning, students typically watch video lectures or instructional content at home, then use class time for problem-solving, discussions, and collaborative projects (Zownorega, 2013). This method lets students learn at their own pace, offering chances for active learning and a deeper grasp of mathematical concepts (Strayer, 2012). For a successful implementation of flipped learning, STEAM teachers need proficiency in using various technologies to create and deliver video lectures, curate online resources and manage learning platforms (Mean et al., 2010)

Enquiry-based learning is a learning where by the teacher supplies the topic to be learnt and allow the students to find out the relevant facts about the topic for themselves. In teaching STEAM education, the teacher can adopt enquiry-based learning that can teach students how to think and solve problems for themselves. Enquiry-based learning is a teaching approach where the teacher guides the classroom. Students are then empowered to make personal inquiries and discover meaningful answers to questions they pose or those given by teachers. When a STEAM teacher uses this method, it helps students develop questions, make observations, research existing information, outline potential explanations, and create predictions for future study.

5E learning approach can also be regarded as problem-based learning. 5E learning approach is a systematic approach that reviews learning competencies in STEAM education. The 5E model applies thinking and reasoning to various problems encountered in life. Students are provided with the necessary data and materials which will enable them to solve problems and arrives to the solution to problems

posed. According to Kaya and Calik (2020), 5E learning approach enhance students understanding and engagement thereby increase their performance.

STEAM education, through all these innovative strategies, involves exposing students to teaching and learning that encourage the active construction of knowledge and the development of critical thinking and problem-solving skills needed to prepare students for the demands of the 21st-century labor workforce.

Importance and Role of STEAM Education

STEAM is an approach to learning and development that incorporates the areas of science, technology, engineering, arts, and mathematics. It provides strong, comprehensive learning experiences in these subjects from an early age. STEAM education encourages students to think critically and develop problem-solving skills. STEAM education encourage students to think critically and create problems-solving skills. STEAM education also cuts across various sectors including information technology. Engineering, healthcare and manufacturing. It is an education that prepares students for real world challenges, including environmental sustainability, economic development, and social inequality. STEAM education, as highlighted by Luckin (2017), is crucial for equipping individuals with the skills and knowledge needed to prosper in a dynamic global economy. It prepares students for scientific argument, critical thinking, problem-solving, inquiry, and exploration, thus arming them with emerging technologies like artificial intelligence and robotics. Although the significance of promoting integrative innovative strategies in STEAM education is widely acknowledged, and numerous studies have been conducted recently, educators still struggle to find suitable teaching strategies. By integrating STEAM education into our learning systems, we can empower students with the necessary skills, knowledge, and values for 21st-century success.

Importance of Teachers' Qualifications for STEAM Education

For a qualified STEAM education, teachers' qualifications are crucial in delivering high-quality education. For STEAM courses to be effective, a teacher must possess subject knowledge and conceptually grasp the underlying principles, rules, definitions, and applications. This conceptual understanding, combined with classroom practice, forms the pedagogical content knowledge essential for a successful STEAM teacher (Inamorato dos Santos &



Machado, 2020). Educators with specialized training and pedagogical knowledge in STEAM can design engaging, effective lesson plans that accommodate diverse learning styles. Teachers who lack these training and knowledge may struggle to communicate concepts and ideas, making it challenging for students to fully grasp the material. These may hinder students' success and well-being. A qualified teacher concentrates not on theory and chalk-talk, instead get the students to apply what they are learning to practical exercises and experimental learning. Through practical and experimental learning, students gain the skills and knowledge needed to succeed in the 21st-century market. Qualified teachers recognize each student's unique strengths and challenges. They offer individualized attention and support, identifying areas where students require extra help and adapting their teaching accordingly. Thus, qualified STEAM teachers can potentially boost student academic achievement and career readiness, underscoring the importance of teacher quality in STEAM education.

STEAM Education

STEAM education is an integrated approach merging science, technology, engineering, arts, and mathematics. This provides a well-rounded educational experience, preparing students for careers in our modern, technological society. It's an activity-based learning method, offering a comprehensive experience. This integrative teaching approach equips students with essential skills and knowledge, enabling them to adapt favorably in a rapidly changing economy. STEAM education utilizes student-centered, experiential learning, providing a comprehensive preparation for careers in a dynamic, interconnected world. The effectiveness of STEAM education hinges on teacher expertise. Professionally trained educators can organize development programs for STEAM teachers, enhancing their knowledge and skills. Professional development allows educators to stay current with emerging trends, refine instructional practices, and foster a growth mindset embracing continuous learning. According to Yakman (2017), a key issue with STEAM education is insufficient focus on educational specialists and the inability to integrate new developments. STEAM education necessitates students gaining 21st-century skills. Zepeda (2019) argues that teachers' attitudes toward science instruction should prioritize acquiring necessary skills for the 21st-century market, beyond just good grades or certificates. These skills empower students to find solutions from diverse perspectives,

think systematically and critically, and offer practical suggestions. STEAM also aims to nurture 21st-century skills from early childhood into adulthood (Acar et al., 2020). By incorporating STEAM education into our learning systems, students will gain the skills, knowledge, and values needed to thrive in the 21st-century job market.

