

GLOBALIZATION OF EDUCATION: VITAL APPROACHES IN STEM EDUCATION

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Summary

The article deals with the contemporary situation in education sphere in terms of globalization process, describing the key aspects of the globalization of education, as well as the main aspects of STEM implementation. The article highlights various technologies of STEM system that are widely used all over the world. Among the most common are augmented and virtual reality, artificial intelligence, internet of things and others. Much attention is paid to recourses needed for implementation of STEM into learning process. Online Courses, Educational Websites, Open-Source Platforms, STEM Education Kits, Maker Spaces and Fab Labs, STEM Competitions and Challenges as well as many others were viewed in the article.

The process of implementation of these resources and technologies was considered on the basis of “Smart Heat” educational project that can serve as a perfect example of successful combination of these approaches into educational process. It's worth noting that the selection of technologies and resources for STEM learning should align with the educational goals. They introduce practical knowledge and emphasize the importance of hands-on, experiential learning that promotes critical thinking, problem solving, and creativity.

Key words: STEM, technologies, resources, educational systems, educational projects.

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1. Introduction

In our contemporary interconnected world, the necessity and importance of globalization in education cannot be overestimated. As borders blur and cultures converge, it is imperative that education evolves to prepare students for a globalized society. Embracing globalization in education is a necessity in today's world. It prepares students to thrive in an interconnected, rapidly changing global society. By using new approaches to education sphere we are preparing students for a global workforce and high competition on the labour market and facing global challenges, we equip the next generation with the tools they need to make a positive impact on the world. Globalization in education is a powerful force for progress, tolerance, and prosperity.

Globalization in education includes various aspects that affect students, educational institutions, curricula and educational systems in general. Universities and secondary education institutions set themselves the goal of improving their positions in world rankings. This stimulates competition and leads to standardization of education on a global scale. Educational programs and teaching materials are becoming more adapted to the global context. One of such

projects is STEM (Science, Technology, Engineering, and Mathematics) approach to education (Nikitina, Ishchenko, 2023). It is widely represented in the modern world.

Therefore, the purpose of the article is to analyze new approaches in the context of globalization of education. In accordance with the goal, the following research objectives were identified:

1. determine the aspects of globalized education;
2. analyze technologies and resources for STEM system;
3. consider the technologies and resources mentioned in the hands-on example.

2. Aspects of globalized education

Globalization for education refers to the changes and transformations occurring in education systems due to increased global interconnectedness and interdependence. This process may encompass the following aspects:

International student and faculty mobility: Globalization of education entails a rise in the number of students and scholars moving across borders for education or research purposes.

International standards and learning criteria: With the growth of globalization, there is an increasing importance of harmonized international standards and criteria for assessing the quality of education.

Utilization of technology for educational access: Globalization of education also means broader access to educational resources and technologies on a global scale.

Multicultural environment in educational institutions: There is an increasing diversity of cultures, languages, and nationalities in educational institutions, providing broader opportunities for cross-cultural learning.

Global competition and choice of educational programs: With the development of the global education market, students have more opportunities to choose programs and institutions in different countries.

More relevant and adaptive curricula: The global nature of contemporary issues requires educational programs that can adapt to changing conditions in the global economy and society.

Increased international collaboration in scientific research: Globalization fosters more intensive collaboration between scientists and research groups in different countries.

These aspects of globalization influence the ways of educational institutions organization, their activities, principles and standards they apply, and the opportunities provided to their students and scholars for international knowledge exchange and experience-sharing.

3. STEM Technologies

The use of smart technologies to support STEM education radically changes the traditional teaching system, when a teacher at the blackboard explains new material to students, and they listen and complete assignments in a notebook. Intelligent technologies make it possible for students to interact interactively with educational materials, to get acquainted in practice, and not in theory, with the laws and phenomena that students study at school. They help develop not only hard, but also soft skills, which will help them find themselves in our rapidly changing world. However, when implementing smart education initiatives, it is necessary to take into account the preferences of students, learning style, level of training of both children and teachers, etc. and consider their potential limitations. Even within the same class, children of

the same age group have different learning preferences, and an intelligent educational tool must be tailored to these preferences.

Technologies provide the necessary equipment, information and environment for effective learning and skill development in these fields. These include laboratory equipment that allows students to conduct experiments and research in scientific and engineering fields, online resources and software that provide students with the necessary information and materials to learn theory and practical skills in these fields. Access to modern computers, software and technologies such as 3D printers and robotics plays an important role in skills development and research in STEM fields. The most important resource is the development of quality training programs and curricula and qualified teachers and instructors with expertise in their fields (Kapral I., Usova I., Maksymova A., Yefymenko T., Boyko S., 2023).

