https://doi.org/10.53656/str2023-4s-8-dev

Education in the Information Society
Образованието в информационното общество

DEVELOPING INTERDISCIPLINARY CONNECTIONS BETWEEN SUSTAINABILITY AND STEM BY INTEGRATING 3D TOOLS IN PRIMARY SCHOOLS

Assoc. Prof. Valentina Voinohovska,
Denis Asenov
University of Ruse

Abstract. Young people are the future of society and agents for social change. That is why it is so crucial to provide education that not only equips them with knowledge and skills but also changes their attitudes and behaviour towards sustainable development. The need for education that supports a more sustainable world has become more evident as it can enhance people's lives and contribute to sustainable development. STEM education is described as an interdisciplinary approach to learning in which students use science, technology, engineering, and mathematics in situations that establish links between school, community, work, and the global enterprise, thus allowing the growth of STEM. 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. Students have access to 3D models that not only allow them to go more deeply into each subject but also make it much easier for them to retain their ideas.

Keywords: interdisciplinary connections; STEM education; 3D tools; project-based learning; environmental education

1. Introduction

Sustainability and STEM education are two important areas that have gained increasing attention in recent years. While STEM education focuses on science, technology, engineering, and mathematics, sustainability education emphasizes the importance of sustainable development, including environmental, social, and economic dimensions. Integrating 3D tools into primary school education provides an opportunity to develop interdisciplinary connections between these two areas, allowing students to learn about sustainability concepts through STEM-based activities. In this paper, we explore the use of 3D tools in primary school education to promote sustainability and STEM learning, and we discuss the potential benefits of this approach for students, teachers, and the wider community.

Over the course of the last several years, sustainable development has emerged as one of the most pressing issues facing the global community. In order to keep our world habitable for future generations, we are going to have to adjust the ways in which we think and behave. (Back & Back, 2020).

Therefore, it is crucial to mainstream sustainability in education, and education in STEM subjects may play an important role in this regard. The incorporation of STEM into the learning process may assist in the formation of links between disciplines and can also boost students' commitment to environmentally responsible practices. (Breiner, Harkness & Koehler 2020).

To accomplish this goal, one might make use of a wide variety of approaches and instruments. Including 3D technologies in the learning process is one technique to facilitate the formation of connections across academic boundaries.

Students will benefit from using these tools to develop models and simulations, which will help them get an understanding of how various systems function and how they are interconnected with one another. (Brown & Thomas 2021; Atanasov & Ivanova 2022).

Using multimedia and interactive learning tools, in addition to participating in interdisciplinary projects, is still another method for establishing connections across academic boundaries.

2. Integration of 3D tools in primary school education

The integration of 3D tools in primary school education provides a unique opportunity to promote sustainability and STEM learning through interdisciplinary connections (Doncheva 2017). With 3D tools, students can create and manipulate virtual objects, allowing them to engage in hands-on activities that promote critical thinking, problem-solving, and collaboration (Shoilekova 2021).

One way in which 3D tools can be used to promote sustainability is through the creation of virtual models of sustainable infrastructure, such as green buildings or renewable energy systems. By designing and building these models, students can gain a better understanding of how sustainable technologies work and how they can contribute to a more sustainable future.

In addition, 3D tools can be used to teach STEM concepts, such as geometry and physics, in a more engaging and interactive way. For example, students can use 3D modelling software to create and test their own designs for simple machines, such as levers and pulleys, or explore the properties of geometric shapes by manipulating virtual objects.

By integrating sustainability and STEM concepts through 3D tools, students can develop a more holistic understanding of how these areas are interconnected and how they can work together to address real-world problems. This approach also helps to promote creativity and innovation, as students are encouraged to come up with their own solutions to sustainability challenges.

Furthermore, the use of 3D tools in primary school education has the potential to benefit teachers and the wider community. Teachers can use 3D models and simulations to supplement traditional teaching methods, providing students with a more interactive and engaging learning experience. And by promoting sustainability and STEM learning, students are better prepared to contribute to a more sustainable and technologically advanced society.

Pupils may create models of eco-friendly technology like solar panels, wind turbines, and energy-efficient dwellings using 3D modelling software. (Colburn & Henriksen 2020). The aforementioned resources aid in the process of letting students see their problems and test out potential solutions in a simulated three-dimensional environment.