AI in STEAM Education

Education has seen AI emerge as a vital field of study. Integrating AI methods into STEAM education improves instruction and decision-making, allowing for personalized learning experiences. According to Hwang, Hie, Wah, and Gasevic (2020), incorporating AI into educational settings transforms traditional teaching and learning approaches. The inclusion of AI in STEAM education enhances personalized learning, boosts student engagement, and provides more efficient assessment feedback. Kim and Kim (2018) state that AI applications in STEAM education help students acquire and develop skills like problem-solving, collaboration, communication, and decision-making.

AI is used in many ways to improve various aspects of teaching and learning. The STEAM fields are increasingly recognized as crucial for exploring innovative teaching and learning approaches (Henriksen et al., 2016). Holmes et al. (2019) note that numerous AI tools for learning enable effective study methods and offer comprehensive assistance for teachers. Some of these AI technologies include chatbots, GitHub Copilot, Gemini, Claude, ChatGPT, Natural Language Processing (NLP), and Robotics. Bender et al. (2021) confirm these technologies have begun making a significant impact in educational settings. According to Kim et al. (2019), chatbots can create interactive learning environments, provide personalized feedback, and facilitate discussions. GitHub Copilot assists students with coding and programming tasks, fostering computational thinking and problem-solving skills (GitHub, 2021). Gemini, on the other hand, can be used for educational purposes like creating interactive simulations and games. OpenAI (2022) confirms that ChatGPT can generate educational content, provide explanations, and offer study guides, supporting student learning and understanding. Hirschberg and Manning (2015) state that NLP improves students' language skills and comprehension. Finally, Robotics can teach programming, engineering, and problem-solving skills, enhancing hands-on learning and STEM education (Benitti, 2012).



Classification and Distribution of STEAM in Education

STEAM classes primarily emphasize project-based learning, focusing on tackling real-world challenges and empowering students to develop innovative solutions. STEAM subjects encompass any discipline classified under Science, Technology, Engineering, Arts, or Mathematics. This approach enables students at all life stages to gain knowledge and learn how to apply it. STEAM classes specifically include: STEAM Science, STEAM Technology, STEAM Engineering, STEAM Arts, and STEAM Mathematics.

STEAM Science explores scientific inquiry, covering subjects like biology, chemistry, physics, and earth sciences. It draws upon three main branches of science: life sciences (e.g., biology, botany, zoology, ecology), physical sciences (e.g., physics, chemistry, earth sciences), and formal sciences (e.g., statistics, logic, mathematics). The science aspect in STEAM helps students analyze problems, modularize them for better understanding, and identify cause-effect relationships within these modules. Courses under STEAM Science include: Biochemistry, Biology, Chemical engineering, Statistics, Physics, Chemistry, Computer Science, and Astronomy.

STEAM Technology encompasses computer science, information technology, and engineering technology. It functions in various ways: educationally, by improving knowledge through new concepts, or instructionally, by providing guidance on implementing ideas or tasks. Courses under STEAM Technology include: Biotechnology, Computer Science, Information Technology, Information Systems, Ethical Hacking, Machine Learning, and Artificial Intelligence.

STEAM Engineering bridges science with arts and mathematics, facilitating the building and design of diverse technological solutions. It covers various engineering disciplines, such as designing, building, and testing structures, machines, and systems. Engineering technology has three sub-headings: mechanical, electrical, and civil engineering. STEAM Engineering courses include: Aerospace Engineering, Civil Engineering, Physics, Mechanical Engineering, Robotic Engineering, Telecommunication Engineering, Computer Science, and Engineering.

STEAM Mathematics includes geometry, algebra, calculus, and statistics, sub-divided into pure and applied mathematics. It translates knowledge from applied sciences, engineering, and arts into

mathematical concepts. STEAM Mathematics aids in problem-solving by incorporating logic. Courses under STEAM Mathematics include: Statistics, Financial Mathematics, Banking, Corporate Accounting, Asset Management, Real Estate Finance, Discrete Mathematics, Algebra, and Geometry.