Here's a brief overview of new technologies that are widely accepted in STEM (Science, Technology, Engineering, and Mathematics) nowadays:

Augmented and Virtual Reality (AR/VR): These technologies immerse users in virtual environments, enhancing learning experiences by simulating real-world scenarios and experiments.

3D Printing: Enables the creation of physical objects from digital models, revolutionizing prototyping and hands-on learning in engineering and design.

Artificial Intelligence (AI) and Machine Learning: These technologies enable computers to perform tasks that typically require human intelligence, allowing for data analysis, pattern recognition, and problem-solving.

Internet of Things (IoT): Connects everyday objects to the internet, allowing for data collection and automation, leading to innovations in fields like smart homes and automation.

Blockchain: Provides secure and transparent record-keeping, with applications in secure transactions, data integrity, and cryptography.

Robotics: Involves the design, construction, and programming of robots, enabling automation in various industries and fields.

Genetic Engineering and Biotechnology: Includes technologies like CRISPR-Cas9, enabling precise manipulation of genetic material, with applications in medicine, agriculture, and beyond.

Nanotechnology: Focuses on manipulating materials at the atomic or molecular scale, leading to breakthroughs in materials science and electronics.

These technologies are driving innovation and reshaping the way STEM disciplines are taught and applied in various industries and research fields. They offer new opportunities for exploration, experimentation, and problem-solving in the realms of science, technology, engineering, and mathematics.

4. STEM Resources

Resources in STEM education also play a crucial role in building students' knowledge and skills, and in preparing them to meet current and future scientific and technological challenges.

Resources such as textbooks, online courses, labs, and software provide students with the necessary knowledge and tools to learn and practice STEM content. Educational institutions and classrooms need access to libraries, databases, laboratories and equipment to conduct research projects, and they need access to computers, software and electronic components. To support research and teaching projects, access to current scientific articles and publications is

required. The Internet provides vast online resources, including webinars, courses, video lectures, and educational platforms that facilitate access to knowledge and learning.

In addition, smart educational tools should complement the teacher, not replace him. The next aspect is choosing effective educational resources and tools to make STEM education smart. The resource should be easy to use and should not require a steep learning curve that may discourage both teachers and students from using it. In addition, it should be effective in terms of time management and not require a lot of effort to manage it. If a resource does not align with learning theories used in STEM education, it may not be effective in improving student learning outcomes. By doing this, we can use smart educational tools that effectively engage students and improve their learning outcomes.

Before adopting any resource, one should review the specific requirements, prerequisites, and age appropriateness of each resource or platform to ensure it meets your students' educational needs and goals. Let us have a close look at these resources.

Online Courses: Platforms like Coursera, edX, and Udemy offer a wide range of online courses related to "Smart-systems" and STEM topics. These courses cover subjects like robotics, AI, IoT, data science, and more, providing structured learning materials, video lectures, quizzes, and assignments.

EdX is the most sophisticated and academic platform for free distance education, a joint project of MIT (Massachusetts Institute of Technology), Harvard University and Berkeley University. Currently, several dozen leading universities in the world participate in the program (*edX, 2023*). The EdX teaching methodology is not much different from other projects: lectures, divided into modules lasting up to 10 minutes, alternate with exercises for better mastery of the material. If an incorrect answer is received, the program analyzes the error and makes recommendations for correcting it.

EdX has an analogue of Coursera specializations – Micromasters Programs. These are a series of graduate level courses. For example, there is a micro-master's degree from Columbia University in Artificial Intelligence that costs \$1,200 (4 courses at \$300 each), and a micro-master's in Android Application Development that costs \$1,000 (5 courses at \$200 each). However, all courses without obtaining a document can be taken for free.

Educational Websites: Websites such as Khan Academy, Code.org, and STEM Learning provide free educational resources, tutorials, and activities for STEM education. They offer lessons on coding, robotics, electronics, and other related topics, suitable for different age groups and skill levels.

"Khan Academy" is a non-profit lighting organization created in 2006 by educator Salman Khan to provide "high-quality education for anyone and everyone." (*Khan Academy, 2023*). The organization creates lectures in the form of YouTube videos. In addition to the microlecture, the organization's website provides practical activities and methodological materials for readers. All resources are available without cost to everyone in the whole world. Khan Academy provides an adaptive web system that generates tasks for students based on their skills (*Khan academy, 2023*).

