

## FEATURES OF ORGANIZING STEAM EDUCATIONAL PROJECTS USING IMMERSIVE TECHNOLOGIES

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### ABSTRACT

**Formulation of the problem.** The rapid development of technologies in the modern world opens up new horizons for education. Integrating science, technology, engineering, arts, and mathematics (STEAM) holds particular significance as a transformative approach, fostering interdisciplinary learning and preparing students for the challenges of a knowledge-based and digitized society. The transition from a traditional approach to STEAM education becomes even more captivating with the incorporation of immersive technologies. This direction, merging technical and creative aspects, requires an innovative approach to the organization of educational projects, considering the new opportunities and challenges presented by virtual reality (VR), augmented reality (AR), and mixed reality (MR).

**Materials and methods.** To achieve the goal of our research, we used the following methods: systematic and comparative analysis of pedagogical, psychological, philosophical, and sociological works, methodic literature, and analysis of the pedagogical experience of using immersive technologies to organize STEAM projects at school; synthesis and generalization to formulate the main provisions of the study; interviews and questionnaires of teachers regarding their understanding and attitude to immersive technologies as a means of implementing STEAM projects at school; interpretation of research results. We analyzed 18 scientific sources, including 14 Scopus-indexed articles, two reports (the educational report from Horizon 2020 and the "State of the Industry Report" from the XR Association), and two scientific studies by Ukrainian researchers. Eighty-seven teachers participated in interviews and surveys conducted through Google Forms.

**Results.** Creating and organizing a STEAM educational project using immersive technologies involves the following teacher actions: forming a project name by the student's learning goals, educational content, and the project result as its product; creating a reference project; determining the subject, topic, age of students, project preparation time, learning time, essential immersive technologies; forming the purpose of the first lesson and project tasks to immerse and motivate students about the project; identifying problematic issues that should reflect the actual context or problem. We have characterized teachers' attitudes towards immersive technologies when organizing and conducting such projects. Based on the study's results, we have identified the features of organizing STEAM projects using immersive technologies: expanding the field of creativity with AR and VR, immersion in scientific concepts and conducting experiments through the use of virtual laboratories, visualizing abstract ideas through the use of augmented reality, interacting with technology through mixed reality projects, and teamwork in immersive environments.

**Conclusions.** Immersive technologies in STEAM education have advantages (e.g., gaining practical experience, forming interdisciplinary connections through interdisciplinary learning, cooperation, communication, adaptive environment, and request for creativity) in teaching.

**KEYWORDS:** *immersive technologies; virtual reality; augmented reality; mixed reality; STEAM educational project; general education institution.*

Для цитування:	Soroko N. Features of organizing steam educational projects using immersive technologies. <i>Фізико-математична освіта</i> , 2024. Том 39. № 2. С. 51-59. DOI: 10.31110/fmo2024.v39i2-07
For citation:	Soroko, N. (2024). Features of organizing steam educational projects using immersive technologies. <i>Фізико-математична освіта</i> , 39(2), 51-59. <a href="https://doi.org/10.31110/fmo2024.v39i2-07">https://doi.org/10.31110/fmo2024.v39i2-07</a>
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## ОСОБЛИВОСТІ ОРГАНІЗАЦІЇ НАВЧАЛЬНИХ STEAM-ПРОЄКТІВ ІЗ ВИКОРИСТАННЯМ ІМЕРСИВНИХ ТЕХНОЛОГІЙ

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### АНОТАЦІЯ

**Формулювання проблеми.** Стрімкий розвиток технологій у сучасному світі відкриває нові горизонти для освіти. Особливого значення при цьому набуває поєднання науки, технологій, інженерії, мистецтва та математики (STEAM) як трансформаційного підходу, який сприяє міждисциплінарному навчанню та готує учнів до викликів суспільства знань та цифровізації всіх сфер діяльності людини. Перехід від традиційного підходу до STEAM-освіти стає ще більш захопливим завдяки використанню імерсивних технологій. Цей напрямок, що об'єднує технічні та творчі аспекти, вимагає інноваційного підходу до організації освітніх проєктів, який враховує нові можливості та виклики, що створюють віртуальна реальність (VR), розширена реальність (AR) та змішана реальність (MR).

