https://doi.org/10.53656/ped2023-7.8

Doctoral Reserch
Докторантски изследвания

„MISSION ON MARS" – INTEGRATED STEM LESSON

Deyana Peykova
University of Plovdiv "Paisii Hilendarski" (Bulgaria)

Abstract. Integrated STEM teaching reflects the effort to combine some or all four disciplines of Science, Technology, Engineering, and Mathematics into one learning unit or lesson. The following work describes good practice for collaboration between teachers in different subjects in order to create effective interdisciplinary lessons. Students are engaged in enjoyable activities in Science, Robotics and Technologies. The lesson is student-led, they prepare themselves for the different activities according to their interests and skills. Students explore Mars, make conclusion, analyze and give solution.

Keywords: STEM education; interdisciplinary learning; problem and project-based learning; integrated STEM curriculum

Introduction

STEM is a learning approach that is based on the idea of teaching students in four specific disciplines – science, technology, engineering and mathematics in an interdisciplinary and applied way. Rather than teaching the four disciplines as separate subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications outside the classroom. This allows children to understand the relationship between the disciplines being studied and understand the facts and phenomena being studied. STEM education is multifaceted and goes beyond the core disciplines that make up the acronym STEM. Through STEM, students develop key skills like problem solving, creativity, critical thinking, teamwork, independent thinking, initiative, communication, digital literacy.

Integrating curricular content from the STEM disciplines

There are several approaches to integrating curricular content from the STEM disciplines and the terminology used for these approaches differs in the literature reviewed. For example, Wang and Moore distinguish between a multidisciplinary and an interdisciplinary approach. According to them, in a multidisciplinary approach, subject-specific concepts and skills are taught separately in each

discipline and students are expected to make connections between the content taught in different subjects (Wang, Moore, Roehrig & Park 2011). An interdisciplinary approach, on the other hand, begins with a real-world problem or issue and focuses on interdisciplinary content and skills (eg, critical thinking and problem solving) rather than subject-specific content and skills.

In contrast, Satchwell and Loep provide a different definition of interdisciplinarity. In their view, interdisciplinary curricula focus on learning within one field while supporting content with implicit connections to other disciplines. On the other hand, integrated curricula absorb concepts from more than one discipline and apply equal attention to two or more disciplines (Satchwell & Loepp 2002).

A similar distinction is made by Roehrig and Moore, who distinguish the integration of content and context. According to them, integrated learning focuses on bringing disciplines together in a single learning activity or unit to highlight the "big ideas" from multiple content areas, while contextual integration focuses on the content of one discipline and uses contexts from others to make content more applicable (Roehrig, Moore, Wang & Park 2012).

Although there is no consensus on terminology, most of the articles reviewed agree that creating strong connections between the various STEM disciplines is necessary to realize an integrated STEM curriculum. Many papers emphasize the importance of applying equal attention to two or more STEM disciplines and/or bringing together concepts from different STEM disciplines.

It is extremely important that content integration is clearly formulated, as students do not immediately integrate concepts and concepts on their own. Therefore, they should be supported in building knowledge and skills in the disciplines. A greater amount of curricular content in STEM disciplines does not necessarily mean better integration of STEM education as a whole. Students need sufficient understanding of relevant subject concepts to connect ideas across disciplines. Therefore, integrated STEM education should also focus on learning objectives and standards in individual STEM disciplines, so that students' interest in learning these subjects is not lost (Pearson 2017).

Technologies in the lesson

Technology is a crucial component of any STEM activity. Technology may contribute to the design and implementation of the STEM activities in multiple ways. Technologies can be used in two ways:| 1) direct integration and embedding of technology into STEM activities and 2) using technology as a tool or facilitator to enrich STEM (Dogan & Robin 2015). There is different software used in the "Mission on Mars" lesson – MozaBook, zSpace, Scratch, Lego Mindstorms, VR reality simulation, Tinkercad. In their work, I. Velcheva and K. Garov present various digital tools that could be implemented in training (Velcheva 2021; Velcheva & Garov 2022).

MozaBook is a software for education available to both students and teachers. They can develop their worksheets, customized tests, or their own digital handbooks, built from scratch or from the textbooks already in electronic format. Integrated applications allow, for example, working in a virtual lab and developing various skills. Teachers can create online homework and they can upload their notebooks created in mozaBook to their mozaWeb account, in order to open them from any other computer. The information transmitted in this way helps understand the presented phenomena, concepts or processes, and the integrated applications develop skills and illustrate phenomena through the virtual lab, boosting students' interest and facilitating the teaching of these concepts. MozaBook:

– It's an easy-to-use educational software and it is based on intuition, being developed based on the feedback received from teachers and students.

– It can be shared, providing access to notebooks or worksheets created by other users.

