Strategies for Policy in Science and Education — *Volume 32, Number 5s, 2024* — *Стратегии на образователната и научната политика*

https://doi.org/10.53656/str2024-5s-16-app *Education in the Information Society*
Образованието в информационното общество

APPLICATION OF ZSPACE TECHNOLOGY IN THE DISCIPLINES OF THE STEM CYCLE

Boyana Ivanova, Assist. Prof.
Dr. Kamelia Shoilekova, Assoc. Prof.
Dr. Desislava Atanasova, Assoc. Prof.
Dr. Rumen Rusev, Assoc. Prof.
University of Ruse "Angel Kanchev"

Abstract. The innovative zSpace technology allows students to learn through holographic content and simulation experiments using Virtual and Augmented Reality (VR/AR). zSpace combines hardware, software, and learning content focused on various STEM disciplines. zSpace features a combination of VR/AR and 3D interactivity. The main advantages of the technology lie in three main aspects: the way of assimilation of knowledge, acceptance of information, and application in practice. The use of zSpace leads to some significant improvements in knowledge acquisition: it activates several sensory functions, resulting in higher levels of engaging learning experience; achieves a high level of realism, which guarantees the memorization and more effective learning of the learning content; motivates students; improves achievement in science, math, career, and technical education.

Keywords: VR; AR; STEM; technology; zSpace; education

1. Introduction

The field of Science, Technology, Engineering, and Mathematics (STEM) is constantly evolving, shaping our world and driving innovation in education. This approach provides significant advantages and benefits to the students and helps them adapt to the digital world. The STEM educational approach is an attractive and engaging way to deliver new knowledge and build practical skills in the students (Hristov et al. 2023). The advantage of this approach is that, on the one hand, it manages to motivate students to learn and expand their knowledge in each subject area, and on the other hand, it smoothly involves them in the "world" of the other disciplines of the STEM cycle, to increase them their skills and knowledge.

STEM education is a part of digitalization where one of the key concepts the engagement of students and learning experiences. This is implemented by creating interactive and immersive learning opportunities that foster collaboration, critical thinking, and problem-solving skills (Beloev et al. 2023).

The hands-on, interactive, and visualization-based learning experience that 3D technologies provide helps students take a more active approach to the academic material that they are studying (Voinohovska & Asenov 2023).

Virtual reality (VR) and Augmented reality (AR) are changing education via innovative teaching and learning methods. STEM education is transformed by VR/AR technology in three main aspects: the ability to visualize complex concepts in a more interactive and immersive manner; the opportunity for STEM education is a part of digitalization where one of the key concepts is the engagement of students in learning experiences. This is implemented by creating interactive and immersive learning opportunities that foster collaboration, critical thinking, and problem-solving skills (Beloev et al. 2023). The third aspect combines experiential learning and hands-on practice as well as personalized and adaptive learning experiences, catering to the individual needs and learning styles of students (Osadchyi et al. 2021).

zSpace technology brings STEM education to a new level. The stereoscopic laptop presents complicated concepts, principles, and models in 3D space.

In a systematic review from 2023, it is concluded that 3D and animated elements were widely used augmented components in Science, Technology, Engineering and Mathematics education (Hidayat & Wardat 2023)

zSpace uses simple and familiar interactions. Using zSpace feels real with natural gestures and movements that allow learners to manipulate objects in a 360-degree screen-breaking experience. With built-in tracking and a stylus held like a pen, learners naturally move their heads and rotate their wrists as they pick up, dissect, and interact with virtual objects. Engaging tactile learning with movement, testing, and trial and error in a non-traditional learning environment supports the retention and recall of information. zSpace delivers a stunning interactive experience by integrating the latest AR/VR technology with science, math, and career and technical education topics (zSpace technology 2024).

Figure 1. zSpace Inspire laptop

Some of the outstanding specifications of the zSpace Inspire laptop (Fig. 1) are the display which is Pantone® validated, the SpatialLabs 3D Stereoscopic module included, and the eye-tracking camera. The software packages of zSpace are divided into different levels of education. The current paper focuses on higher education, specifically the education of Transport technology (zSpace technical specifications 2024).

2. Methodology

STEM teaching is implemented in zSpace with several applications, which are listed in Table 1. The developed applications are in different scientific fields, mainly in medicine and sciences. The activities are theoretical and practical.