**Матеріали і методи.** Для досягнення мети нашого дослідження ми використовували наступні методи: системний і порівняльний аналіз педагогічних, психологічних, філософських, соціологічних праць, методичної та спеціальної літератури; аналіз педагогічного досвіду використання імерсивних технологій для організації STEAM-проєктів у школі; синтез та узагальнення для формулювання основних положень дослідження; інтерв'ю та анкетування вчителів щодо розуміння та ставлення до імерсивних технологій як засобу реалізації STEAM-проєктів у школі; інтерпретація результатів дослідження. Було проаналізовано 18 наукових джерел, з яких: 14 статей, що індексуються Scopus, 2 звіти (освітній звіт Горизонта 2020 та «Звіт про стан галузі» компанії XR Association) та 2 наукових дослідження науковців України. У інтерв'ю та анкетуванні, що проводилося за допомогою Google Form, взяло участь 87 вчителів.

**Результати.** Створення та організація освітнього проєкту STEAM з використанням імерсивних технологій передбачає такі дії вчителя: формування назви проєкту відповідно до цілей навчання учня, змісту освіти та результату проєкту як його продукту; створення реферативного проєкту; визначення предмета, теми, віку учнів, часу підготовки проєкту, часу навчання, основних імерсивних технологій; формування мети першого уроку та завдань проєкту для занурення та мотивації учнів щодо проєкту; визначення проблемних питань, які мають відображати реальний контекст або проблему, а також стимулювати дослідження та вирішення проблем учнями завдяки їхнім знанням у сферах STEAM та використанню імерсивних технологій; опис діяльності учнів у проєкті; планування презентацій проєктних продуктів учнями. Нами охарактеризовано ставлення вчителів до імерсивних технологій при організації та проведенні таких проєктів. За результатами дослідження ми виділили особливості організації STEAM-проєктів з використанням імерсивних технологій: розширення поля творчості за допомогою AR та VR, занурення в наукові концепції та проведення експериментів завдяки використанню віртуальних лабораторій, візуалізація абстрактних концепцій через застосування доповненої реальності, взаємодія з технологіями через проєкти із використанням змішаної реальності, командна робота в імерсивних середовищах.

**Висновки.** Використання імерсивних технологій у STEAM-освіті має переваги (набуття практичного досвіду, формування міждисциплінарних зв'язків завдяки міждисциплінарному навчанню, співпраця і комунікація, адаптивне середовище, запит на креативність тощо), які забезпечують цілісний та ефективний підхід до навчання.

**КЛЮЧОВІ СЛОВА:** імерсивні технології; віртуальна реальність; доповнена реальність; розширена реальність; навчальний STEAM-проєкт; заклад загальної освіти.

### INTRODUCTION

In the dynamic education' development the fusion of Science, Technology, Engineering, Arts, and Mathematics (STEAM) has emerged as a transformative approach, fostering interdisciplinary learning and preparing students for the challenges of a rapidly evolving world. The rapid development of technologies in the modern world opens up new opportunities for education and training. The transition from a traditional approach to STEAM education is now even more exciting, thanks to the use of immersive technologies (Soroko, 2020; 2021). This direction, combining technical and creative aspects, requires an innovative approach to the organization of educational projects that takes into account the new opportunities and challenges created by extended reality (XR), also known as cross reality (CR), which includes augmented reality (AR), virtual reality (VR), mixed reality (MR), and any other reality that might emerge (Meccawy, 2022).

The XR Association (XRA) and the International Society for Technology in Education (ISTE) found that 77% of teachers believe immersive technologies ignite curiosity and improve engagement in class (XR association releases "State of the industry report", 2023).

The survey by XR Association (XRA) and the International Society for Technology in Education (ISTE) presented this conclusion based on a poll of over 1,400 high school teachers across 50 US states, namely

XR experiences would be beneficial for students: Earth sciences (94%), Physics and space science (91%), Math (89%), English language (86%), World languages (87%), History and social studies (90%), Social sciences (91%), Computer science (91%), Visual and performing arts (91%), Physical education (88%), Career and technical education (91%).

