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Education 4.0: Hybrid Learning and Micro Learning 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 intelligent and connected technologies (Big Data, Internet of Thing, Artificial Intelligence, Cloud Computing, Machine Learning, Augmented Reality, Virtual Reality etc.). In the last few years, work and education have been inextricably linked, since education needs to prepare workforce for the demand. Education and training are becoming more closely related to the labour market, and so the goal is to foster smart learners to meet the needs of the work and life in the 21st century. Building such a future-ready education system requires designing educational curricula, that impart the knowledge and skills actually relevant to the modern workplace and to the fourth industrial revolution, which requires lifelong learning, adapting and developing new abilities. Therefore, we need learning and working environments that support the lifelong learning in the digital age. Enabled by the various pedagogical and technological innovations, brand new learning environments can be created to optimize learners' ability to learn. They are collectively referred as the commonly known "smart learning environments" which can best delineate the future learning environments. Innovative education based on advanced Technologies should not only focus on stimulating thinking and creativity, but also considering the individual differences and learning styles among the learners.

The purpose of this paper is twofold. First, we combine some educational concepts such as micro- and hybrid learning with the support of immersive technologies in order to develop smart learning environments for a personalized and gamified seamless learning experience.

Second, we show how the concept of Micro-hybrid-immersive learning could bridge the gap between academia and industry for new required skills and knowledge, enables a seamless transition between school and the world of work and achieves an educational inclusion.

Keywords

Education 4.0, Lifelong learning, Immersive technologies, Multiplayer experience, Authentic learning, Smart learning environment, Educational and professional inclusion

1. Introduction

Many of today's children will work in new types of professions that do not yet exist, with an increased premium on both digital and social-emotional skills in the coming years. The gap between education and jobs is further widened by limited innovation in education systems. Therefore, the Fourth Industrial Revolution has made it imperative that education systems adapt (WEF 2020). The technologies related to the "4.0 revolution" become an irreversible force driving the transformation of teaching and learning. For over a decade, educational researchers have been exploring how different innovative technologies could be integrated into traditional learning in order to enrich learning experience and enhance learning effectiveness (Cheung 2021). With advances in new technologies, education is rapidly taking off in new directions changing the way learners learn but also the way teachers teach (Sghari 2020). On 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 increase students' academic experiences and learning outcomes, as well as enhancing social networking and collaboration opportunities among students. Researches revealed that learning with technology does strengthen teaching and learning experiences (Pearce 2021). Smart education has also gained significance attention in recent years. Multidisciplinary researchers and educational professionals are continuously discussing the concept of smart learning (Zhu 2016) and there is no clear and unified definition of smart learning so far. Some researchers have promoted smart education through technologies, such as cloud computing (Kim et al. 2011), learning analytics (Lee 2020, Tempelaar 2021) and big data (Chaurasia 2018) in order to capture and analyse learning data towards improving learning and teaching (Cantabella 2019), as well as supporting the development of the personalized and adaptive learning (Peng 2019). Further researchers have promoted smart education through Internet of Things (Kuppusamy 2019), in which objects equipped with sensors, actuators, and

processors communicate with each other to design complex learning scenarios and keep track of the learner is learning experience. The Industry 4.0 paradigm has introduced several relevant changes in the competences and skills of employees, therefore many recent researches deal with the education in the context of Industry 4.0 (Assante 2019). Technology plays a large role in the education system, because it gives students new ways to experience learning, to create their own media, to gain a deeper understanding of the world around them and ignite their imagination. Immersive technologies such as augmented reality (AR) (Iatsyshyn 2019) and virtual reality (VR) (Vesisenaho et al., 2019) have recently gained prominence and have become increasingly a popular teaching and learning support tool across different disciplines. It provides an opportunity for students and teachers to experience, as well as interact with learning phenomena. Furthermore, other studies have established the pedagogical benefits of VR, such as the ability to support students with diverse learning styles (Oyelere 2020).

