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# EDUCATION 4.0: HYBRID LEARNING AND MICROLEARNING IN A SMART ENVIRONMENT

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## Abstract

*The term "4.0" refers here, as in all areas whether Industry 4.0, Work 4.0, or Society 4.0, to the paradigm of digitalization and support through new technologies. In the last few years, education and training are becoming more closely related to the labor market, and so the goal is to foster competent learners to meet the core skills for life and work in the 21st century. Building such a future-ready education system requires the design of curricula, that impart the necessary knowledge and skills for the modern workplace. The various pedagogical and technological innovations in recent years have created new concepts of learning environments, that optimize learners' ability to learn. They are commonly referred to as "smart learning environments". Innovative education based on advanced technologies should focus on stimulating thinking and creativity and address the individual differences of learners. The purpose of this paper is twofold. First, combines some educational concepts such as micro and hybrid learning with the support of immersive technologies to develop smart learning environments for a personalized and gamified seamless learning experience. Second, demonstrates how the concept of Micro-hybrid-immersive*

*learning enables a seamless transition between school and the world of work and achieves educational inclusion.*

**Keywords**

Authentic Learning, Education 4.0, Hybrid Learning, Immersive Technologies, Lifelong Learning, Microlearning, Smart Learning Environment

## 1. Introduction and Literature Review

Many of today's children will work in new types of jobs that do not exist today, and in such jobs digital and social-emotional skills will become increasingly important. The gap between education and employment will be further widened by the limited innovation in education systems. Therefore, the Fourth Industrial Revolution has made it imperative that education systems adapt (WEF, 2020). Technologies associated with the "4.0 revolution", such as Artificial Intelligence, Big Data, Cloud Computing, Augmented and Virtual Reality, are becoming an irreversible force driving changes in teaching and learning. Education researchers are exploring how innovative technologies can be integrated into curricula to enrich the learning experience and increase learning efficiency (Raja & Nagasubramani, 2018; Cheung et. al., 2021). Advances in new technologies have led to a rapid evolution of education in new directions, changing the way learners learn and the way teachers teach (Sghari, 2020). In the next decade, teachers and entire education systems will leave outdated teaching methods to create a high level of teacher and student engagement thanks to innovative technologies, which should be embedded across the educational experience. Technology-based learning has great potential in increasing students' academic experiences and learning outcomes, as well as enhancing social networking and collaboration opportunities among students. Research revealed that learning with technology does strengthen teaching and learning experiences (Pearce, 2021). In recent years, smart education has gained significant attention. Multidisciplinary researchers and educational professionals are continuously discussing the concept of "smart learning" and trying to find a clear and unified definition for it (Zhu et. al., 2016). Some researchers have promoted smart education through technologies, such as cloud computing (Kim et. al. 2011), learning analytics (Lee & Cheung, 2020; Tempelaar et. al., 2021; Broughan & Prinsloo, 2019), and big data (Chaurasia et. al., 2018) to capture and analyze learning data towards improving learning and teaching (Cantabella et. al., 2019), as well as supporting the development of the personalized and adaptive learning (Peng et.

al., 2019). Other researchers have promoted smart education through the Internet of Things (Kuppusamy, 2019), by equipping objects in the learning environment with sensors, actuators, and processors. This has enabled tracking the learner in the learning experience.

The industry 4.0 paradigm has introduced several changes and new competency requirements and skills of employees. For this reason, much current research focuses on education in the context of Industry 4.0 (Assante et. al., 2019). Technology plays a major role in the education system as it provides new opportunities for students to experience learning differently, to gain a deeper understanding of the world around them and ignite their imagination. Immersive technologies such as augmented reality (AR) (Laine, 2018; Iatsyshyn et. al., 2019) and virtual reality (VR) (Vesisenaho et al., 2019) have become popular teaching and learning tool in various disciplines. They offer students and teachers the opportunity to experience and interact with learning content. Furthermore, other studies have highlighted the pedagogical benefits of VR and Gamification by supporting students with different learning skills (Bryan et. al., 2018; Boboc et. al., 2018; Pavlidis & Markantonatou, 2018; Oyelere et. al., 2020).