By exploring the synergy between these cutting-edge tools and various STEAM fields, we unlock the potential to reimagine the educational experience, fostering student creativity, critical thinking, and teacher technological mastery.

## THEORETICAL BACKGROUNDS

The STEAM education concept has many features such as interdisciplinary, contextual, multidimensional, artistic, design, collaborative, experiential, and technical, and its teaching methods are diverse. As STEAM is a unique teaching concept, several excellent teaching methods can be used for its instruction. Researchers highlight project-based learning (PBL), discovery-based learning, cooperative teaching methods, inquiry-based learning, and problem-based learning (Usman et al., 2022; Almulla et al., 2020; Morze et al., 2020, Makransky et al., 2023; Del Moral Pérez et al., 2023).

While methods specified by scientists may share some common elements, they have their distinct features and differ in their approach to organizing and conducting educational activities, namely, some key differences:

– *Focusing on the process of knowledge discovery vs. creating a product:*

Discovery learning: the primary emphasis in discovery learning is on the process of self-discovery and assimilation of knowledge, and students may engage in exploration, experimentation, and uncovering new facts, with the product or result not always being the focus.

PBL: PBL centers around the creation of a specific product or project by students, and this product can include research, presentations, artifact creation, or solving a particular problem.

Cooperative teaching method: focuses on collaborative work and group interaction.

Inquiry-based learning: centers on stimulating questions and solving tasks through investigation.

Problem-based learning: concentrates on solving real-world problems through collaboration and analysis.

– *Teacher's role and student autonomy:*

Discovery Learning: Discovery learning assumes greater student autonomy in the research process. The teacher acts as a facilitator, creating conditions for discovery but not always directing the outcome.

PBL: In PBL, the teacher may have more input in defining project parameters and goals, providing specific tasks, and assessing the final product. However, there can still be an element of student autonomy, especially in choosing the approach to project implementation.

Cooperative Teaching Method: The teacher facilitates group dynamics, ensuring equal participation and effective communication.

Inquiry-Based Learning: The teacher guides the inquiry process, helps formulate questions, and provides support in task resolution.

Problem-Based Learning: The teacher facilitates problem identification, guides the process, and assesses the application of knowledge to real-world scenarios.

– *Form of assessment:*

Discovery Learning: Assessment in discovery learning may be more focused on the learning process, development of critical thinking, and student independence.

PBL: Assessment in project-based learning often emphasizes the results and the quality of the product students create. Evaluation may also consider the process and student involvement in project implementation.

Cooperative Teaching Method: Assessment may consider the quality of collaboration, communication, and group interaction.

Inquiry-Based Learning: Assessment is oriented toward the inquiry process and students' ability to formulate and answer questions.

Problem-Based Learning: Assessment focuses on the outcome, which manifests in real-world applications, and may evaluate the group's ability to collaborate and think critically.

– *Approaches to Knowledge Acquisition:*

Discovery Learning: More oriented towards personal investigation and the discovery of new knowledge. Students may formulate questions and seek answers independently.

PBL: While it may include elements of knowledge acquisition, project-based learning places a greater focus on the specific project, allowing students to apply and implement acquired knowledge.

Although these approaches may intertwine, incorporating some elements of one method into the other, they have unique characteristics and values in education.

Cooperative Teaching Method: Involves collective efforts to solve tasks or projects where students interact and share knowledge.

Inquiry-Based Learning: Encourages students to actively ask questions, conduct research, and arrive at conclusions through their exploration.

Problem-Based Learning: Oriented toward solving real problems and applying knowledge to specific scenarios.

These methods differ in their approaches and emphases, but each is characterized by active student participation, fostering autonomy, and developing critical thinking. The choice of a method may depend on educational goals, content, and desired learning outcomes.

Scientists especially note the method of an educational project for the implementation of STEAM education.