One of the most important concepts of STEM education is technology. The focus of the present work is on three software applications, delived by zSpace – the Electric Automotive Mechanic application, Vived Anatomy software for medicine field of science, Experiences software for physical science.

The first software allows students to practice assembling and disassembling an electric vehicle and its various systems in a virtual workshop where safety is guaranteed, and repair procedures can be repeated (Electric Automotive Mechanic by GTAFE 2024).

The second medicine software is practice-orientited, where students could make lab sessions and are capable of virtual dissections. The human body is fully dissectable and abelled for a better understanding (Vived Anatomy software 2024).

The third software is experiential-based simulations in Earth and Space Science, Life Science, Physical Science, and Mathematics (Experiences by zSpace 2024).

Table 1. zSpace STEM software applications

Application	Field of science
BioDigital Human zSpace	Anatomy
BlockCAD	Math and Computer science
Computer Science Essentials	Computer science
Experiences	Science and math
Foundations of Web and Game development	Computer Science
Franklin’s Lab A3	Electronics
ICT introduction to AI	Data science
Newton’s Park A3	Physics
ParaView	Data
Visible Body+	Medicine
Vived Anatomy	Anatomy
Vived Chemistry	Chemistry

Vived Science	Botany, Zoology, Earth science, Microbiology
Electric Automotive Mechanic	Transport
zSpace Physics	Physics

Fig. 2 shows the methodology for the implementation of zSpace in STEM cycle disciplines. It consists of five steps that define the main considerations for implementing zSpace. The first step is the topic of the lesson – which part of the software to include. The second and third steps are about the theoretical and practical activities respectively. The next step is to prepare a test or exam to check the students' knowledge. The last two steps are related to the evaluation of the methodology.

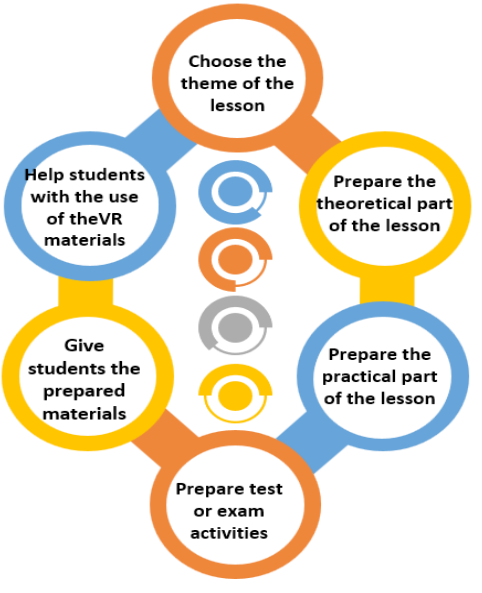

Figure 2. Methodology of developing zSpace materials

Implementation of the methodology in all levels of education

Electric Automotive Mechanic – Higher education

The Electric Automotive Mechanic application consists of theoretical and practical parts. The theoretical part is implemented in the Components section of the software. In the center is the vehicle model with a transparent shell. Its internal components include Powertrain, Power battery, High voltage cable, High voltage distribution box, Charging port, Motor controller, DC/DC, and Electric air conditioner compressor. When the ray is moved over a corresponding component, the hint label pops up, highlighting the selected component. Each of the components has subsections/submenus that explain the theory of the parts.

The topic of the lesson: Observation of the vehicle battery, one of the most important components of electric cars.

Theoretical part of the lesson: The modules that deal with the battery are the structure of the battery, the principles of the battery, the training to remove the battery and the training to install the battery (Fig. 3).

