Digital Twin: Bridging Virtual and Real Learning at School center Slovenske Konjice-Zreče

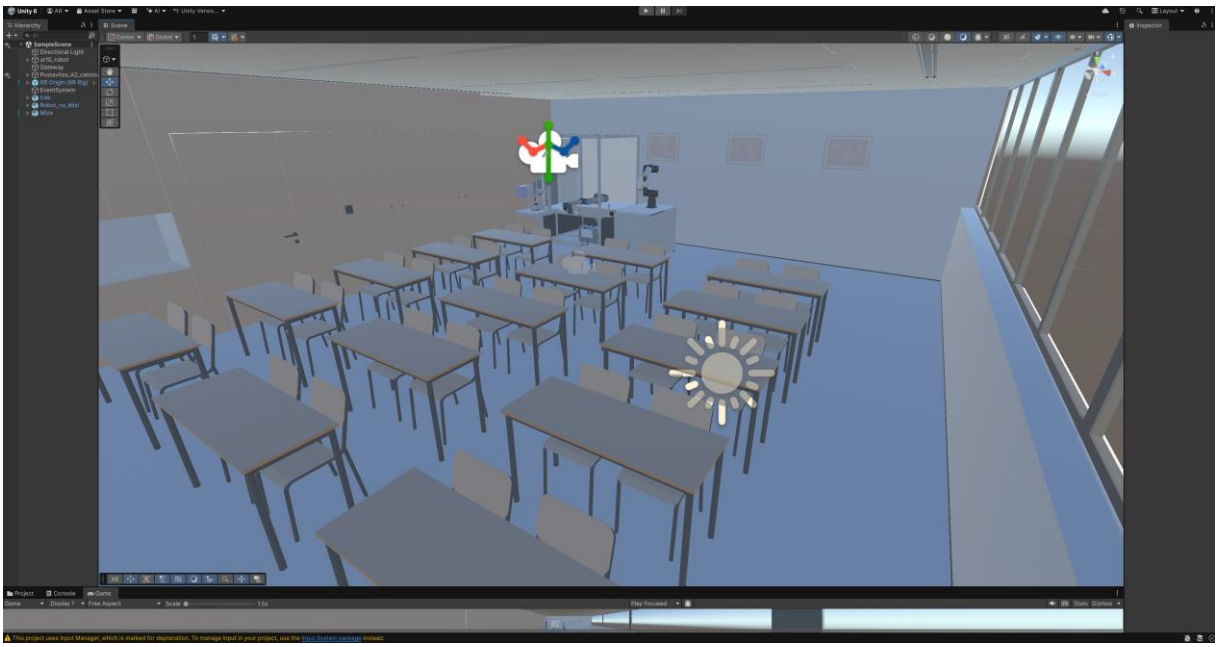
At School center Slovenske Konjice-Zreče, we have been systematically implementing advanced digital technologies for nearly a decade, laying the foundation for one of the most promising didactic approaches: the digital twin.

At the heart of our development is the transition from Industry 4.0, which emphasizes automation, to Industry 5.0, where humans play a central role as co-creators of technology. This shift is directly reflected in the learning process. Where education was once primarily focused on knowledge acquisition, we now emphasize the development of competencies such as complex problem-solving, critical thinking, and collaboration with technology. The digital twin—a virtual copy of a physical system—facilitates precisely this type of learning, allowing students to interact directly with simulated yet realistic processes.

The development of VR content and a digital twin is based on the gradual integration of advanced equipment and highly professional knowledge. An important milestone was the purchase of equipment and the introduction of advanced technologies such as robotics with the collaborative robot UR 10 and ABB GoFa, CAD-CAM-CNC technology with Creo, Solidworks and CNC lathe and CNC milling machine, and additive technologies with an industrial 3D printer. These technologies formed the basis for the realization of successful projects from IDEA - DESIGN - CONSTRUCTION - MANUFACTURING - APPLICATIONS, but the development of VR content and DT also requires broader interdisciplinary knowledge such as advanced programming skills in Unity or Unreal Engine, where the digital model is connected to the real one with scripts and artificial intelligence algorithms for simulation, optimization and prediction of system behaviour.