– It's versatile, the users may create their own digital textbooks, with interactive content downloaded also from the media library.

– It's complex, with over 1000 interactive 3D animations, audio files and hundreds of video tutorials.

– It's flexible, it can be run on a computer, tablet, or cell phone.

– It's multilingual.

zSpace is a one-of-a-kind technology through which students learn through virtual 3D holograms and virtual and augmented reality experiment simulations. zSpace is a combination of hardware, software and learning content specifically aimed at preparing students in various STEM disciplines. A combination of virtual and augmented reality (VR/AR), 3D, interactivity, zSpace changes the way students learn (collaborative, personalized), receive information (three sensory modalities – virtual reality (VR), 3D, interactivity), learn new knowledge (in overall context; student question types; knowledge accumulation) and put it into practice in the classroom (virtual, safe, lower cost, higher results, impossible for standard classroom activities).

Scratch is designed for children and this block based programming tool makes animated stories, video games and interactive artwork. Scratch uses a simple graphical interface that is easy and lets users put together multimedia programs without any programming knowledge. Students can create projects on the website using a block-like interface. Projects can be exported to HTML5, JavaScript, Android apps and EXE files using external tools. Scratch has been translated into 70+ languages and it is used in most parts of the world.

LEGO Mindstorms EV3 is a hardware and software structure which develops programmable robots based on Lego building blocks. Each version includes computer Lego bricks, a set of modular sensors and motors, and Lego parts. The system is controlled by the Lego bricks. Sensors provide robots with information

about their environment. With the sensors that come with the EV3, students make a robot respond to being touched, react when someone or something comes too close, follow a line, or measure how far they have turned.

In the lesson the model of VR glasses that is used is VR Box 2. These virtual reality glasses are compatible with all VR apps available for download from Google Play or Apple Store. The position of the phone can be adjusted at any time, even while watching a movie or playing games. There is possibility to adjust the lenses according to individual needs. For this purpose, special sliders are provided, with which you can adjust the focal distance and interpupillary distance. Smartphones with a screen size of 4" to 6" and a body size of up to 163 x 83 mm can be used.

Interdisciplinary STEM lesson "Mission on Mars"

Title: „Mission on Mars"

Summary: This lesson aims to integrate content from the curriculum in the STEM discipline in one unit. Students work together or individually in the different parts of the unit. All the activities are corresponding with the knowledge about Mars. Students create, investigate, analyze and give solutions.

Subjects:

– STEM subjects: Science, Physics, Computer Science, Mathematics, Coding and robotics

– Non-STEM subjects: English language

All the parts of the lesson are connected – when one activity finishes it re-send to another with a common task – to find or discover something on Mars.

Real-life questions: Is there life out there? Can people live on Mars?

Aims of the lesson: Students will:

– Learn about Mars

– Participate in activities to explore the planet

– Design a game "Mission on Mars"

Connection to STEM careers:

Some potential career paths for the students:

– Astronaut

– Computer engineer

– Scientist

Age of the students: 10 – 11.

Time: 2 hours to plan activities in each subject with colleagues

Students lead the lesson – they are the teachers

Teaching time: 50 min.

Teaching resources (material & online tools): MozaBook , zSpace station , computer, interactive displays, VR glasses , Lego Mindstorms EV3, 2 lollipops / people from the Earth/, soap, water, permanganate and hydrogen peroxide, copper, zink, dye , candies, potatoes.

21st century skills:

This lesson plan will enhance among the students the following skills, defined as 21st century skills:

1. Learning skills

– Critical thinking: they find solutions to problems

– Creativity: Thinking outside the box

– Collaboration: Working with others

– Communication: Talking to others

2. Literacy skills – Information literacy, media literacy and technology literacy

3. Life skills – flexibility, leadership, initiative, productivity, social skills.

Assessment: The assessment is made by using online tool - Kahoot. Students play quiz about Mars, answering different questions. Students shared their positive feedback about the activities and expressed their motivation to continue studying through integrated content.

Procedure

1. Lead-in (5 min)

A student explains his project on the Solar System. He gives infomation how he did the project – materials, infomation about the planets, but he is really impressed by one – Mars, because nowadays scientist discover the planet if there can be possible people to live. He also tells the others about Space X – the company wants to send astronauts for the first time. He tells the aim of the lesson: his classmates will learn more about Mars and they will discover more about the planet and the conditions there.

Figure 1. Solar System project

2. Learn about Mars with MozaBook (5 min)

A student works on the interactive display, shows and displays the Red planet together with the information about Mars. MozaBook is used in this part of the lesson as a way the other students to get familiar with the planet, conditions,etc. She gives information about Mars' satellites.