PBL is a student-centered approach that focuses on students actively engaging in real-world, projects to gain knowledge and develop skills. PBL emphasizes hands-on, experiential learning, rather than passive learning through lectures. In a PBL students work on a project over an extended period, during which they explore and investigate a specific topic or problem resulting in a product that is presented publicly (Kuhail et al., 2022; Almulla, 2020).

STEAM (science, technology, engineering, art, mathematics) projects are interdisciplinary offerings that promote learning resulting from the convergence of content from different fields and emphasize the role of the arts in the pedagogical competencies involved in the development of immersive literary environments: a combination of STEAM projects and creators' cultures (Del Moral Pérez et al., 2023). The STEAM methodology is aimed at developing critical and creative thinking, problem-

solving, and the application of various skills (Celis & González, 2021). This type of project is becoming widespread in various fields, from the school (Polihun et al., 2019; Hawari & Noor, 2020; Martins et al., 2021; Mohd, 2020) to the university (Carter et al., 2021; Thompson, 2021), preferring to study in additional fields.

Scientists (Polihun et al., 2019) note that the process of organizing STEAM projects is influenced by a significant number of factors (such as integrated disciplines, the qualifications of project leaders, the age category of students, personal qualities of participants, natural, technical, material opportunities, project implementation timelines, etc.). In light of this, it can be stated that each project will be unique since different resources are utilized during its implementation to achieve the same goal. In the organization and implementation of STEAM projects, it is necessary to adhere to a sequence of actions and focus on the main types of educational activities and technologies.

The use of immersive technologies to build an educational environment within the implementation of STEAM educational projects can provide new ideas for the design of STEAM educational resources (Brown et al., 2020; Fombona, 2020; Çebi, Reisoğlu, 2020; Del Moral Pérez et al., 2023).

**The purpose of the article is** to analyze the use of the features and benefits of organizing STEAM educational projects using immersive technologies.

## RESEARCH METHODOLOGY

To achieve the goal of our research, we used the following methods: systematic and comparative analysis of pedagogical, psychological, philosophical, and sociological works, methodical and special literature; analysis of the pedagogical experience of using immersive technologies to organize STEAM projects at school; synthesis and generalization to formulate the main provisions of the study; interviews and questionnaires of teachers regarding their understanding and attitude to immersive technologies as a means of implementing STEAM projects at school; interpretation of research results. We analyzed 18 scientific sources, including 14 Scopus-indexed articles, 2 reports (the educational report from Horizon 2020 and the "State of the Industry Report" from the XR Association), and 2 scientific studies by Ukrainian researchers. In interviews and surveys conducted through Google Forms, 87 teachers participated.

## RESULTS OF RESEARCH

Systematic and comparative analysis of pedagogical, psychological, philosophical, and sociological works, methodical, and special literature allowed us to single out the main positions regarding the organization of the STEAM project with immersive technologies (Fig. 1).