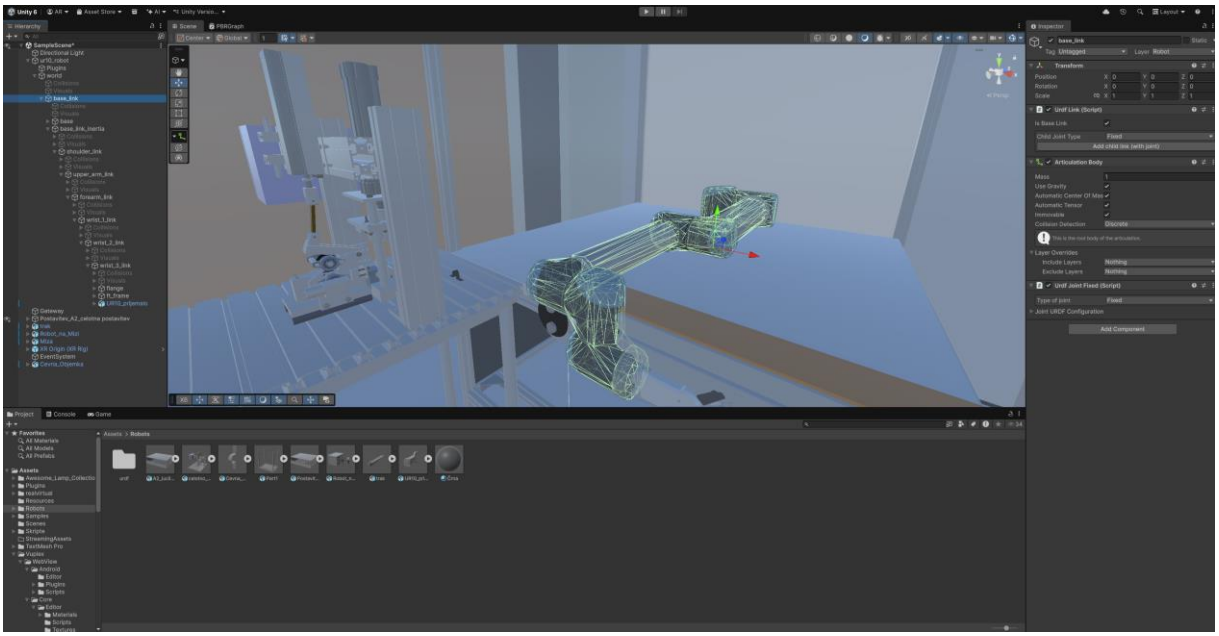
At our organisation, we have included this knowledge into educational process through the Open Curriculum - ULab Programming module and through obligatory educational modules, where participants learn about another important building block of the digital twin - industrial communication networks and protocols such as Ethernet/IP, Profinet and, especially important for DT, OPC UA. The latter enables standardized, secure and scalable data exchange between the digital twin and the real system.

The digital twin currently under development accurately mirrors the operation of the physical robot and its peripherals.



Picture 1: A classroom with a robotics cell set up in Unity.

The system is based on a two-way connection between the real and virtual environments, allowing for real-time monitoring of processes – either via a computer, VR headsets or directly on a physical device. This integration provides a highly realistic simulation that allows students to analyze movements, optimize procedures and test different scenarios without the risk of damaging the equipment.