STEAM Arts embraces music, visual arts, drama, dance, and other creative fields. It's categorized into visual arts, performing arts, and design arts. STEAM Arts fosters creativity, self-expression, and aesthetic appreciation, integrating arts and design into traditional STEM fields. STEAM Arts projects can be more engaging and motivating for students than traditional STEM education (Sweeney & Jarahi, 2016).

Suggestions

Science, Technology, Engineering, Arts and Mathematics (STEAM) education is an essential tool for lifelong learning which if promoted will help to develop knowledge and skills.

Thus, the following suggestions are made.

- School counselors could organize STEAM counselling programs for diverse settings, using one-on-one and group counselling methods to promote and help people of all ages understand and apply STEAM skills.
- Educational policymakers should collaborate with curriculum planners to incorporate innovative strategies, fostering learners who are catalysts for cultivating critical thinking, adaptability, and a passion for exploration.
- STEAM teachers can enhance their creative thinking by adopting innovative strategies during teaching and learning.
- The government, through the Ministry of Education, and professional bodies like the Mathematical Association of Nigeria (M.A.N) and Science Teachers Association of Nigeria (S.T.A.N), should provide in-service training, workshops, seminars, and conferences for STEAM teachers on how to motivate their students in learning science.
- Government and non-governmental agencies should give urgent attention with respect to fund, which will help cushion the sorry state of STEAM education in our country, Nigeria.

Conclusion

Despite many efforts to enhance STEAM education's effectiveness, educators encounter significant challenges in finding suitable teaching strategies. Nevertheless, numerous innovative strategies exist for teaching and learning STEAM, including project-based learning, gamification, virtual reality and augmented reality, collaborative learning, flipped learning, enquiry-based learning, and the 5E learning approach. Therefore, it's essential to prepare STEAM teachers to meet the challenges of teaching and learning STEAM education. Consequently, integrating innovative strategies into STEAM education instruction is necessary, as this will significantly boost students' STEAM activities.

References

- Acar, D. Teteniz, N. & Tasdenur, A. (2020). The relationship between mathematics and problem-solving skills and achievement of students who were being educated with STEM. *Bratin University Journal of Educational and Research*, 3(2), 12-23.
- Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. (2021). On the dangers of stochastic parrots: Can language models be too big? *In Proceedings of ACM Conference on Fairness, Accountability, and Transparency*, 610-623.
- Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every day. International Society for Technology in Education.
- Benitti, F.B. (2012). Exploring the educational potential of robotics in schools: A systematic review. *ComputerS & Education*, 58(1), 314-324.
- Bishop, J.L. & Verleger, M.A. (2013). The flipped classroom: A survey of the research. American Society of Engineering. 120th ASEE Annual conference.
- Bybee, R. W., & Powell, J. C. (2001). Teaching science as inquiry. In J. A. Bianchetti & A. M. P. Rodrigues (Eds.), *Proceedings of the 2000 International Conference on Science Education*, 17-34.
- Chen, P., & Liu, X. (2024). Exploring the potential of augmented reality in science education. *Journal of science education and technology*, 33(3), 257-271.
- Capar, G. & Tarim, K. (2015). Efficiency of cooperative learning method on mathematics achievement and attitude: A meta-analysis research. *Educational Science: Theory and Practice*. 15(2), 553-559.
- Caudell, T. P., & MiZell, D. W. (1992). Augmented reality: An application of heads-up display technology to manual manufacturing processes. *Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences*, 2, 659-669.
- Cakir, F. N., & Yilmaz, R. (2020). The impact of viral reality on student' academic achievement in science education. *Journal of Educational Computing Research*, 58(4), 419-435.
- Cevik, M. & Bakioglu, B. (2022). The Effect of STEM Education Integrated into Teaching-Learning Approaches (SEITLA) on Learning Outcomes: A Meta-Analysis Study. *International Journal of Progressive Education*, Volume 18 Number 2,2022, INASED.
- David, J. (2008). What research says about project-based learning? *Educational Leadership*, 65, 80-82.
- Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. Macmillan.
- Dichev, C., & Dicheva, D. (2017). Gamification and game-based learning in the educational process. *International Journal of Instructional Technology and Distance Learning*, 14(2), 3-15.
- Dougherty, D. (2005). The maker mindset. *Make*: 1, 12-13.
- GitHub. (2021). GitHub Copilot. Retrieved from (link unavaliabie).
- Hornby, A.S. (2016). *Oxford Advanced Learners Dictionary of Current English*, 9th edition, Oxford University Press.
- Henriksen, D., MiSHRA, P., & Fisser, P. (2016). Infusing creativity and technology in 21st century education: Systemic view for change. *Educational Technology & Society*, 19(3), 27-37.
- Hew, K.F., Lan, M., Tang, Y., Jia, C., & Lo, C.K. (2019). Where is the "theory" within the field of educational technology research? *British Journal of Educational Technology*, 50(3), 956-971.
- Holmes, W., Bialik, M., & Fadel , C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.