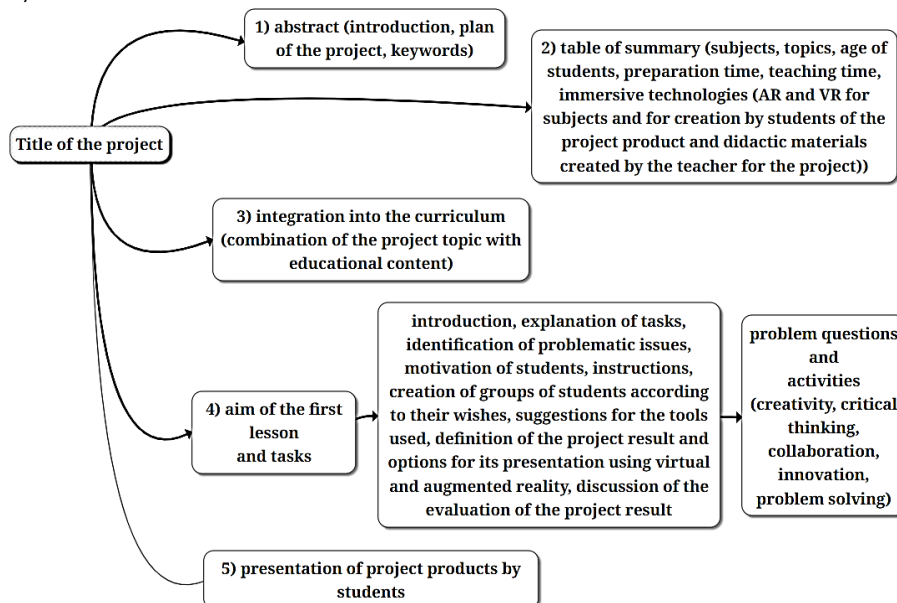


Fig. 1. The Project creation and organization plan

Source: Own work.

The project creation and organization plan include the following teacher's actions:

- formation of the project's title by the goals of student learning, topics of other educational subjects, and the planned product of the project;
- create an abstract of the project so the teachers understand the main problem and the purpose of its implementation, consisting of the following parts: introduction, plan of the project, keywords;
- write a table of summary (subjects, topics, age of students, preparation time, teaching time, immersive technologies (AR and VR for conducting research and experiments within specific academic subjects and creation presentation of project products by students, for the project product and didactic materials created by the teacher));
- check and think about integrating the project plan into the curriculum (combination of the project topic with educational content);
- formation the aim of the first lesson and tasks of the project, and is to introduce and create the school class project group with the role of coordinating and monitoring all actions planned for the students (introduction, explanation of tasks,

identification of problematic issues, motivation of students, instructions, creation of groups of students according to their wishes, suggestions for the tools used, definition of the project result and options for its presentation using virtual and augmented reality, discussion of the evaluation of the project result);

- think about problem questions and their formation (a problem question should reflect a real-world context or problem and should stimulate research and problem solving from multiple fields of knowledge);
- describe the students' activities in the project (student activities in the project should cover creativity, critical thinking, collaboration, innovation, problem-solving, communication, productivity);
- planning presentations of project products by students.

We pay particular attention to the culmination of a STEAM project as a presentation where students showcase their work and communicate the outcomes of their collaborative efforts. This presentation phase is crucial as it not only demonstrates the students' grasp of the subject matter but also hones their communication, presentation, and digital skills.

Here's a breakdown of the key aspects involved in the presentation of project products.

Students should:

- showcase prototypes, designs, or models created during the project;
- present the results of practical experiments and data analysis;
- share insights gained from experiments and observations;
- highlight the use of virtual and augmented reality in problem-solving, as well as in creating the project presentation;
- demonstrate any coding, software development, or technological solutions;
- discuss the role of technology in achieving project goals;
- demonstrate the integration of art and creativity, showcasing any artistic elements incorporated into the project and explaining how artistic choices enhance the overall project;
- identify the individual contributions of each participant and discuss team dynamics, sharing how effective collaboration led to project achievements;
- address any problems encountered during the project, highlighting approaches to problem-solving and adaptation;
- share thoughts on how the project could be expanded or applied in the future.

Essentially, the presentation of project products in the context of STEAM is an opportunity for students not only to showcase their technical skills but also to refine their ability to effectively communicate complex ideas to a diverse audience.

We offered the tools to the teachers, among which they had to choose the ones they don't know, the ones they used, and the ones they used when conducting STEAM projects (Table 1). In the survey conducted through Google Forms, 87 teachers participated.

**Table 1. The results of teachers' answers**

VR/AR	I don't know this tool (%) /number of respondents	I use this tool (%) /number of respondents	I used this tool when conducting STEAM projects (%) /number of respondents	I know this tool but don't use (%) /number of respondents	Comments and suggestions
Unity/VR	36,8%/32	32%/28	17%/15	37%/27	Unity is a powerful engine for developing games and applications in virtual reality
Google Expeditions/VR	-	67%/59	39%/34	32%/28	
Google VR SDK	16%/14	68%/60	55%/48	15%/13	
ARCore (for Android) and ARKit (for iOS)	36,8%/ 32	32%/28	17%/15	37%/27	
Vuforia/AR	36,8%/ 32	32%/28	17%/15	37%/27	This resource is charged
Zappar/AR	36,8%/ 32	-	-	63%/55	Zappar is a tool for creating AR notations and displaying interactive content via mobile devices
Cospaces Edu/VR	-	36,8%/ 32	30%/26	63%/55	Cospaces Edu is a web platform that allows teachers and students to create virtual worlds and interactive VR lessons without programming
AltspaceVR	16%/14	27%/24	9%/8	56%/49	
Metaverse Studio/AR	21%/18	79%/69	61%/53	-	Metaverse Studio is a platform for creating AR applications and interactive games without programming
Blippar/ VR and AR	21%/18	79%/69	42%/37	-	