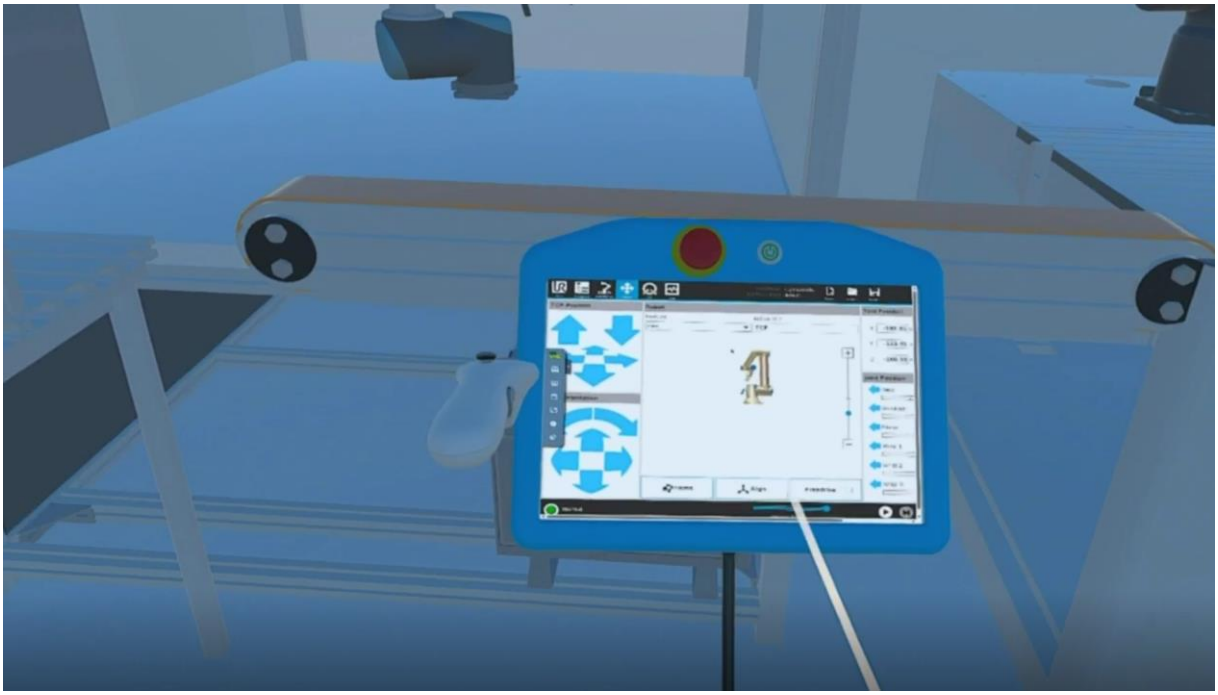
Slika 2: Bending device for making pipe clamps and a robotic cell with UR 10 for material manipulation in Unity.

When applied in technological and industrial environments, digital twins can significantly improve the reliability of system behavior predictions and process optimization compared to traditional simulation approaches, highlighting their potential utility in educational contexts where safe experimentation is crucial.

The adavantages of digital twins are not only technological, but also pedagogical. Such a learning environment encourages the development of abstract and systematic thinking and supports better transfer of knowledge to real-world situations. Students learn to anticipate the consequences of their decisions, analyze errors, optimize processes, and evaluate achievements - essential skills for understanding modern production systems.

Another important aspect is the psychological safety of the learning environment. Since the work takes place in a simulated environment, the fear of making mistakes is reduced, which encourages experimentation and independent learning. One student found that it was only by using the virtual environment that he truly understood the connection between the program code and the robot's movement. These experiences highlight the importance of experiential learning, where knowledge is developed through direct experience, reflection, and subsequent practical application.

Digital twins also increase the accessibility of learning resources. Multiple students can work on the same process simultaneously in a virtual environment, which improves teaching efficiency and enables individualized learning. Developed competencies – from digital modeling to data literacy – are increasingly important in the labor market, where a comprehensive understanding of the interaction between humans and technology is expected.



Slika 3: Touch control panel with UR 10 robotic arm controller and URSim simulator, connecting the robot model in the VR environment to the physical device

Despite these advantages, implementing digital twins also presents challenges. Prolonged use of virtual reality can lead to digital fatigue, so its application must be pedagogically considered and time-limited. Developing high-quality learning scenarios requires additional expertise and time, and simulation cannot entirely replace the responsibility of working with real equipment. Therefore, it is crucial to view the digital twin as a complement, rather than a complete substitute, for practical training.

Virtualized content and digital twins are no longer just technological novelties; they have become an essential part of modern education. They bridge theory and practice and enable the development of competencies demanded by contemporary industry.

At School center Slovenske Konjice – Zreče, this approach creates a learning environment that not only educates students but actively prepares them for future challenges, where the boundary between digital and physical worlds gradually disappears in areas of meaningful application.

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