## 2. Research Issue: An Approach to Education 4.0

The 4th industrial revolution is based on technological innovations such as virtual reality, blockchain, artificial intelligence, big data, and other new technologies, which are summarized under the keyword Digital Transformation. The core concept of Industry 4.0 and Digital Transformation is based on the improvement of information technologies and their introduction in many fields, to transform existing industries and to create new ones, as well as to transform areas of life into new, more efficient, and modern ones. This technological progress of the society is called the technological age, for which it is important to train qualified workers, make them competitive and enable them to quickly master the professions of the future. Skills such as complex critical thinking, problem-solving, collaboration, digital literacy, and creativity are important for people to be flexible enough to adapt to the changing demands of the job market. Therefore, educational institutions and universities must promote digitization skills in addition to the typical hard and soft skills. Digital literacy and the ability to understand and apply technology to practical solutions is becoming a must across all jobs and all sectors, as well as life outside work. Employees in their various roles will be dealing with these technologies. Giving students these skills is a challenge, that teachers have to face. However, technologies are a way to master this challenge

and offer the opportunity to deliver learning in gamified and personalized ways, which could change the traditional role of teachers and improve the learning experience. This new form of learning is essential for the demands of the workplace and society and it requires innovative didactic approaches, new ways of learning and teaching, as well as concepts for supporting lifelong learning.

Lifelong learning is the key to future education and a new learning plan, which makes the vision of "Education 4.0" become a reality. It will no longer be possible to distinguish between learning at school, learning while working, and learning to have a better role in society. The future of learning is no longer limited to the classroom; it goes beyond the scope of a classroom, learning will continue in life, in everyday work through many different situations. Learning will be lifelong and voluntary, learners will actively acquire knowledge for personal and professional goals, strengthen social integration and develop their skills to increase personal competitiveness in the workplace and meet the demands of the fourth revolution. Technology plays an important role in supporting smart learning, but the focus should not be solely on the use of smart devices and integrating new technologies to adapt the curriculum to this innovation. Innovative education based on advanced technologies requires innovative didactic approaches, new ways of learning, and teaching and learning environments, which can recommend the right learning content in the right place and at the right time.

In this paper an approach to a smart learning environment based on Micro-Hybrid-Immersive Learning is presented, which:

- Integrates different technologies and smart devices into a seamless whole, to deliver the same content, but adapted to the different learner characteristics and individual abilities,
- Uses diverse methods of transmitting knowledge in an immersive setting combined with the concept of Microlearning, to achieve real learning efficiency and effectiveness, and
- Allows hybrid learning i.e., the seamless switch between formal and informal settings, the variation of learning times and places, usage of analog and digital learning formats, and integration of activities, that promote both independent and class learning.

## 3. Methodology: Micro-Hybrid-Immersive Learning as An Educational Concept

Since Virtual Reality (VR) and Augmented Reality (AR) have entered education, the learning experience has changed tremendously and become much more interactive than traditional methods (Hentsch, 2018). While VR provides a constructed reality, AR provides an augmented view of a real image. Mixed reality (MR), as an umbrella term for augmented and virtual reality, offers many advantages, especially in the area of vocational education and training, where remote support and step-by-step guidance are very useful. In a previous publication (Mekacher, 2019), we presented various possible applications of this technology in our educational institution and a concept for integrating immersive technology in the learning- and training process. In today's paper, the concept is extended by additional elements to meet the requirements of Education 4.0 and the results of the implementation are presented.

The features of our learning concept include formal and informal, collaborative and personalized, as well as flexible and seamless learning. The focus is to provide self-learning and self-motivation in a learning environment enabling a seamless switch across any style of interaction and between a physical real environment and a virtual one. In the following sections, the main features of the proposed concept using different learning experiences are presented.

### 3.1. Combining Augmented Reality and Microlearning

In the proposed approach, the concept of Microlearning has been combined with augmented reality for the theoretical lessons:

- Microlearning is a form of e-learning that focuses on time-efficient knowledge transfer. This could either be short-term learning activities or small learning units. Content can take many forms e.g., text, images, videos, audio, tests, quizzes, games, etc., but should always be short.
- Augmented reality is one of the most modern information visualization technologies. It uses the existing environment and overlays digital information on top of it to give an augmented view of a real image.