2. Our approach to Education 4.0

The 4th industrial revolution is based on technological innovations such as artificial intelligence, big data, virtual reality, blockchain, 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 improvement of information technologies and their introduction in many fields, in order 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 new evolutionary stage of society is called the technological age, for which it is important to train skilled workers, make them competitive and able to quickly master the professions of the future. Skills such as complex problem solving, critical thinking, creativity, collaboration, and digital literacy - are important for enabling people to be flexible enough to adapt to the changing needs of the job market. Therefore, in addition to the typical hard and soft skills, the academic institutes and universities must add another category of skills, i.e., digitalization 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 we have to face as teachers. However, the technologies are a way to master this challenge and represent an opportunity to deliver learning in new, gamified, and personalized ways, which could change the traditional role of teachers and facilitate 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 the lifelong learning.

Lifelong learning is the key to the future education and a new learning plan, which makes the vision of “Education 4.0” becomes a reality. We will no longer 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. The technology plays an important role supporting smart learning, but the focus should not be just on the utilization of smart devices and integrating new technologies in order 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 we present our approach to smart learning environment based on a micro-hybrid-immersive learning, which:

- integrates different technologies and smart devices into a seamless whole, in order to deliver the same content, but adapted to the different learner characteristics and individual abilities
- uses diverse methods of transmitting knowledge in immersive setting combined with the concept of microlearning, in order to achieve real learning efficiency and effectiveness
- allows the hybrid learning i.e., the switch between formal and informal settings, independent and class learning, varying learning times and places, and analog and digital learning formats.

3. Micro-Hybrid-Immersive learning as an educational concept

Since Virtual Reality (VR) and Augmented Reality (AR) came to education, the learning experience has undergone a tremendous change. Learning has become much more interactive than traditional methods. While VR provides a constructed reality, AR gives an enhanced view of a real image. Mixed reality (MR), as 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 our 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 we extend that concept with additional elements to meet the requirements of Education 4.0 and we present the results of the implementation.

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 we present the main features of our concept using different learning experiences.

3.1 Combining Augmented Reality and Microlearning

In our approach, we have combined for the theoretical lessons the concept Microlearning with augmented reality:

- Microlearning is a form of e-learning that focuses on time-efficient knowledge transfer. This could either be small learning units or short-term learning activities. 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 computer-generated information on top of to give an enhanced view of a real image.

Bei 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.

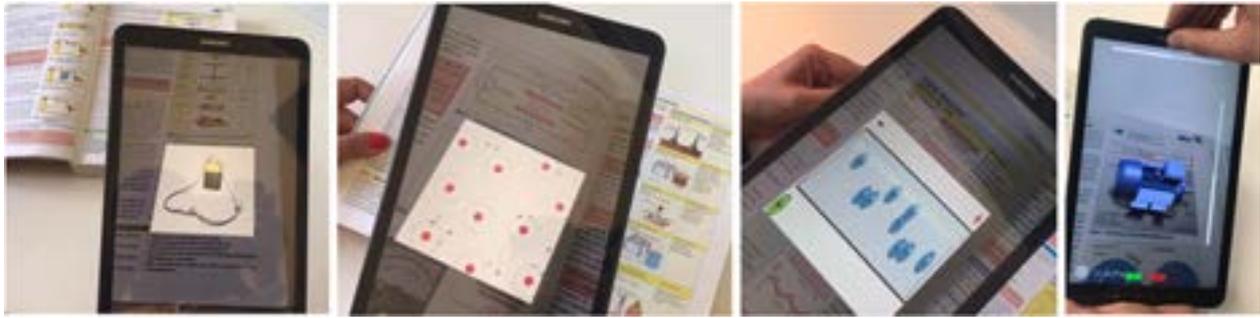


Figure 1: *AR-animation of our textbook for electrical engineering*

When the camera of the smartphone or tablet detects a trigger image in the book, a digital content is displayed. This could be a video, a 3D Model to interact with, an animation, an exploded view of a machine or a link to relevant websites. Students can control their own 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. 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 growing up with computer games, Internet and other digital media, which have shaped how they receive information and how they learn, want their own workstyles, to better fit the way they think and learn. These new workstyle and interface options help students focus on their work and learning, as their devices become more aligned with their personal preferences for how they interact with them.