Figure 2. Using MozaBook to learn about Mars

3. Marvelous Mars (5 min)

The activity continues with a student working on zSpace station. The virtual simulation that the student opens in called „Marvelous Mars". He explains and gives information about the layers of the planet and the layer composition. There is a projection on a big display so every student can see it.

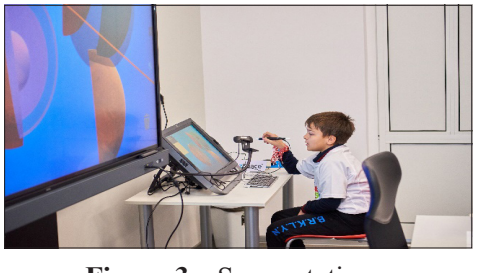

Figure 3. zSpace station

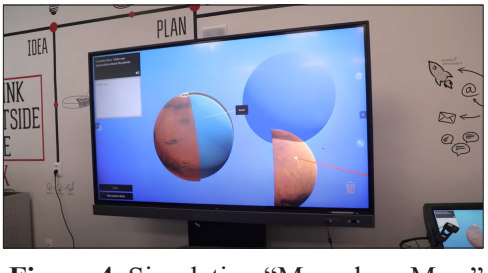

Figure 4. Simulation "Marvelous Mars"

4. Scratch game „Mission on Mars" (5 min)

The game is created with Scratch 2.0 and presented on an interactive table. The people from the Earth have to go to Mars and discover if we can live there. But

they need oxygen. Stepped on Mars they must overcome some obstacles in order to produce oxygen and continue their mission.

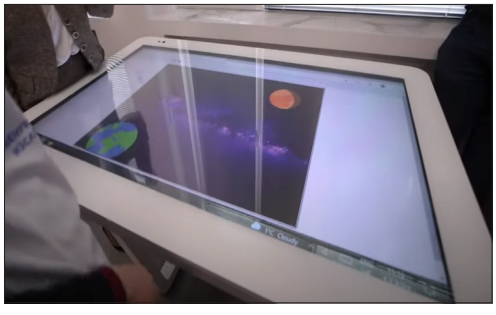

Figure 5. Presentation of "Mission on Mars"

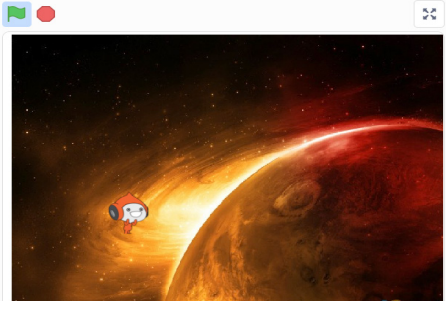

Figure 6. Game "Mission on Mars"

5. Mars – virtual reality (5 min)

For the needs of lesson the application Mars VR is used. Students can download it on Google Play. It allows students to travel to the planet Mars and explore it's surface in VR. They just select a landing site and then once they reach the martian surface they can explore Mars by tilting their head left and right to change the direction of flight. Looking up and down will change your altitude and in the settings they can enable a head up display to help navigate further over the martian terrain.

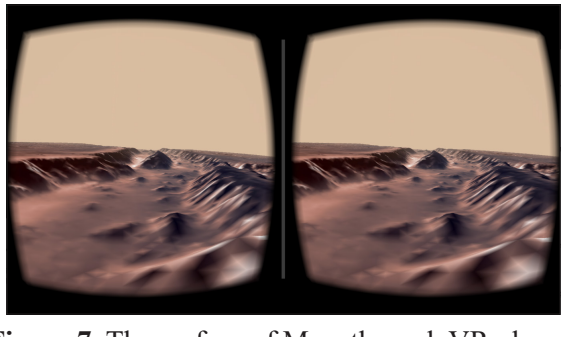

Figure 7. The surface of Mars through VR glasses

6. Mission on Mars (5 min)

In this mission students must help people from the Earth to come back to our planet. They create Mars-rover, then they programme it. Carrying out a series of commands without interruption, the rover rescues the people and brings them back to Earth.

Figure 8. Rescuing people from the Earth

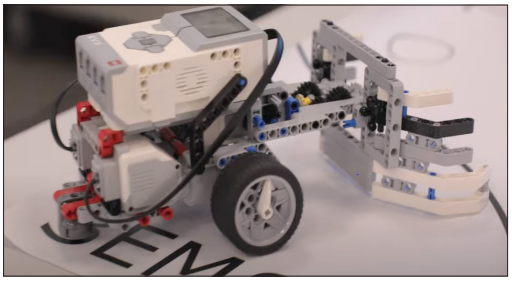

Figure 9. Mars-rover

7. Elephant toothpaste (5 min)

A student explains that with the masr-rover his classmates took a substance from Mars. He checks if this substance changes if he mixes it with other substances from our planet. He needs potassium permanganate and hydrogen peroxide. The water is mixed with the soap and some of the Mars substance. It turns into a liquid homogeneous mixture called "Elephant toothpaste".