By combining both issues, the interactive AR has added an exciting new dimension to our educational textbooks. Small learning bites are easily consumable by the learner and by using an AR device, learners can interact with the book and have a more attractive view and deeper understanding of new material. Figure 1 shows an animation of our textbook for electrical engineering using augmented reality and the concept of Microlearning. When the camera of the smartphone or tablet detects a trigger image in the book, digital content is displayed. This could

be a video, a 3D Model to interact with, animation, an exploded view of a machine, or a link to relevant websites. Students can control their learning because the digital content is displayed context-dependent and the Microlearning elements can be individually adapted to different learner groups and updated as required.

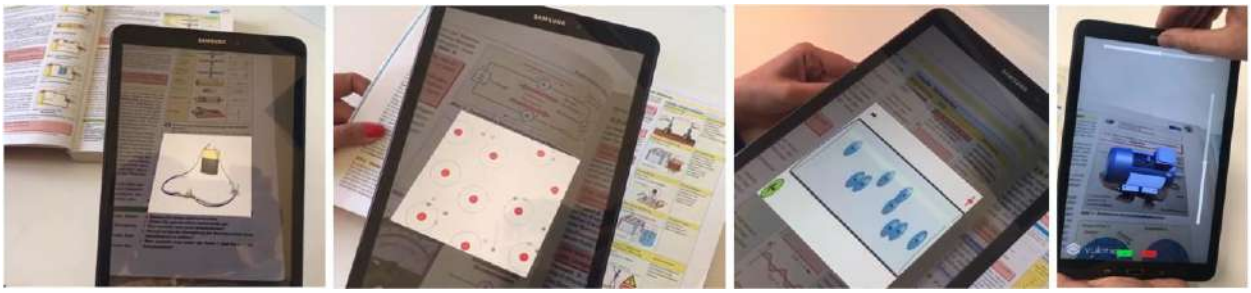

**Figure 1:** *AR-Animation of A Textbook for Electrical Engineering*
*(Source: Self Illustrations)*

The application of augmented reality increases the motivation to learn, as well as the level of information assimilation due to the variety and interactivity of its visual representation. Augmented reality turns the textbooks, which have previously been static sources of information and knowledge, into interactive dynamic tools that can better serve their readers and deepen the experience. This learning method was very useful during the Covid19 pandemic because the students were able to learn at home, acquire the knowledge through the AR animated content, and were not dependent on their teachers.

### 3.2. Hybrid Learning Elements for A Personalized Learning Experience

Today's students, who have grown up with computer games, the Internet, and other digital media that have shaped the way they receive information and learn, want their work style that better fits the way they think and learn. These new work styles and interface options help students focus on their work and learning because their devices are better aligned with their personal preferences for using them.

For this purpose, the same learning content has been developed in a hybrid way i.e., with different technologies, virtual and mixed reality. While in VR the user is fully immersed in a computer-generated virtual world, MR can superimpose holograms onto a user's view of the real world. These holograms respond to our interactions like physical objects. Figure 2 shows the example of a milling machine, which can be visualized as a hologram for Students using MR-Headsets (Hololens2), or in a fully virtual environment when learning with VR-Headsets (Oculus

Quest). Both technologies provide a powerful learning framework, that allows learners to deepen and solidify their knowledge through practical exercise.

**Figure 2:** *Training on The Same Content (Milling Machine) Using Different Technologies (VR and MR) Because Of Different Types of Learners*

*(Source: Self Illustrations)*

### 3.3. Multiplayer Experience for Collaborative Learning

Real-time collaboration is an important feature of the smart education of the future. For example, a multiplayer learning experience can promote team-based learning activities and foster curriculums based on group tasks. This kind of learning unit improves communication, teamwork skills, and the ability to coordinate in work with many different personalities having different capabilities, weaknesses, and strengths. Figure 3 shows a collaborative training situation in a fully virtual automation laboratory. The trainees learn how to operate and disassemble machines. They are immersed in that virtual world using VR-Headset.