Open-Source Platforms and Communities: Platforms like GitHub and Hackster.io provide access to open-source projects and resources for "Smart-systems." These platforms allow students and educators to explore and contribute to projects, access code repositories, and collaborate with a community of developers.

GitHub is an online platform for storing, managing and collaborating on open-source projects. It is a tool that has become an integral part of modern software development and is widely used in various fields, including science, business and the public sector. GitHub's main

focus is on code management, but the platform can also be used to store and collaborate on different types of files and documents. (*GitHub, 2023*). The platform promotes collaboration on projects.

Hackster.io (*Hackster.io, 2023*) is an online platform and community for Internet of Things (IoT), electronics and robotics enthusiasts. It is a place where developers, engineers and students can collaborate on projects, exchange knowledge and ideas, and find inspiration to create new technical solutions. There, users can ask questions, share experiences and find solutions for their projects, communicate with other developers and receive feedback from the community.

The platform provides educational materials, training courses and tutorials on various aspects of electronics, programming and IoT. Hackster.io organizes various technical competitions where participants can compete and showcase their projects. And most importantly for us, the platform supports interactive projects that can be implemented in educational programs and demonstration events to attract attention to engineering sciences and electronics.

STEM Education Kits: Various companies and organizations offer STEM education kits tailored to "Smart-systems" topics. Examples include Arduino kits, Raspberry Pi starter kits, robotics kits (e.g., LEGO Mindstorms), and IoT development kits. These kits often come with hardware components, sensors, and programming resources to support hands-on learning.

For example, the large 275-piece Makeblock STEAM Education Kit Robot Science offers a state-of-the-art open-source platform-based learning kit designed to teach programming with a STEM approach. UsingmBlock, a visual programming software, the kit is easy and convenient to use to introduce classroom work, practice, and create fun projects. The kit includes an assortment of sensors, electronic modules, mechanical components, 16 accompanying lessons (*Makeblock, 2023*).

Maker Spaces and Fab Labs: Maker spaces and fabrication laboratories (Fab Labs) provide physical spaces equipped with tools, machinery, and materials for hands-on learning and experimentation. They offer resources, workshops, and mentorship for students interested in "Smart-systems" and other STEM disciplines.

Makerspaces fit right into every school and educational setting and are often found in public libraries, where large empty spaces are ideal for engaging Makerspace participants in hands-on activities that teach twenty-first century skills. The emphasis at Makerspaces is on hands-on learning for students in STEAM subjects—science, technology, engineering, art, and math—as well as digital and information literacy (*Kyiv, 2023*).

The creation process on which the Makerspaces concept is built is a powerful tool for learning at all levels. Spaces for creation, creativity and production are considered one of the most important advances in innovative educational technologies, and are a tool for engaging students in higher-order creative problem solving through hands-on design, construction and iteration.

Fab lab (fabrication laboratory) is a small workshop that provides everyone with the opportunity to individually manufacture the products and parts they need. Such a laboratory usually has, in addition to hand tools and measuring instruments, modern CNC machines. At the same time, the task is to give a chance to make "almost everything" from "practically nothing" (*Fablab Kiev, 2023*).

Research Papers and Publications: Academic journals and publications in fields like robotics, AI, and IoT provide valuable research papers and articles that can be accessed by educators and students. These works are a form of communication and dissemination of new research, discoveries and knowledge in these areas. Scientific articles and publications play a

key role in the dissemination of knowledge and scientific progress in STEM fields. They allow researchers to share their discoveries and evaluate and build scientific knowledge on the work of other scientists. Exploring these publications can deepen understanding and expose learners to cutting-edge research and developments in "Smart-systems."

Webinars and Conferences: Webinars and conferences in the STEM field are important vehicles for sharing knowledge, research and innovation ideas, and for training and professional development in the field. These events provide students with the opportunity to present their research and projects and also teach presentation and science communication skills. Webinars and conferences focused on "Smart-systems" and STEM education offer opportunities to learn from experts, gain insights into emerging technologies, and network with professionals in the field. Organizations like IEEE (Institute of Electrical and Electronics Engineers) often organize webinars and conferences on related topics.

Online Forums and Communities: Engaging with online forums and communities can provide support, resources, and opportunities for discussion and collaboration. Platforms like Stack Overflow, Reddit, and specialized forums dedicated to "Smart-systems" topics allow students and educators to ask questions, share knowledge, and participate in discussions.

Platform Reddit (*Reddit, 2023*) is a site that combines the features of a social network and a forum where registered users can post links to any information they like on the Internet and discuss it. There are many subreddits on Reddit dedicated to various aspects of STEM. For example, r/science, r/technology, r/math and others.