CoSpaces Edu Merge Cube/AR	-	65%/57	39%/34	34%/30	
Mozilla Hubs/VR and AR	54%/47	-	-	46%/40	
SketchUp/VR and AR	36,8%/ 32	32%/28	17%/15	37%/27	
EasyAR	13,8%/12	25%/22	11%/10	61%/53	
Spark AR	13,8%/12	-	-	86%/75	The function of the tool is to create masks for Instagram
Other					100%/87 teachers who participated use AR and VR for conducting research and experiments within specific academic subjects

Source: Own work.

Educators exhibit diverse levels of familiarity and usage across VR and AR tools. While some tools, like Google Expeditions, enjoy high usage, others, such as Mozilla Hubs, show lower usage percentages.

In Table 1, the survey results from teachers are presented. Below, we provide a more detailed analysis of the data.

This analysis provides an overview of the familiarity, usage, and feedback for various VR and AR tools among the respondents. It indicates the popularity and specific applications of each tool in the context of STEAM projects.

The prevalence of "I don't know this tool" responses suggests a need for targeted training programs and awareness initiatives (Unity/VR, Vuforia/AR, Zappar/AR, ARCore (for Android) and ARKit (for iOS), Cospaces Edu/VR, SketchUp/VR and AR – 36.8% (32 respondents); Google VR SDK – 16% (14 respondents); Metaverse Studio/AR, Blippar/VR and AR – 21% (18 respondents); EasyAR, Spark AR – 13.8% (12 respondents)). Educators may benefit from comprehensive training to enhance their proficiency with these immersive technologies.

The prevalence of "I used this tool when conducting STEAM projects" responses suggests that tools like Metaverse Studio, Google VR SDK, Blippar, Google Expeditions, CoSpaces Edu are popular choices for STEAM projects (Metaverse Studio/AR – 61% (53 respondents); Google VR SDK – 55% (48 respondents), Blippar/VR and AR – 42% (37 respondents); Google Expeditions/VR – 39% (34 respondents); CoSpaces Edu – 30% (26 respondents)). These tools offer a range of capabilities, from game development to creating virtual worlds, aligning with the interdisciplinary nature of STEAM education.

The mention of tools like Vuforia being charged raises questions about the financial accessibility of certain resources. Addressing these challenges could involve exploring alternatives or advocating for subsidized access to enhance widespread adoption.

Comments highlighting the interactive and engaging nature of tools like Zappar, CoSpaces Edu, and Metaverse Studio indicate a growing emphasis on immersive and interactive learning experiences in educational settings.

Educators are leveraging tools across both VR and AR domains, indicating a potential for cross-disciplinary projects. This interdisciplinary approach aligns with the holistic goals of STEAM education.

**DISCUSSION**

The analysis of scientific literature and teachers' pedagogical experience has allowed us to identify the features of organizing STEAM educational projects using immersive technologies, namely: expanding the field of creativity through AR and VR, immersion into scientific concepts and conduct experiments through virtual laboratories, visualization of abstract concepts through AR, interaction with technology through MR-projects, teamwork in immersive environments (Fig. 2).