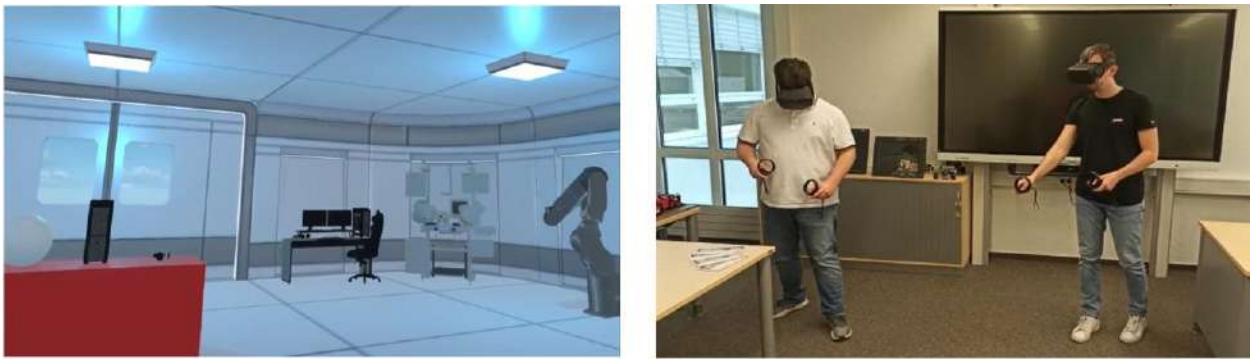

**Figure 3:** *Collaborative Training Situation in Virtual Reality: Operating and Disassembling Machines in A Fully Immersive Way*

*(Source: Self Illustrations)*

The trainee in figure 4 using MR-Headset can see their real environment and interact with each other while working with a hologram of a machine. They learn together, review the construction of a machine (full-size) in the classroom and make the needed changes in real-time. They can freely move around the machine, open and disassemble it. The linking of the real environment with virtual content increases the learning effect and the fun factor during the training experience.

**Figure 4:** *Collaborative Training Situation in Mixed-Reality, Where Holograms of Machines Appear as A Natural Part of The Real World*

*(Source: Self Illustrations)*

### 3.4. Authentic Learning Through Virtualization of Real Environments

To increase the quality and authenticity of learning, virtual learning environments as a one-to-one mapping of real environments have been developed (Figure 5). The virtual world simulates the real world to allow students to experiment with different concepts, switch between different learning activities, and move freely in the virtual learning space through teleportation. Learning in a virtual world provides users with a game-like learning environment, and this "game" character, as well as the realism of the developed virtual world, has a positive impact on student motivation and engagement. It enhances the learning experience and provides learners with the opportunity to learn without impacting the real world and personalize their learning experience. By performing tasks in virtual learning environments, learners could apply their abstract knowledge in authentic, virtual contexts that resemble real-world environments. This helps them to better understand the context. In the next step, such realistic virtual environments will be used as escape rooms. The concept of Escape Rooms is relatively new in education and has become an increasingly popular

method for transforming physical classrooms into exciting, alternative reality-based learning environments.