3. Methodology for developing interdisciplinary connections between sustainability and STEM by integrating 3D tools in primary schools

The integration of 3D tools in primary school education to promote interdisciplinary connections between sustainability and STEM has the potential to benefit both students and teachers in a number of ways.

For students, this approach provides an opportunity to develop a more holistic understanding of sustainability and STEM concepts by engaging in hands-on, interactive learning experiences. By using 3D tools to create and manipulate virtual models of sustainable infrastructure and explore STEM concepts, students can gain a deeper understanding of how these areas are interconnected and how they can work together to address real-world problems.

In addition, the use of 3D tools can promote creativity and innovation by encouraging students to come up with their own solutions to sustainability challenges. By exploring different design options and testing their ideas in a virtual environment, students can develop critical thinking and problem-solving skills that will serve them well in their future academic and professional endeavours.

For teachers, the use of 3D tools can supplement traditional teaching methods by providing a more interactive and engaging learning experience for students. With 3D models and simulations, teachers can help students to visualize complex concepts and processes in a way that is more accessible and relatable. This approach can help to increase student engagement and motivation, leading to improved learning outcomes.

Furthermore, the integration of sustainability and STEM concepts through 3D tools can help to promote cross-curricular connections and provide a more integrated approach to education. By breaking down the traditional boundaries between subjects, teachers can help students to see how different areas of study are interconnected, leading to a more holistic and well-rounded education.

Overall, the integration of 3D tools in primary school education to promote interdisciplinary connections between sustainability and STEM has the potential to benefit both students and teachers in a number of ways. By providing a more engaging

and interactive learning experience, this approach can help to develop the critical thinking, problem-solving, and innovation skills that are essential for success in the 21st century.

The methodology describes the process of using 3D modelling software to engage students in hands-on learning activities that promote sustainability and STEM concepts. It contains the following: defining learning objectives, choosing 3D modelling software, introducing sustainability and STEM concepts, demonstrating 3D modelling techniques, assigning design challenges, facilitating student collaboration, providing feedback and evaluation, and reflecting and iterating.

By using this methodology, students will develop skills in 3D modelling, critical thinking, and collaboration, while also gaining a deeper understanding of sustainability and STEM concepts. They will also have the opportunity to engage in creative problem-solving and contribute to a more sustainable future.

The teachers are encouraged to follow each step carefully and adapt the methodology to meet the specific needs of the classroom and students. This methodology could provide a valuable tool for engaging primary school students in sustainable and STEM-focused learning experiences.

Define learning objectives: Begin by defining specific learning objectives that align with both STEM and sustainability concepts. These objectives should be age-appropriate and achievable within the given timeframe.

Choose 3D modelling software: Select a 3D modelling software that is accessible and appropriate for primary school students. Tinkercad is one example of a user-friendly software that is well-suited for younger learners.

Introduce sustainability and STEM concepts: Introduce students to sustainability and STEM concepts through interactive and engaging activities. This can include group discussions, hands-on experiments, and multimedia resources such as videos and animations.

Demonstrate 3D modelling techniques: Demonstrate basic 3D modelling techniques to students, such as creating shapes, manipulating objects, and using design tools. This can be done through a combination of teacher-led instruction and independent exploration.

Assign design challenges: Assign design challenges that incorporate both sustainability and STEM concepts. These challenges should be open-ended and allow for creative solutions. For example, students could design a sustainable building that incorporates renewable energy sources or a product that reduces waste.

Facilitate student collaboration: Encourage students to work collaboratively on their design projects, promoting teamwork and communication skills.

Provide feedback and evaluation: Provide ongoing feedback to students throughout the design process, offering suggestions for improvement and acknowledging their successes. At the end of the project, evaluate student work based on specific criteria such as creativity, functionality, and adherence to sustainability and STEM concepts.

Reflect and iterate. Finally, encourage students to reflect on their design projects and the connections they made between sustainability and STEM concepts. Use this reflection as an opportunity to iterate and improve future projects.