- Hirschberg, J., & Manning, C. D. (2015). Advances in natural language processing. *Science*, 349(6245), 261-266.
- Hwang, G. J., Xie, H., Wah, B. W., & Gasevic, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computer and Education: Artificial Intelligence*, 1, 100001. <https://doi.org/10.1016/j.caeai.2020.100001>.
- Inamorato dos Santos, A., & Machado, R. L. (2020). Teacher training in STEAM education: A systematic review. *Journal of Science Teacher Education*, 31(1), 53-72.
- Jantakoon, T., Jantakun, K., Jantakun, T., Trisupakitti, S., & Limpinan, P. (2024). STEAM education with gamification: A bibliometric analysis. *Higher Education Studies*, 14(3), 90-103.
- Johnson, D.W., & Johnson, R. T. (2009). Collaborative learning and social interdependent theory. In Gillette & M.M. Piowar (Eds.), *Theory and research on small groups*, 144-176. New York, NY: Springer.
- Liu, D., & Hou, H. (2023). Exploring the effectiveness of virtual reality-based learning in science Education and Technology. 32(3), 354-358.
- Luckin, R. (2017). *Machine Learning and AI for educators*. Routledge.
- Karampelas, A. (2020). Artificial Intelligence and Machine Learning in the STEAM Classroom: Analysis of Performance, Data and Reflections International High School Students. *Hellenic Journal of STEM Education*, 1(2), 59-66.
- Kaya, S., & Calik, M. (2020). The effect of 5E instructional model on students' achievement and attitudes toward STEAM education. *Journal of Educational Research and Practice*, 10(1), 1-15.
- Kellek, T.R., & Knowles, J.G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education* 3(11). <https://doi.org/10.1186/s40594-016-0046-z>
- Kim, J., Lee, Y., & Kim, B. (2019). A study on the effectiveness OF chatboT-based learning in STEM education. *Journal of Educational Computing Research*, 58(4), 419-433.
- Kim, J. O., & Kim, J. (2018). Development and application of Art Based STEAM Education PROGRAM USING Educational Robot. *International Journal of Mobile and Blended Learning (IJMBL)*, 10(3), 46-57. <https://doi.org/10.4018/IJMBL.2018070105>.
- Mean, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). Evaluation of evidence-based Practices in online learning: A meta-analysis and review of online learning studies. IUS Department of Education.
- OpenAI. (2022). ChatGPT. Retrieved : (link unavaliable)
- Radianti, J., MajchrZak, T.A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778.
- Salameh, H. (2005). Blended learning: The National Development of E-Learning. *E-Learning Forums*, retrieved from: www.elearning.edu.sa/forum/attachment.php?attachmentid=635&d=118206521
- Strayer, J. (2012). How the flipped classroom affects student Learning Environment, 15(2), 171-186?
- Sutherland, I. E. (1965). The ultimate display. *Proceedings of the International Federation of Information Processing Congress*, 2, 506-508.
- Sweeney, R., Jarahi, M. (2016). STEAM education: Integrating arts and design into STEM. *Journal of Science Education and Technology*, 25(2), 267-277.
- Thomas, J. W. (2000). *A review of research on project-based learning*. San Rafael, CA: Autodesk Foundation.
- Wilson C, Lennox P, Hughes G, Brown M. (2017). How to develop creative capacity for the fourth industrial revolution: Creativity and employability in higher education. In F. Reisman (Ed.): *Proceedings of the Creativity, Innovation and Wellbeing*. Available:<http://hdl.handle.net/10545/621932>
- Yakman, G. (2017). STEAM education: A comprehensive approach to learning. *Journal of STEM Education*, 18(3), 5-9.
- Zepeda, S. J. (2019). *Professional development: What works*: Routledge
- Zownorega, B. (2013). *The flipped classroom for dummies*. John Wiley & Sons. Retrieved from www.mdpi.com.