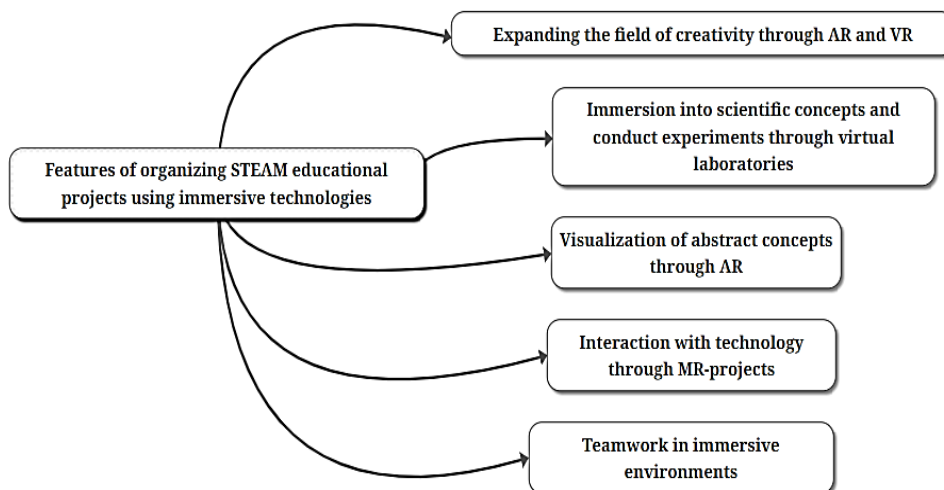


Fig. 2. Features of organizing STEAM educational projects using immersive technologies

Source: Own work.

We look at these features in more detail to demonstrate the unique capabilities of immersive technologies for project management.

#### 1. *Expanding the field of creativity through AR and VR.*

Augmented Reality and Virtual Reality serve as catalysts for expanding the boundaries of creativity within the STEAM framework. AR overlays digital information onto the physical world, seamlessly integrating computer-generated elements into real-life scenarios. This augmentation of reality provides students with an immersive and interactive platform, transforming mundane subjects into captivating experiences.

On the other hand, Virtual Reality creates entirely simulated environments, transporting students to realms beyond the confines of the classroom. In the context of STEAM, VR facilitates virtual experiments, architectural simulations, and artistic endeavors, fostering a hands-on learning approach that transcends conventional limitations.

Integrating AR and VR into STEAM educational projects opens up avenues for dynamic and multidimensional learning. For instance, students studying biology can engage with lifelike 3D models of cells through AR applications, gaining a deeper understanding of microscopic structures. In VR, budding engineers can virtually construct and test architectural designs, providing a practical dimension to theoretical concepts.

Moreover, AR and VR technologies facilitate collaborative projects, allowing students to work together in virtual spaces, irrespective of physical distances. This not only nurtures teamwork and communication skills but also prepares them for a future where remote collaboration is increasingly prevalent.

While the integration of AR and VR into STEAM education brings forth numerous opportunities, it also poses certain challenges. Schools need to invest in the necessary hardware and software, and educators must undergo training to effectively incorporate these technologies into their teaching methodologies.

In conclusion, the marriage of AR, VR, and STEAM education propels students into a realm of limitless possibilities, fostering creativity, critical thinking, and a profound understanding of complex concepts.

#### 2. *Immersion into scientific concepts and conduct experiments through virtual laboratories.*

The integration of virtual laboratories aligns seamlessly with STEM education principles. Educational institutions globally are adopting these virtual environments to complement traditional teaching methods, providing students with a comprehensive and dynamic learning experience.

Examples of VR and AR experiments:

- chemical reactions (for example, Crocodile Chemistry, Model Chem Lab, VirtualLab (VLab)): simulating various chemical reactions allows students to observe and understand reaction mechanisms and stoichiometry;
- physics simulations (for example, ROQED Physics Lab, Roqed Science): exploring concepts like motion, force, and energy through physics simulations aids students in visualizing abstract principles;
- biology Dissections (for example, Google's AR Microscope, ConfocalVR, HoloAnatomy): virtual dissections offer an ethical alternative, providing an in-depth exploration of anatomy and biological processes;
- environmental science (for example, Climate Change (<https://docubase.mit.edu/project/this-is-climate-change/>); Virtual iCool, ClassVR (<https://www.classvr.com/school-curriculum-content-subjects/virtual-reality-resources/>)): simulating environmental scenarios helps students grasp the impact of pollutants or climate change on ecosystems.