4. 3D modelling software

Tinkercad

Tinkercad is an online 3D design and modelling platform that allows pupils to create 3D models with an easy-to-use interface. It was created by Autodesk, a company that is well known for its AutoCAD software product used to design 2D and 3D models. Designed for educational and hobby purposes and is suitable for novice users who want to learn the basics of 3D modelling and create their own 3D objects. (Crampton & Dyment 2021).

The platform offers a simple, intuitive interface with a large number of tools for creating different shapes and details, such as cubes, cylinders, cones, spheres and many others. Pupils can also import photos and images to use as a basis for creating their 3D models.

Tinkercad is free and does not require any software to be installed on the computer as it is accessible through a web browser. Models created in Tinkercad can be saved to the cloud or downloaded to a local computer in a variety of formats, such as STL, OBJ or SVG.

One of the key features of Tinkercad is its ability to integrate with other software and hardware tools commonly used in the classroom, such as 3D printers and robotics platforms. This allows students to not only design and model their ideas but also bring them to life through physical prototyping and testing.

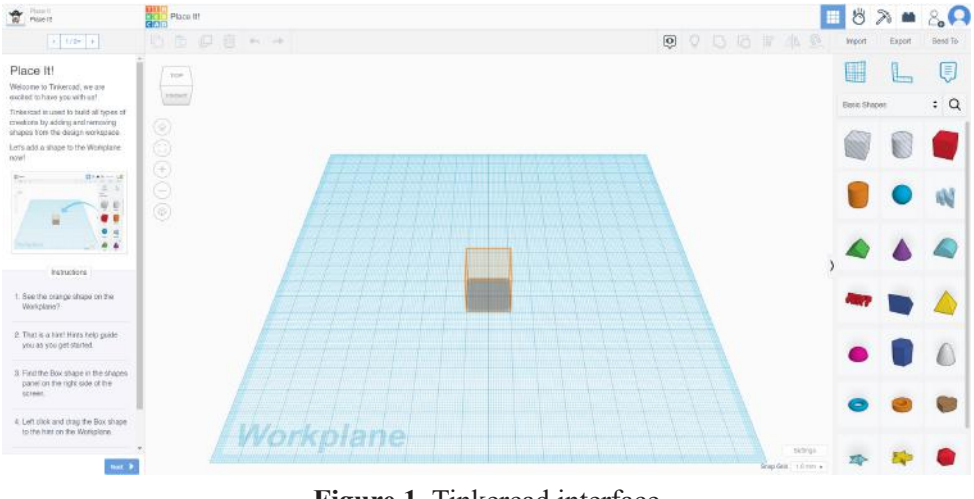

Figure 1. Tinkercad interface

SketchUp

SketchUp for Schools is a web-based version of SketchUp that is optimized for use in educational institutions, including elementary school. This version offers the same capabilities as the full version of SketchUp, but is available for free to students and teachers without installing the software on the computer.

SketchUp for Schools also has some valued features that are targeted towards education, such as the "Teacher Dashboard" feature that allows teachers to monitor and manage student activities within the app.

SketchUp for Schools allows students to design and visualize 3D models of various objects and objects, while also giving them the opportunity to work as a team, share and present their projects. There are also lessons and exercises designed specifically for students and teachers that incorporate the integration of sustainability and STEM education. (Crampton & Dyment 2021).

Using SketchUp for schools can help create interdisciplinary connections between sustainability and STEM education, and can also help students develop their 3D design skills and introduce them to innovative technologies that can help me create solutions for problems in the world around them.

