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Stem Education

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Annotation. The article considers STEM-education as an innovative ap-proach to learning, which combines science, technology, engineering and mathe-matics. The authors analyse the essence of STEM-education, its advantages and disadvantages, as well as offer practical recommendations for the implementation of STEM-approach in the educational process. It is emphasised that STEM-education contributes to the formation of critical thinking and creativity in stu-dents.

Keywords: STEM-education, science, technology, engineering, mathemat-ics, innovation, educational process, 21st century competences, project activities, interdisciplinary approach, practice-oriented learning.

INTRODUCTION

In today's world, which is characterised by the rapid development of sci-ence and technology, STEM education is becoming more and more in demand. STEM is an acronym that stands for Science, Technology, Engineering and Mathematics. STEM education is an educational approach that integrates these four disciplines into a single learning process aimed at developing students' com-petences necessary for successful self-realisation in the 21st century.

STEM education is not just the study of individual subjects, but, first and foremost, the formation of students' ability to apply the acquired knowledge in practice, solve real-life problems and create innovative products. The STEM ap-proach involves active participation of students in project activities, experimen-tation, research and solving practical problems. It blurs the boundaries between individual disciplines, allowing students to see the interconnection between them and apply their knowledge in an integrated way.

Unlike traditional education, where the emphasis is on memorising theoret-ical material, STEM education is oriented towards practical application of knowledge. Pupils do not just listen to lectures and solve problems from the textbook, but actively participate in research and project activities. They them-selves formulate problems, look for ways to solve them, conduct experiments, construct models and create their own products.

STEM education is not only about science and technology, it is also about developing soft skills such as critical thinking, creativity, communication and teamwork. While working on STEM projects, students learn to analyse infor-mation, identify problems, generate ideas, argue their point of view and com-municate effectively with each other.

STEM education is an investment in the future. It prepares students for life in a world where science and technology play a key role. People with STEM competences are in demand in the labour market and are able to contribute to the development of society.

MAIN PART

The essence of STEM education is that students acquire knowledge and de-velop skills not by passively absorbing information, but by actively participating in the learning process. The STEM approach involves an interdisciplinary ap-proach to learning, where students learn different subjects not in isolation, but in the context of solving specific problems and projects.

STEM education has a number of advantages that make it so attractive in today's educational landscape.

Developing critical thinking is one of the key outcomes of STEM educa-tion. Imagine a student who is not just memorising a formula, but trying to un-derstand how it works in practice, what factors influence the result and how con-ditions can be changed to achieve the best effect. This approach builds students' ability to analyse information, identify problems, formulate hypotheses and evaluate the results of their work. For example, when studying physics, students can not only solve problems from the textbook, but also design a model of a bridge and investigate how different factors (weight, material, construction) affect its strength.

Developing creativity is another important benefit of STEM education. STEM approach stimulates students' creative thinking, encourages them to search for non-standard solutions and realise their ideas. For example, as part of a biology project, students can not only study the structure of plants, but also create their own botanical garden, coming up with original ways of placing plants and an automatic watering system.

Problem-solving skills - STEM education teaches students to apply what they have learnt in practice, solve real-world problems and create innovative products. For example, when studying maths, students can not only solve prob-lems, but also develop a mathematical model to predict the weather in their re-gion.

Developing teamwork skills - working on STEM projects often involves collaboration with other students, which fosters teamwork, communication and collaboration skills. For example, when creating a robot for a competition, stu-dents assign roles in a team (programmer, structural engineer, designer) and work together to achieve a common goal.

Increased motivation to learn - STEM education tends to make students in-terested and motivated to learn because they see the practical relevance of their work and are given the opportunity to choose their own topic and direction. For example, a student with a passion for space can propose a project topic to create a model of the solar system or explore life on other planets.

Despite its many advantages, STEM education, like any other educational approach, also has some disadvantages.

Demanding resources is one of the most significant challenges. Organising STEM education requires not only modern equipment such as 3D printers, ro-botics kits, science experiment kits, but also quality materials such as various constructors, electronic components, consumables for laboratory work. In addi-tion, STEM education requires specially equipped facilities such as laboratories, workshops, STEM centres. For example, to implement a project to create a robot helper, it is necessary not only to buy a robotics kit, but also to provide students with a place where they can assemble and program their robot.

An equally important resource is qualified teaching staff. Teachers working in STEM education must not only have a deep knowledge of STEM disciplines, but also master modern pedagogical methods, such as the project method, re-search-based learning, and teamwork. They should be able to motivate students, organise their activities, advise and support them in the process of working on projects. For example, a physics teacher leading a STEM project to create a solar power plant should not only know the laws of physics well, but also be able to organise the work of students in assembling an electrical circuit, taking measure-ments and analysing the results obtained.

The complexity of assessing outcomes is another challenge facing STEM education. Evaluation of the results of STEM projects cannot always be ex-

pressed in concrete figures and indicators. It is important to evaluate not only the final product, but also the process of working on the project, the students' activi-ty, their ability to cooperate, solve problems and make decisions. For example, when evaluating a project to create a robot artist, it is important to consider not only how well the robot draws, but also how students designed and programmed it, what technical decisions they made, and how they solved problems.