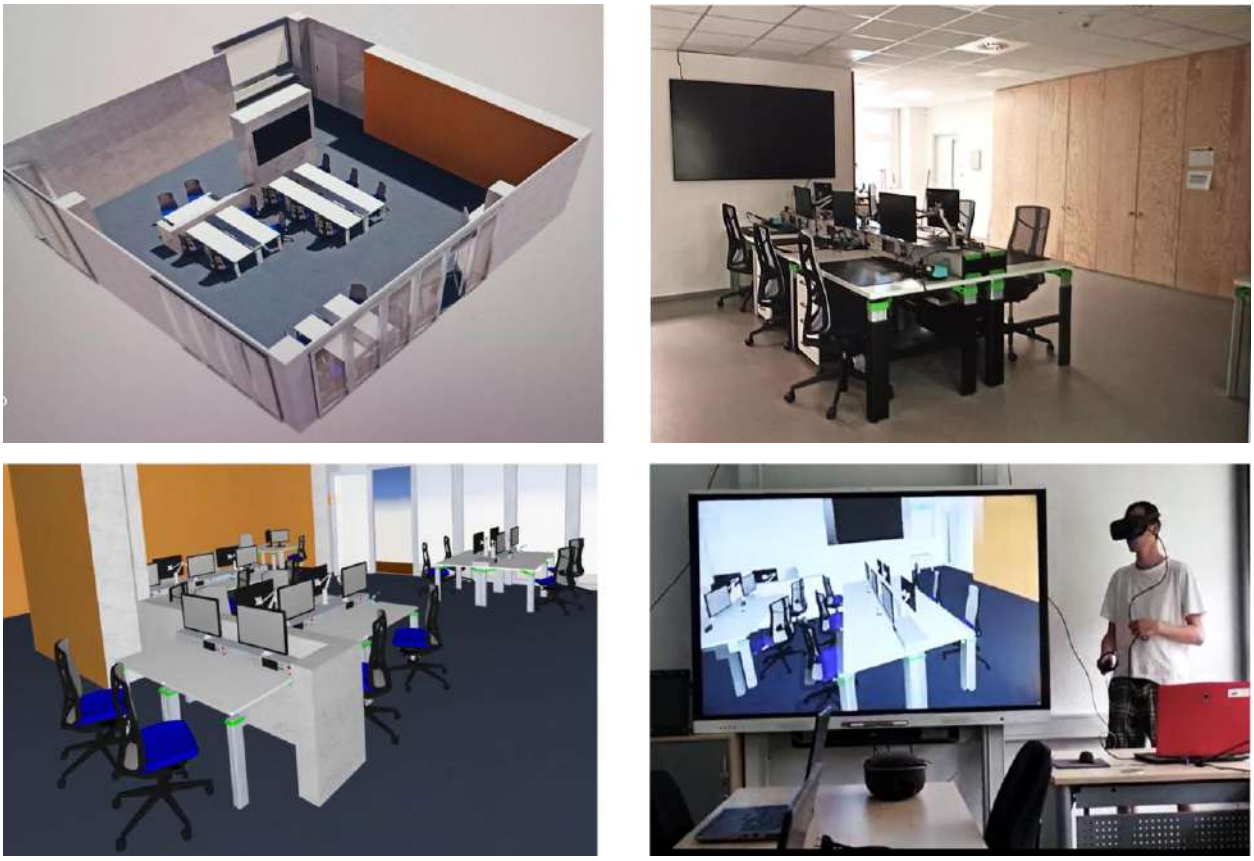

**Figure 5:** *Reality-Based Learning Environments as Virtual Environments, Which Simulate Real Environments for An Authentic Learning Experience*
*(Source: Self Illustrations)*

## 4. Results and Discussions

In the previous sections, it was shown, that virtual- and augmented reality are fantastic examples of technologies, that inspire and engage students by giving them new ways to experience learning. Smart learning environments allow the students to explore objects, learn concepts and develop skills. In this section, the benefits and impacts of the developed approach are to be listed, discussed, and additionally reflected on the educational and professional inclusion.

### 4.1. The Benefits and Impacts of The Proposed Educational Approach

The combination of Microlearning and immersive technologies using hybrid elements (Analog and digital, formal and informal, virtual and real environment, etc.) for educational purposes have resulted in the following advantages:

- Learners become more motivated and active due to the interactive application characteristics and because they live an experience using new technology.
- Learners understand the subject deeply because of the detailed visualization of processes and objects animation from different view angles.
- Learning in an MR environment fosters creativity, enhances the learning experience, and provides equal opportunities for students with different abilities, learning styles, and learning needs.
- Learners can direct their learning by choosing what they want to learn at their own pace and according to their own needs, matching their abilities.
- Learners improve their communication skills and teamwork through collaborative and cooperative learning. The immersive learning experience encourages interaction and cooperation among students and teachers and provides the chance to work together.
- Learners achieve a deeper understanding of how to use innovative technologies, and so they develop digital fluency and STEM skills at an early age before going into industry, where such technologies are daily tools.