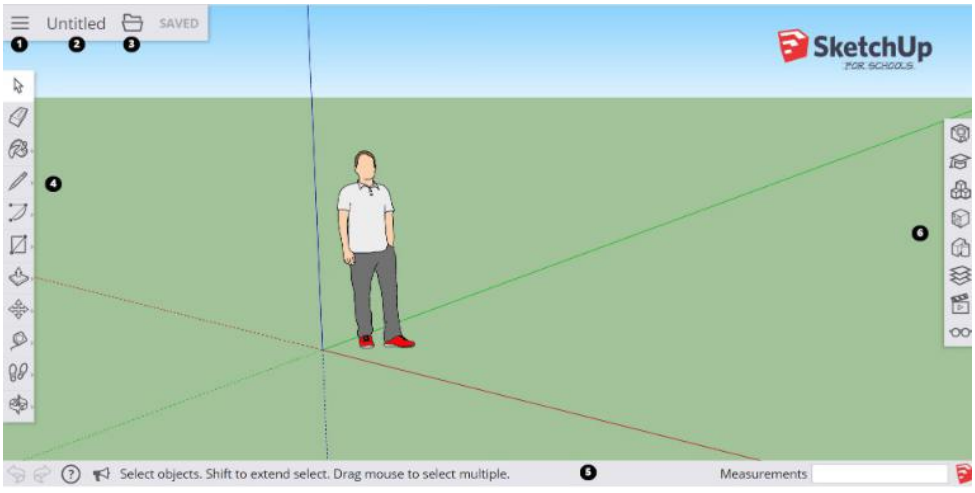

Figure 2. SketchUp interface

5. Examples of projects

Modelling a building with renewable energy sources

Modelling a building with renewable energy sources: Students can use 3D tools to model a building that uses renewable energy sources such as solar panels or wind turbines. (DeLuca & Stockwell 2021). They can learn about the different

ways of using renewable energy and how they can contribute to environmental sustainability.

In this task, primary school students will use 3D modelling software, such as Tinkercad, to design and create a virtual model of a building that incorporates renewable energy sources.

To begin, students should research different types of renewable energy sources, such as solar panels, wind turbines, and geothermal energy, and how they can be used to power a building.

Next, students should brainstorm ideas for their building's design, considering factors such as the building's location, orientation, and energy needs. They should also consider how they can incorporate the renewable energy sources they have researched into their design.

Once students have developed their design concept, they should begin creating a virtual 3D model using the modelling software. They should consider the placement of their renewable energy sources and how they can optimize their use to maximize energy efficiency.

Finally, students can present their designs to the class and explain their thought process and design choices. This can include discussing the benefits of using renewable energy sources and how their design promotes sustainability.

Through this task, students will not only learn about renewable energy sources and sustainable design principles but also develop skills in 3D modelling and design thinking.

Figure 3. Modelling a building with renewable energy sources

Designing recycling containers

In this task, students will use creativity and problem-solving skills to design and construct a recycling container that is functional, visually appealing, and promotes sustainability.

Pupils could utilize these resources again, this time to create and construct recycling bins intended for use within their school or community. To begin, they can learn about the various recyclable materials and how they can be reused to cut down on waste and keep the environment sustainable. Understanding sustainability and recyclable materials is necessary for designing recyclable containers.

Next, students should sketch their design ideas, considering both the practical and aesthetic aspects of their container. They should consider how their container can be easily accessed and emptied, as well as how it can promote sustainability and environmental awareness.

Once students have developed their design concept, they should begin constructing their container using materials such as cardboard, paper, or plastic bottles. They can also use decorating materials such as paint, markers, or stickers to add a personal touch to their design.

Finally, students can present their recycling container to the class and discuss their design choices and thought process. They can also explain how their container promotes sustainability and encourages recycling.

The containers must be made out of a material that is both easy to recycle and resistant to outside influences. (Hergert & Kim 2020). The process of designing should take into account ways to encourage and facilitate recycling. While being efficient at containing waste and avoiding liquid spills, containers must also be convenient to use and simple to open. A learning process that integrates sustainability and STEM education can include creating recycling bins in the classroom. (Kazungu 2021). This may inspire pupils to use their knowledge and creativity to solve problems in the real world.

6. Conclusion

In conclusion, the use of 3D tools to integrate sustainability and STEM education in elementary school can contribute to the formation of interdisciplinary links between these fields and to a broader understanding of issues related to sustainable development. This approach can encourage students to think outside of the single lesson and encourage them to develop a holistic approach to problem solving. (Lindgren & McPherson 2021).

As such, students will be able to apply their knowledge in real life to address the challenges they encounter in the world around them. Additionally, these lessons and projects can be fun and interactive for students, which can foster their interest in sustainability and science in general. Ultimately, the integration of sustainability and STEM education in elementary school can contribute to

the formation of future leaders and innovators who will work for the sustainable development of the world.