The need for careful planning - successful implementation of STEM educa-tion requires careful planning and organisation of the learning process. It is nec-essary to think about project topics, identify necessary resources, develop an as-sessment system, and create a timeline. For example, before starting a STEM project to create a weather station, it is necessary to plan what data will be col-lected, what equipment is needed, how the results will be processed, and in what form the progress report will be presented. Without careful planning and organi-sation, STEM education can become a chaotic and inefficient process.

For successful implementation of STEM approach in the educational pro-cess it is necessary to follow several key principles. Integration of STEM disci-plines is not just studying separate subjects, but creating a single educational space where science, technology, engineering and mathematics intertwine and complement each other. For example, when studying the topic "Solar System", pupils can not only study the physical laws of planetary motion, but also create a model of the solar system using a LEGO constructor, programme its motion using the Scratch language and calculate spacecraft flight trajectories using math-ematical formulas.

Practice-oriented learning is learning by solving real-life problems and cre-ating innovative products. Pupils do not just acquire knowledge, but learn to ap-ply it in practice, solve specific problems and create their own projects. For ex-ample, pupils can develop a project for a smart house that automatically regu-lates lighting and temperature depending on the time of day and weather condi-tions, or create a prototype of a robot that can collect rubbish on city streets.

Active student participation means involving students in the learning pro-cess, giving them the opportunity to plan their own activities, make decisions and take responsibility for the result of their work. Pupils should be not just lis-teners, but active researchers, experimenters and creators. For example, pupils can independently choose the topic of a STEM project, develop a plan for its im-plementation, find the necessary information, conduct experiments and present the results of their work.

Collaboration and co-operation is about developing students' teamwork skills, the ability to negotiate, listen to each other and make joint decisions. Working on STEM projects often involves collaboration with other students, teachers, parents, and even specialists from different fields. For example, when creating a school robotics project, students may divide into groups, each respon-sible for a different area of work: design, programming, construction, and testing.

Reflection and evaluation is about students analysing their work, assessing what they have achieved and identifying areas for growth. At each stage of a STEM project, students should have opportunities to reflect on and evaluate their performance. They can analyse what they did well and what they could have done better, and make adjustments to their work.

Reflection in STEM education is not just the final stage of a project, but an important part of the whole learning process. It helps students realise what they have learned, what skills they have developed and how they can apply this knowledge in the future.

Here are some examples of how reflection can be organised in STEM pro-jects:

Keeping a project diary: students can record their thoughts, ideas, observa-tions and conclusions throughout the project.

Regular meetings with the teacher: the teacher may have individual or group meetings with students to discuss their progress, answer questions and provide guidance.

Project presentation: presenting a project in front of an audience is a great opportunity for students to share their achievements, talk about the difficulties they have encountered and get feedback from others.

Self- and peer-evaluation: students can evaluate their own work and that of their classmates using criteria developed with the teacher.

Evaluation in STEM education also has its own peculiarities. It should be not only quantitative but also qualitative, taking into account not only the result but also the process of working on the project.

Examples of evaluation criteria for STEM projects:

Relevance of the project to the goals and objectives.

Quality and originality of the solution.

Utilising STEM knowledge and skills.

Ability to work in a team and communicate.

Quality of presentation and defence of the project

It is important to note that reflection and assessment in STEM education is not only a way to control knowledge, but also a tool for students' development. They help them to become more independent, responsible and critical thinkers.

STEM education can be organised in different ways. For example, students can be given ready-made STEM project topics or they can choose their own re-search direction. Projects can be individual or group, short-term or long-term. The forms and methods of work on a STEM project can be very diverse: it can be research, experimentation, design, programming, modelling, etc.

It is important to note that STEM education is not a universal method of learning and cannot replace traditional forms of learning. However, it can be an effective complement to them, allowing students to gain experience of independ-ent activity, develop key competences and increase motivation for learning. STEM education is not just a set of disciplines, but a philosophy of education that prepares students for life in a world of high technology and innovation.

CONCLUSION

STEM education is a modern educational approach that plays an im-portant role in preparing students for life in the 21st century. It contributes to the formation of students' critical thinking, creativity, problem-solving skills and ability to adapt to the rapidly changing conditions of the modern world. To suc-cessfully implement STEM education, a number of principles must be observed and the necessary conditions must be created. STEM-education can become an effective tool for improving the quality of education and preparing students for successful self-realisation in the modern world.

In today's world, where technology advances at an incredible rate and knowledge becomes obsolete literally before our eyes, STEM education is becom-ing not just desirable, but a prerequisite for a person's successful adaptation to life. This approach not only equips students with knowledge in science, technol-ogy, engineering and maths, but also gives them the skills they need to solve complex problems, generate ideas and create innovative products.

STEM education is not just the sum of knowledge in individual disciplines, but an integrated approach that allows you to see the connections between them and apply this knowledge in practice. Students who have received STEM educa-tion have a better understanding of how the world works, how different mecha-nisms

and systems work, and how new technologies and solutions can be creat-ed.

It is important to note that STEM-education is not only preparation for fu-ture professional activity. It is, first of all, personal development, formation of the ability to think critically, creatively and systematically. People who possess these skills are more successful in any sphere of activity, they adapt more easily to changes and are able to contribute to the development of society. STEM edu-cation is an investment in the future, in the future of our children and in the fu-ture of the country. It is a way to educate a generation of innovators, inventors and leaders capable of meeting global challenges and creating a better world.

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