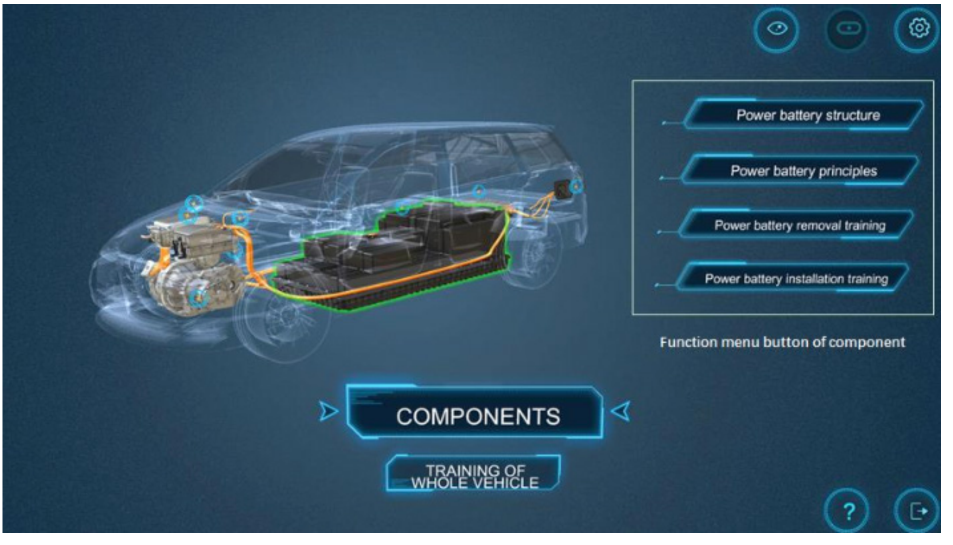

Figure 3. Power battery modules

Practical part of the lesson – The GTAFE Electric Automotive Mechanic software has a training module. For the needs of this lesson, the “High Voltage Safety and Handling Rules" part was chosen. There are five modules: Environmental Requirements, Safety Requirements, Precautions, Charging Training, and Energy Flow.

Exam activity – The software consists of one module for the exam. The student must enter their name and student ID to begin the exam. The results are based on the exam duration. Fig. 4 shows the flow of the exam.

Materials for students – all these modules are given to the students where the first part is related to the theory, the second for the practice, and the third is the exam.

Using the VR materials – after students start using the prepared materials, they may need help to operate the vehicle. This step of the proposed methodology can be improved if the students have too much difficulty with the software.

The study was conducted with students who used the zSpace technology during the course and with students who had traditional classes without the use of this technology. The results reported at the end of the experiment were that the students who used the zSpace technology were much more engaged in the learning process and the final results were significantly better. This in turn shows that the modern generation – the zGeneration – only understands the subject matter and actively participates in lessons if the learning objectives are taught using innovative approaches and with the help of a specific technology.

Vived Anatomy – High school

Topic of the lesson: Bone classification – human body has 206 bones that are classified as long, short, flat, sesamoid, or irregular.

Theoretical part of the lesson: Bones have different shapes that suit different functions within the body. The skeleton has many functions: it provides a structure for muscles to use to create levers, it protects internal organs, and it is an important storage location for calcium, phosphate, and the red blood cell-producing tissues of the body.

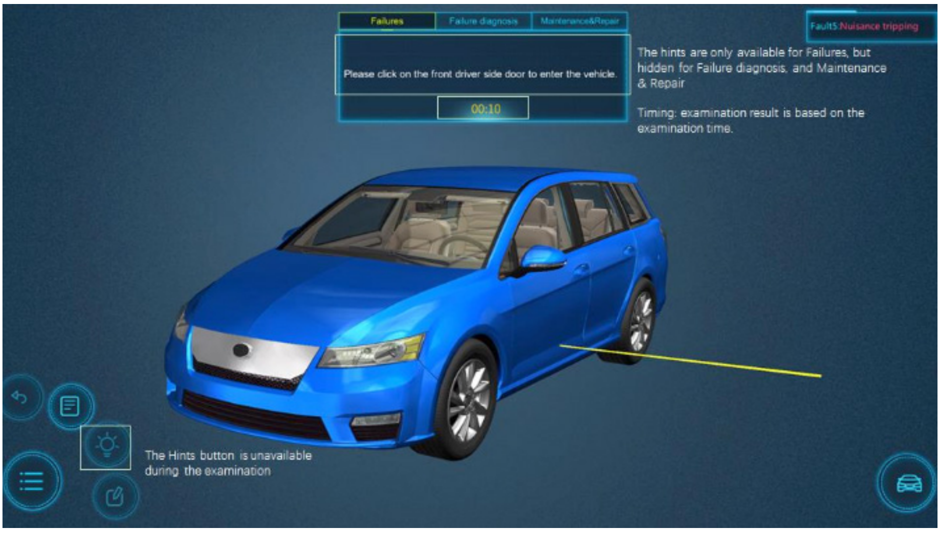

Figure 4. Exam process

Practical part of the lesson – students see the skeleton and can dissect each bone. Bones can be grouped into two broad categories. These are appendicular, meaning related to the appendages (arms and legs), and axial, which roughly translates to "line." The axial skeleton consists of the head, ribs, and vertebrae.