Figure 10. Elephant toothpaste

8. Soap and milk (5 min)

The girl continues with exploring the substance from Mars. For her the substance from Mars looked exactly like soap to me. Let's check if this is true by trying to wash off the fat. She uses milk because it has fat in it. He also uses dye to see if detergent is enough. The soap binds to the fats in the milk and destroys them. So if we put soap in the milk, it tries to remove the fat and as it does, the colors scatter and mix, creating an amazing color explosion.

Figure 11. Soap and milk

9. Battery from potatoes (5 min)

Everything around us is made of matter, and matter is made of building particles. Atoms are such particles. They have electrons in them, and they are very important. Thanks to them, we use electricity today. A students explains that she irradiated potatoes with the substance from Mars. Her task is to check whether this new substance is an acid. If it is, then the potato will be able to create electricity. One plate is copper and the other zinc. This is necessary to create a flow of electrons.

Figure 12. Battery from potatoes

10. Rainbow (5 min)

Another student makes a conclusion that they have understood that the substance from Mars behaves like soap and acid. She checks whether different substances can be dissolved in it. In this experiment, she uses water in which the Mars substance was previously immersed. She explains about the diffusion. It is the interpenetration of molecules of one substance between the molecules of another, which leads to

uniform mixing of substances throughout the volume. She shows a color diffusion between the molecules of the dye with which these candies are colored and the molecules of the water in which until a moment ago the substance from Mars was.

Figure 13. Diffusion

Conclusion

Integrating STEM subjects will allow students contextualize the knowledge acquired in each subject, and connect it with real world challenges or STEM professions. For example, if the teachers want to introduce students to the importance of sustainability, they will need to examine this theme from various angles. Consequently, in the Technology subject students will learn how to seek relevant information, in their Mathematics class they will be introduced in ways to gather and present data and in their Biology or Economics class they will have the time to reflect and learn about the ecosystem or design projects about sustainability respectively. This is the first step to ensure that students even as early on as in Primary school will be able to understand how this knowledge can help tackle or solve everyday problems. By integrating more than one STEM subjects teachers encourage the use of pedagogical methods such as Project-Based Learning and prompt students to work collaboratively. The use of hands-on activities and the respective resources is required, but most importantly, teachers need to make good use of the resources they have among them and work with their colleagues. The collaboration between teachers in different STEM disciplines is already reported as a positive factor to self-efficacy. Integrating engineering and science provides opportunities for improving student learning and interest, especially when they are exposed not just to science content but also to scientific enquiry. In fact, scientific inquiry and design-based thinking underlie decision-making processes across Science, Technology, Engineering, and Mathematics.

REFERENCES

DOGAN, B. & ROBIN, B., 2015. Technology's Role in Stem Education and the Stem SOS Model. In: A. SAHIN, *A Practice-based Model of STEM Teaching.* pp. 77 – 94. Rotterdam: Sense Publishers.

PEARSON, G., 2017. National academies piece on integrated STEM. *Journal of Educational Research*. vol. 110, pp. 224 – 226. Available from DOI: https://doi.org/10.1080/00220671.2017.1289781.

ROEHRIG, H.; MOORE, T.; WANG, H. & PARK, S., 2012. Is adding the E enough? Investigating the impact of K-12 engineering standards on the implementation of STEM integration. *School Science and Mathematics*, pp. 31 – 44. Available from DOI: https://doi.org/10.1111/j.1949-8594.2011.00112.x.

SATCHWELL, E. & LOEPP, L., 2002. Designing and Implementing an Integrated Mathematics, Science and Technology Curriculum for the Middle School. *Journal of Industrial Teacher Education,* vol. 39, no. 3, pp. 41 – 66. ISSN: 0022-1864.

VELCHEVA, I. & GAROV, K., 2022. Digital tools for computer presentations used in teachers' training. *Education and technologies,* vol. 13, no. 2, pp. 349 – 355. ISSN 1314-1791.

VELCHEVA, I., 2021, Main characteristics of digital tools and their application in training. *Pedagogical forum,* vol. 9, no. 2, pp. 52 – 60. ISSN: 1314-7986.

WANG, H.; MOORE, J.; ROEHRIG, H. & PARK, S., 2011. STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 1, no. 2. Available from DOI: https://doi.org/10.5703/1288284314636.

✉ **Mrs. Deyana Peykova, PhD student**
ORCID iD: 0000-0002-7029-0790
Faculty of Mathematics and Informatics
University of Plovdiv "Paisii Hilendarski"
Plovdiv, Bulgaria
E-mail: deyana.peykova@uni-plovdiv.bg