The integration of 3D tools in primary school education to promote interdisciplinary connections between sustainability and STEM holds tremendous potential for fostering meaningful and engaging learning experiences. By harnessing the power of 3D modelling software, students can explore and create virtual models that incorporate sustainable practices and STEM principles. Through this integration, students not only develop crucial technical skills in 3D modelling but also gain a deeper understanding of sustainability concepts and their application in real-world contexts. They learn to think critically, problem-solve, collaborate, and innovate while exploring the interconnectedness between sustainability and STEM fields.

Furthermore, by engaging in hands-on design projects that address sustainability challenges, students develop a sense of ownership and agency in contributing to a more sustainable future. They become agents of change, equipped with the knowledge, skills, and attitudes necessary to make informed decisions and take sustainable actions.

By fostering interdisciplinary connections between sustainability and STEM, primary schools can play a pivotal role in nurturing environmentally conscious and scientifically literate citizens. This approach not only prepares students for future academic and career pathways but also empowers them to actively participate in shaping a more sustainable and resilient society.

As educators it is our responsibility to recognize the value of integrating 3D tools in primary school education and to provide the necessary resources and support to implement such initiatives. By doing so, we can inspire and empower the next generation to become passionate advocates for sustainability and leaders in driving positive change in their communities and beyond.

REFERENCES

ATANASOV, V., IVANOVA A., 2022. A framework for evaluation of web-based learning content. *International Journal on Information Technologies & Security*, vol. 14, no. 4, pp. 13 – 24, ISSN 1313-8251.

BACK, R. S. & BACK, K. W., 2020. Sustainable Development Goals and STEM education: An interdisciplinary approach. *International Journal of Sustainability in Higher Education*, vol. 21, no. 7, pp. 1264 – 1284.

BREINER, J. M.; JOHNSON, C. C.; HARKNESS, S. S. & KOEHLER, C. M., 2020. What is STEM? A discussion about conceptions of STEM in education and partnerships. *Journal of STEM Education: Innovations and Research*, vol. 21, no. 3, pp. 5 – 15.

BROWN, T. & THOMAS, G., 2021. Developing interdisciplinary sustainability curricula through collaborative design. *Journal of Environmental Education*, vol. 52, no. 1, pp. 17 – 29.

COLBURN, A. & HENRIKSEN, D., 2020. Project-based learning and sustainability: Integrating environmental sustainability into STEM. *Journal of STEM Education: Innovations and Research*, vol. 21, no. 3, pp. 16 – 26.

CRAMPTON, A. & DYMENT, J., 2021. Examining primary students' environmental actions in the context of STEM education. *Environmental Education Research*, vol. 27, no. 5, pp. 623 – 639.

DELUCA, V. & STOCKWELL, R., 2021. Connecting sustainability and STEM in primary school education: A case study. *Environmental Education Research*, vol. 27, no. 1, pp. 79 – 94.

DONCHEVA, J., 2017. Principles of training in line with the new thinking and action, *SEA – Conf., 3 International Conference*, Naval Academy, Constanta, No 3, pp. 74.

HERGERT, T., & KIM, J., 2020. Teaching sustainability in a STEM course: Developing and accessing an interdisciplinary, problem-based learning activity. *Journal of STEM Education: Innovations and Research*, vol. 21, no. 3, pp. 27 – 35.

KESSY, S. J., & KAZUNGU, S. S., 2021. The role of 3D printing in STEM education: A systematic review. *Journal of Computer Assisted Learning*, vol. 37, no. 1, pp. 53 – 67.

LINDGREN, R., & MCPHERSON, M., 2021. Teaching for sustainability in STEM: An interdisciplinary professional development program for primary teachers. *Journal of Science Teacher Education*, vol. 32, no. 1, pp. 29 – 49.

SHOILEKOVA, K., 2021. Advantages of Data Mining for Digital Transformation of the Educational System. *Artificial Intelligence in Intelligent Systems: Proceedings of 10th Computer Science On-line Conference*, Vol. 2. Springer International Publishing.

✉ **Dr. Valentina Voinohovska, Assoc. Prof.**
ORCID iD: 0000-0001-5700-8167
Mr. Denis Asenov
"Angel Kanchev" University of Ruse
7017 Ruse, Bulgaria
E-mail: vvoinohovska@uni-ruse.bg
E-mail: denisasenov9696@gmail.com