The appendicular skeleton consists of the arm and leg bones as well as the pectoral and pelvic girdles. The pectoral girdle is made of the shoulder blades (scapulas) and collarbones (clavicles). The pelvic girdle is made of the hip bones (each of which can be broken down into the ilium, pelvic bone, and ischium). In practice, students color each of the appendicular bones by clicking on the bone and then a color.

Using the possibilities offered by zSpace technology, you can check at the end of the lesson on the classification of bones to what extent the students can distinguish the individual bones by grouping them. After the first student has succeeded in grouping 10 of the bones of the human skeleton, the second student begins his work. He must first check whether his classmate's work is correct and, if not, explain why he thinks so. The work continues until all the bones have been classified. Then the teacher checks whether there is a deviation from the correct solution and puts it up. All this is a prerequisite for the students to be attentive during the lesson and to acquire knowledge to prove that they have understood the material not only to the teacher but also to their classmates.

Exam activity – the focus of the examination is to check if the students can recognize a bone and classify it. Students are asked to explain the bone's structure and match its function.

Fig. 5 shows the bones part of the activity in Vived Anatomy software.

The execution of the last two steps of the proposed methodology is the same as in the previous implementation. The lessons could be improved if there were difficulties in the use of the materials – it can be added more theory regarding the bones' structure, functions, and classes.

Experiences – elementary school

Topic of the lesson: What is energy and how it changes – students are going to understand how energy can be transferred by sound, light, heat, and electric currents.

Theoretical part of the lesson: explanation of the concept that sound, light, heat, and electric currents can transfer energy from place to place; 3D models are used to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move; models are used to describe that light reflecting from objects and entering the eye allows objects to be seen.

Fig. 6 shows how heat energy is moving from a warmer object to a cooler one. At an early age, students manage to understand the essence of the concept of thermal energy. Educators with an interest in physics, and more specifically in thermodynamics, are inspired by the technology because they can see how heat is transferred between different systems. This is a prerequisite for increasing children's interest in the world of physics.

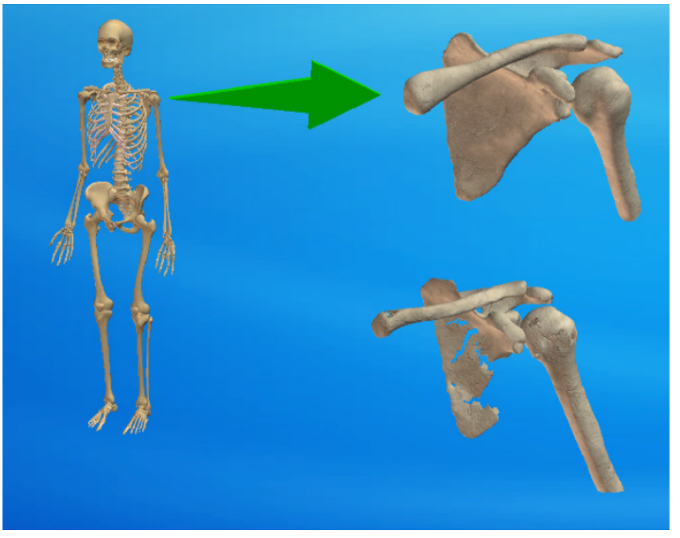

Figure 5. Vived Anatomy – bones

Figure 6. Moving heat energy

Practical part of the lesson – students are introduced to the components of an electric circuit. They are challenged to create an electric circuit to keep a locked metal box safe in a ticket booth.

Fig. 7 shows the practical part of the lesson where students design and build the circuit.

Exam activity: students present their electric circuit and try to improve the design of the circuit.

Materials for students: all prepared materials are given to students. They are divided into teams.

VR materials are improved according to the level of gaining knowledge in the field of electricity.

In many schools, this type of lessons is conducted where the students are divided into several groups and each group has to build an electrical circuit. In the standard flow of this activity, learners get to see the result of the task after connecting the entire circuit. This in turn acts as a demotivator for the students who failed to connect the circuit correctly and the process of organizing to correct their mistake takes a lot of time and boredom on the part of the students. With the help of zSpace technology and the possibilities it offers:

– the time to successfully solve a similar type of task is significantly less;

– the satisfaction on the part of the students is much greater because the time for realization and change of the route to design successfully an electrical circuit is much less.