Stack Overflow (*Stack Overflow, 2023*) is one of the most popular and influential online resources for programmers and developers. It is a question-and-answer platform where programmers can ask questions, get answers, discuss technical problems, and share programming and information technology knowledge.

STEM Competitions and Challenges: Participating in STEM competitions and challenges related to "Smart-systems" can be an engaging way to apply knowledge and skills. Competitions like FIRST Robotics Competition, Intel International Science and Engineering Fair, and Hackathons provide opportunities for students to showcase their abilities and problem-solving skills.

But there are also local festivals. Family STEM festival ROBOTICA is a festival of educational innovations and modern technologies in the field of education where its participants could share their work in the field of robotics, programming, and LEGO®-engineering (*ROBOTICA, 2023*). The festival included:

- robot competition;
- free master classes on programming and design;
- innovative technologies in the field of education;
- incredible scientific experiments;
- board games area and lots of fun with LEGO® for adults and children

Local Institutions and Organizations: Local universities, research institutions, and STEM-focused organizations often offer workshops, seminars, and outreach programs related to "Smart-systems" and STEM education. Exploring their resources and events can provide valuable learning opportunities and networking possibilities.

All of these resources promote quality education and training for students in STEM fields. It is important to provide access to a variety of resources to maintain and stimulate interest in science and technology subjects and develop the skills needed for a successful career in STEM. Remember to check the specific requirements, prerequisites, and age appropriateness of each resource or platform to ensure it aligns with the educational needs and goals of the students.

5. STEM Resources Implementation

As STEM education has been a priority in many countries for several years let us take "Smart Heat" Project as an example.

Imagine, it is morning, it is still dark outside. The children entered the classroom, the lesson began. Indoor temperature is, for example, 24 °C. During the lesson, the temperature in the room may increase due to heat emissions from the students who are there, from changes in the intensity of solar radiation. Taking into account the conditions of natural insolation and infiltration in the classroom, schoolchildren, using teaching systems should

- create a model for gradually reducing the level of artificial lighting in the classroom.
- then, by regulating the heating devices, reduce the amount of circulating coolant, thereby lowering the temperature in the classroom to the optimum. Moreover, it is also taken into account that the heating system is quite inertial and a predictive calculation is required for the entire period of the lesson.

The project itself included the following sections:

1. Modernization of the heating system:

- arrangement of the weather regulation system;
- installation of microclimate control sensors in rooms, controlled thermodynamic heads on heating devices; balancing valves and metering devices could also be installed on heating risers;
- development and implementation of "Smart Heat" software in an educational institution.

2. Creation of the "Smart Heat" system. These sections

- provide for the development of software that would allow receiving data from embedded systems, visualizing the operation of these systems (levels of consumption, illumination, temperature, pressure, etc.);
- ensure the management of the operation of these systems;
- give students a tool that allows them to further participate in filling the information system with data, working with information flows, developing models and algorithms for operating the institution's power supply systems.

The next step is the presentation of the work. The best way to do this is by publishing its results on a special forum. Participation in a conference on STEM education can completely change the algorithm for completing the project, because conferences offer a great opportunity to meet and network with other professionals in the field. Students can learn about other experiences, share their own, and make valuable connections that can lead to collaborations and partnerships (*STEM Education Conferences: Top 5 To Attend In 2023*). Conferences provide a platform for young researchers to expand their knowledge, provide an opportunity to go beyond the daily routine and explore new perspectives and ideas.

6. Conclusions

The globalization of education is a complex and multifaceted process that involves the exchange of knowledge, skills, and ideas across borders. It opens up a world of possibilities for students. By incorporating new technologies and resources such as robotics, IoT, AI, data analytics, and other related technologies into contemporary methods of teaching students can be engaged in hands-on, experiential learning that bridges the gap between theory and real-world applications and therefore make it easier to compete in labour market all over the world.

Students can also gain practical skills, develop critical thinking and problem-solving abilities, and cultivate a deep understanding of STEM concepts. They learn to work collaboratively, leveraging interdisciplinary knowledge and applying it to design and implement innovative solutions. With access to online courses, educational websites, maker spaces, competitions, and other resources, educators can provide students with rich learning experiences that ignite their curiosity and passion for learning and the very process of learning and teaching may become amazing both for teachers and learners.

These technologies are driving innovation and reshaping the way STEM disciplines are taught and applied in various industries and research fields. They offer new opportunities for exploration, experimentation, and problem-solving in the realms of science, technology, engineering, and mathematics.

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