The use of technology in the classroom for presenting and teaching, for interacting with contents and holograms, and for entertainingly conveying knowledge has given students new ways of obtaining, analyzing, and understanding information as well as the world around them. This influenced the teaching process very positive and led to a greater willingness to learn as well as an increase in student performance. Furthermore, the application of digital technologies is important for the preparation of new technology professionals, who are learning skills and training on the job. Dealing with these cutting-edge technologies, which will become part of future industries, will enable students a seamless transition from education into the working world of the future and increase their chances in the labor market.

### 4.2. The Impacts on The Educational and Professional Inclusion

Augmented reality is not only revolutionizing education but also has enormous benefits for disabled learners. For example, it supports people with learning difficulties through specifically selected digital content, be it an explanatory video (with sign language), 3D models, or exploded

views for people with spatial awareness deficits. It can also be a link to a barrier-free website on the Internet in easy language. Sound and moving images make Augmented reality an exciting medium for people with concentration problems and reading difficulties because it could be adapted to their disability and cognitive abilities.

It is foreseeable that AR/VR will also bring many advantages in professional inclusion. A good example is the trainees in our Technological Education Centre, who have worked on the developments, presented above in this paper. They are people with disabilities and through their exposure to AR and VR to support this research, they have developed expertise and qualification in this field. This qualification increases their chances on the labor market significantly since mixed reality is becoming one of the most sought-after technologies. Market analysis shows, that AR/VR technology will grow exponentially in the coming years and that professionals in this field will be in high demand. After all, smart glasses and mixed reality headsets will become standard tools in the workplace of the future, so it makes sense to prepare trainees and students for such scenarios e.g., remote maintenance and consulting, working with holograms of machines, virtual product presentation in Sales and After-Sales. Expertise in AR/VR gives people with disabilities the best chance for employment.

For the evaluation of the work, the learners have filled out a feedback form. They showed enthusiasm, fun in learning and confirmed that they could remember the content better. Normally, new information is forgotten very quickly, which affects learning success. But with the help of immersive learning technologies, learning becomes an unforgettable experience and helps to better retain what has been learned.

## 5. Conclusion

Good education is the best foundation for a good life and a good future in society. For this reason and due to the technological change in the world of work and professions, new methods of learning and working are needed. To better meet the demands of a rapidly evolving economy and society, education systems must change. Therefore, it is very necessary to modify and update the current curricula to familiarize future generations of students with the new technological innovations and to facilitate their transition into the world of work.

In this research and to design and deliver learning experiences that increase learning engagement and enable learners to learn more efficiently, flexibly, comfortably, and effectively,

new learning solutions have been explored. These blend the power of immersive technologies with a proven learning methodology, namely Microlearning. This combination is innovative and offers a lot of benefits. It allows teachers to adapt to students' interests, learning preferences, and abilities and ensures that students acquire 21st-century skills. These are primarily digital literacy, creative thinking, problem-solving, effective communication, teamwork, and the ability to produce creative projects. Using smart devices learners can access digital resources, connect and collaborate. Learning through immersive elements in small learning units creates deeper learning experiences that learners can remember and internalize. When learning is fun and learners understand what they are doing or learning, they are active and engaged. Learning through play by using technology in a hybrid smart learning environment (combining physical and immersive elements) enables the acquisition of knowledge in different contexts and allows learners to develop cognitive, social, and emotional skills. Including all elements of the Micro-Hybrid-Immersive educational concept, some advantages of technology-based education have been shown. AR and VR solve the limitation of materials and space, open up a new creative space for students to think innovatively. However, there are some limitations and hurdles, such as the inadequacies and the immaturity of the technology (The weight, comfort, usability of XR glasses), also the High procurement or development cost. These problems will be solved with time, as the potential of these technologies has been recognized all over the world. Also, the COVID-19 pandemic will further accelerate its breakthrough, and the work with these virtual tools will grow even faster and become more popular in the coming years. What we and other scientists should focus on is the development of the didactic concepts for technology-based education to help other teachers and learners to get started without putting the technology in the foreground. For this reason, in our future research, we will focus more on the combination with the classical methods and concepts, e.g. by designing Escape Rooms that include VR/AR game elements.

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