Figure 7. Design and build a circuit

3. Conclusion

In conclusion, zSpace technology is applicable at all levels of education where students can implement knowledge in different disciplines and acquire practical skills. zSpace technology offers a new way of learning in STEM education. The catalog of available software packages enriches students' minds, and the activities encourage interaction with these complicated concepts. Detailed materials enhance the absorption of knowledge and acceptance of information. With the 3D models in each lesson, memorization becomes easier and more fun. This type of learning motivates students and improves their performance Research shows that when the material is presented visually and students can "touch" it, albeit with the help of technology, it is remembered much better and for longer, and assessment results are higher.

The zSpace lessons and projects can be fun and interactive for students, which can foster their interest in science in general. As presented in the paper, educational institutions can play an extremely important role in the development and implementation of STEM courses.

Implementing zSpace technology will revolutionize STEM learning and transport students into incredible VR simulations and experiences that would otherwise be impossible. Implementing in elementary school will unlock the excitement of early learning.

The adoption of the technology in the high school will visualize key concepts in Biology, Chemistry, Computer Science, and Physics fields of science. At the end of this stage, students will have a clearer vision of future development and a field of realization. The implementation in higher education will let the students dive deeper into complex problems that engage them and support their path to career readiness.

Acknowledgments & Funding

This study is financed by the European Union – NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.013-0001-C01.

REFERENCES

BELOEV, H., SMRIKAROV, A., VOINOHOVSKA, V., & IVANOVA, G., 2023. Determining the degree of digitalization of a higher education institution. *Strategies for Policy in Science & Education-Strategii na Obrazovatelnata i Nauchnata Politika*, vol. 31, no. 4s, pp. 9 – 21. https://doi.org/10.53656/str2023-4s-1-det.

ELECTRIC AUTOMOTIVE MECHANIC BY GTAFE, URL: https://zspace.com/edu/info/vr-electric-automotive-mechanic, accessed: 02.05.2024.

EXPERIENCES BY ZSPACE, URL: https://zspace.com/edu/info/zspace-experiences, accessed: 04.05.2024.

HIDAYAT, R., WARDAT, Y., 2023. A systematic review of Augmented Reality in Science, Technology, Engineering and Mathematics education. *Educ. Inf. Technol.*, https://doi.org/10.1007/s10639-023-12157-x.

HRISTOV, G.; BELOEV, I.; ZAHARIEV, P.; GEORGIEV, G., 2023. The role of the universities as accelerators for the integration of the STEM learning methods in the primary and secondary schools *Strategies for Policy in Science & Education-Strategii na Obrazovatelnata i Nauchnata Politika*, vol. 31, no. 4s, pp.74 – 88, doi: 10.53656/str2023-4s-6-rol.

OSADCHYI, V.; VALKO, N & KUZMICH, L., 2021. Using augmented reality technologies for STEM education organization. *Journal of Physics: Conference Series.* 1840. 012027. 10.1088/1742-6596/1840/1/012027.

VIVED ANATOMY SOFTWARE, URL: https://zspace.com/edu/info/vived-anatomy, accessed: 03.05.2024.

VOINOHOVSKA, V.; ASENOV, D., 2023. Developing interdisciplinary connections between sustainability and STEM by integrating 3D tools in primary schools. *Strategies for Policy in Science & Education-Strategii na Obrazovatelnata i Nauchnata Politika*, vol. 31, no. 4s, pp. 101 – 110, doi: 10.53656/str2023-4s-8-dev.

Internet sources

ZSPACE TECHNICAL SPECIFICATIONS, URL: https://cdn.zspace.com/downloads/documentation/specifications/inspire-pro-techspecs.pdf, accessed: 02.05.2024.

ZSPACE TECHNOLOGY, URL: https://zspace.com/technology, accessed: 01.05.2024.

✉ **Boyana Ivanova, Assist. Prof.**
ORCID iD: 0000-0003-4833-1012

✉ **Dr. Kamelia Shoilekova, Assoc. Prof.**
ORCID iD: 0009-0001-2415-9599

✉ **Dr. Desislava Atanasova, Assoc. Prof.**
ORCID iD: 0000-0001-7147-3890

✉ **Dr. Rumen Rusev, Assoc. Prof.**
ORCID iD: 0000-0002-0969-0760
University of Ruse “Angel Kanchev”
8, Studentska St.
7000 Ruse, Bulgaria
E-mail: bivanova@uni-ruse.bg
kshoylekova@uni-ruse.bg
datanasova@uni-ruse.bg
rir@uni-ruse.bg