For this purpose, we have developed the same learning content 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 full 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*

3.3 Multiplayer experience for collaborative learning

Real-time collaboration is one of the important new feature sets characterizing smart education of the future. For example, a multiplayer learning-experience can foster more effective collaboration, team-based learning activities and curriculums based on group tasks. This kind of learning units 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. 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 3: *Collaborative training situation in virtual-reality: operating and disassembling machines in a full immersive way.*



Figure 4: *Collaborative training situation in mixed-reality, where holograms of machines appear as a natural part of the real world*

3.3 Authentic learning through virtualization of real environments

With the aim of increasing the quality and authenticity of learning, we have developed virtual learning environments as a one-to-one mapping of real environments (Figure 5). The virtual world simulates the real world and allows students to experiment with different concepts, to switch between different learning activities and to navigate the virtual learning space easily by teleporting without any physical constraints. Virtual world learning provides a game-like learning environment for users and this “game” nature as well as the realism of the developed virtual world have a positive impact on student’s motivation and engagement in the learning activities. It enhances the learning experience and provides learners with opportunities to learn without real-world repercussions and personalize their learning experience. By performing specific tasks in the virtual world environment, learners could apply their abstract knowledge on situation in authentic, virtual contexts that are similar to the real environment. This helps them to better understand the context. In a next step, we will use such realistic virtual

environments as escape rooms. The concept of escape rooms is fairly new to education and is gaining popularity as a method for converting physical classrooms into exciting, alternative reality-based learning environments.