#### 3. *Visualization of abstract concepts through AR.*

AR enables the visualization of abstract and theoretical concepts that are challenging to represent through traditional methods. It transforms complex ideas into interactive and visually stimulating experiences.

AR enables students to interact with abstract ideas in a three-dimensional, immersive environment. For instance, intricate mathematical equations or complex scientific theories can be visualized in a way that transcends traditional two-dimensional representations (for example, GeoGebraAR/VR).

AR allows for dynamic visualization of data, turning static information into interactive and evolving displays. Abstract concepts, such as historical timelines or geological processes, can be animated and manipulated in real time. This dynamic aspect of AR enhances comprehension and retention by offering a more engaging learning experience. Students can interact with abstract content at their own pace, exploring different facets of a concept until they achieve a comprehensive understanding. This adaptability ensures that education becomes more inclusive and accessible to a broader range of learners.

#### 4. *Interaction with technology through MR projects.*

MR projects redefine learning experiences by immersing users in interactive environments. Complex concepts come to life as users engage with digital overlays in real-world contexts. This immersive quality enhances understanding and retention, making education more engaging and impactful.

A distinctive strength of MR lies in its ability to simulate real-world scenarios. Whether in education, healthcare, or industry, MR projects provide users with hands-on experiences, allowing them to interact with virtual representations as if they were physically present. This simulation aspect enhances practical skill development and problem-solving.

MR technology facilitates personalized and adaptive learning experiences. Tailoring content to individual preferences and learning styles ensures a customized educational journey. The adaptability of MR projects enhances the effectiveness of the learning process, accommodating diverse needs.

#### 5. *Teamwork in immersive environments*

Immersive teamwork provides an opportunity for skill development within a collaborative context. Team members can hone their communication, leadership, and adaptability skills in a virtual setting, preparing them for real-world scenarios where these skills are paramount.

The immersive and interactive nature of these environments contributes to increased engagement and motivation among team members. The sense of presence and shared experiences fosters a positive team dynamic, driving members to actively contribute to common goals.

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**CONCLUSIONS AND PERSPECTIVES FOR FURTHER RESEARCH**


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Through a comprehensive examination of the data and insights presented, it becomes evident that leveraging immersive technologies in STEAM education offers a myriad of advantages. Incorporating immersive technologies into STEAM education projects opens a world of possibilities for educators and students alike. The hands-on experiences, interdisciplinary learning, global collaboration, adaptive environments, enhanced creativity, and real-world applications contribute to a holistic and effective approach to education. As technology continues to advance, the integration of immersive technologies in STEAM education will play a pivotal role in preparing the next generation for the challenges of the future.

We singled out the following features of the organization of STEAM educational projects using immersive technologies, such as: expanding the field of creativity with the help of AR and VR, immersion in scientific concepts and conducting experiments through virtual laboratories, visualization of abstract concepts through AR, interaction with technologies through MR-projects, teamwork in immersive environments.

We found out that the plan for the creation and organization of the STEAM educational project involves the following actions of the teacher: formation of the name of the project by the goals of student learning, educational content, and the result of the project as its product; creating an abstract project; determination of the subject, topics, age of students, time of preparation, time of the study, immersive technologies; formation of the goal of the first lesson and the tasks of the project for the students' immersion and motivation regarding the project; defining problematic questions that should reflect a real context or problem, as well as stimulate research and problem solving by students thanks to their knowledge of STEAM fields and the use of immersive technologies; description of students' activities in the project; planning presentations of project products by students.

STEAM projects using immersive technologies often mirror real-world scenarios, providing students with a glimpse into the practical applications of their knowledge. Whether it's simulating a scientific experiment, designing a virtual city, or troubleshooting a technological system, students gain insights into how their STEAM skills translate to real-world challenges.

A perspective for further research is the development of courses for teachers to enhance their pedagogical practices in organizing and conducting educational STEAM projects using immersive technologies.

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*Text of the article was accepted by Editorial Team 20.02.2024*