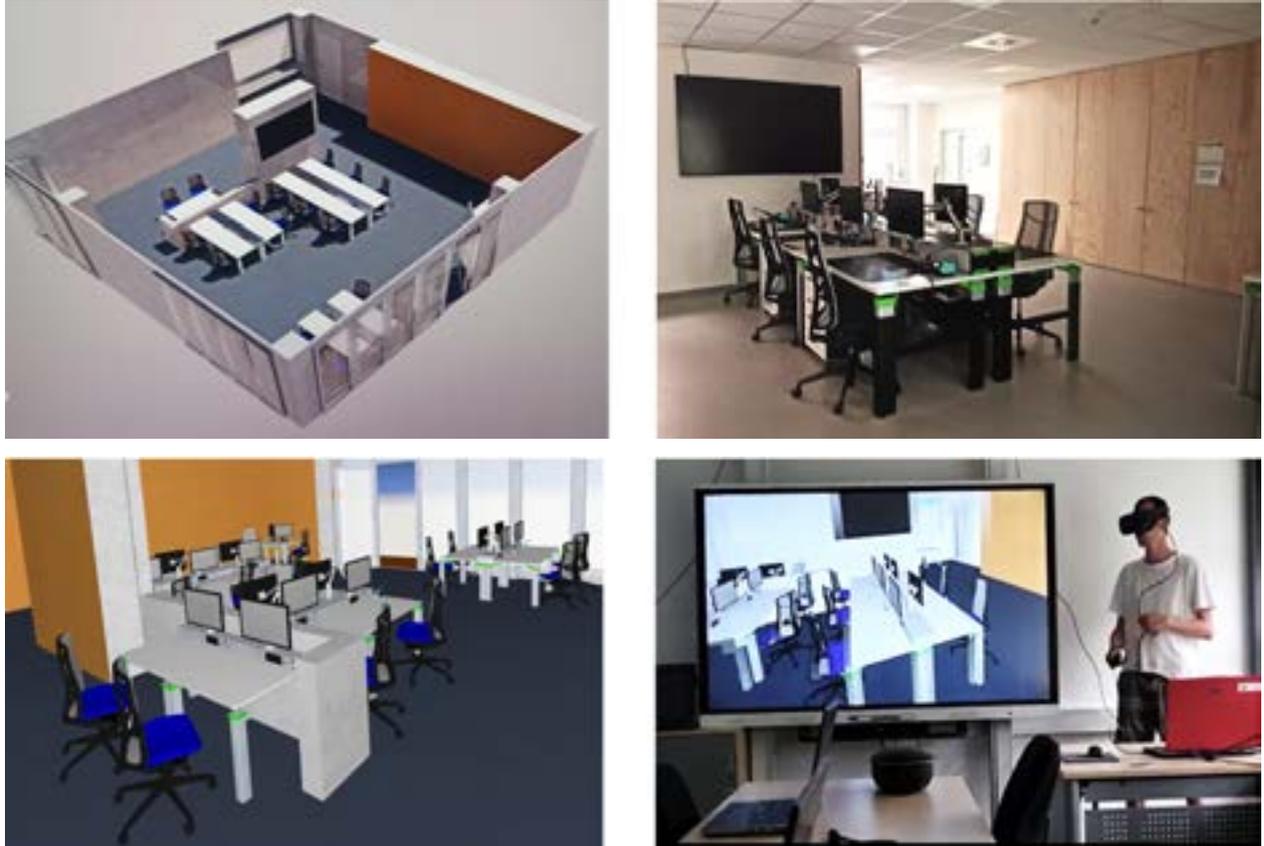


Figure 5: *Our reality-based learning environments as virtual environments, which simulate real environments for an authentic learning experience.*

4. The Benefits and Impacts of Our Educational Approach

Reforming the current education systems is needed to better equip today's students to meet future skills requirements. In the previous sections we have shown, that virtual- and augmented-reality are fantastic examples of technologies, that inspire and engage students by giving them new ways to experience learning and even create their own media. Smart learning environments allow the students to explore objects, perform tasks, learn concepts and develop skills. 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:

- Learner become more motivated and active due to the interactive application characteristics and because they live an experience using a new technology.
- Learner understand the subject deeply because of the detailed visualization of processes and objects animation from different view angles.
- Learning in MR-environment encourages creativity, improves the experience and provides equal opportunities to students with different skills, learning styles and learning needs.
- Learner can control their own learning by choosing what to learn in their own speed and need, which better suits to their individual characteristics.
- Learner 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.
- Learner achieve a deeper understanding of how to use innovative technologies, and so they develop digital fluency and STEM skills at an early age befor 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 conveying knowledge in an entertaining way has given students new ways of obtaining, analyzing and understanding information as well as the world around them. This influenced the teaching process very positively 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 for students a seamless transition from education into the working world of the future and increases their chances on the labor market.

5. The Impacts on the educational and professional inclusion

Augmented reality is not only revolutionizing on education but also has enormous benefits for disabled learner. 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 are the trainees in our Technological Education Center, 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 labour market significantly, since mixed reality is becoming one of the most sought-after technologies. Market analysis show, 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.

6. Conclusion

Good education is the best foundation for a good life and for 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. Education systems around the world will need to change to better meet the needs of a rapidly evolving economy and society. As Educators, we have to prepare our today's students for tomorrow's jobs. Therefore, it is vital to modulate and upgrade the current educational curriculums to educate and familiarize future generations of students with new technological innovations to support their transition into the world of work.

In order to design and deliver learning experiences that increase the learning engagement and enables learners to learn more effectively, efficiently, flexibly and comfortably, we have explored new learning solutions that blend the power of immersive technologies with a proven learning methodology, namely Microlearning. This combination is innovative and offers a lot of benefits. In comparison to the traditional teaching methods, immersive smart education is an interactive, collaborative and visual model, designed to increase student engagement and learning outcomes. It enables teachers to adapt to students' skills, interests and learning preferences and ensure, that students acquire the 21st century skills, including digital literacy, inventive thinking, problem solving, effective communication, teamwork and the ability to create creative projects. Using smart devices learners can access

digital resources, connect and collaborate. Purposeful learning through immersive elements in small learning units creates deeper learning experiences that a learner will remember and internalize. When learning is experienced as joyful and learner find meaning in what they are doing or learning, they are active and engaged. Learning through play with technology in a hybrid smart learning environment (combining physical and immersive elements) provides opportunities for young learners to acquire knowledge across a variety of contexts, while developing a range of holistic skills, such as cognitive, creative, physical, social and emotional skills. Including all elements of the Micro-Hybrid-Immersive educational concept has increased student engagement, have enhanced student satisfaction, and have positively impacted the learning experience.

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