“LEARNING 4.0"
VIRTUAL IMMERSIVE ENGINEERING EDUCATION

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New Working World with new players

→ New Working World

![Image of people and robots]

- Digitalization of the world of work
- Collaborative methods of working
- Advances in automation
- Enhanced human robot cooperation
- Contribution to demographic change

Source: http://newworldofwork.wordpress.com/

Technical world
- New phase of automation technology
- Robots outside fences/cages
- Mobile robotics...
- Robots in everyday life

Globalized organizations
- Structures above geographical distances
- Globalized virtual communication

Human resource management
- Active Sourcing 4.0
- IT-supported recruiting
- Shift from “permanently employed” to “temporarily employed”

Organizational functioning
- New types of organizations
- New ways of performance and success measurement

Source: http://www.weidmuller.com/bausteine.net/i/75013/Motiv-Sondertafel-Industrie-4.jpg
Everybody and everything is networked

“The first three industrial revolutions came about as a result of mechanization, electricity and IT. The introduction of the Internet of Things is ushering in a fourth industrial revolution. ... Industry 4.0 will address and solve some of the challenges facing the world today such as resource and energy efficiency, urban production and demographic change.”

Henning Kagermann et al., acatech, 2013

Vision of Wireless Next Generation System (WINGS) Lab at the University of Texas at San Antonio, Dr. Kelley

Weidmüller, Vision 2020 - Industrial Revolution 4.0

Intelligently networked, self-controlling manufacturing systems

“local” to “global”

around 1750

1st industrial revolution
Mechanical production systematically using the power of water and steam

around 1900

Power revolution
Centralized electric power infrastructure; mass production by division of labor

around 1970

Digital revolution
Digital computing and communication technology, enhancing systems’ intelligence

today

Information revolution
Everybody and everything is networked – networked information as a “huge brain”
Industry 4.0 will increase the amount of remote work and working in virtual spaces due to a higher degree of globalization.

Thus, the amount of remote education will increase (see MOOCs): 1,000+ students across the internet, joined at a VLE.

For Industry 4.0 virtual reality is promising to train e.g. the handling of new human-machine interfaces and also to serve remote and virtual working locations to fit the needs of further globalization.
Leading to new education models

“The innovation and development of Cyber-Physical Systems will require computer scientists and network professionals to work with experts in various disciplines. This, [...] will revolutionize how universities educate engineers and scientists.”


Solving complex, multidisciplinary, open-ended problems within changing and partly anonymous teams

Thinking critically and making judgements

21st Century skillset

Creativity and entrepreneurial thinking

Communicating and collaborating in new ways

Making innovative use of knowledge and information

Leading to new education models
Virtual Worlds and Natural User Interfaces

Virtual world = A model of the physical world

Identification through avatars
Real-time communication
Interaction and modification

“A natural user interface (NUI) describes an interface, which is controlled directly by one or many senses of the user. Therefore it forms a superordinate concept for many ways of interaction through the human-machine-interface”

Bollhoefer 2009

http://www.gamedesignideas.com/tag/well-testing-welltest-simulator-in-3d
Contributions of Virtual Reality to “4.0”

1. Learners (represented by avatars)
   - alone or with partners
   - autonomous or guided

2. A model of the world
   - use
   - historical events
   - industrial processes
   - inaccessible places
   - nonexistent places

3. Communication tools
   - by
   - chats and panels
   - virtual documents
   - talk via headsets
   - mimic, gesture, emojis

4. Modifications
   - as well as

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**Benefits**

In times of “4.0” virtual environments offer the possibility of

- **hazard-free, explorative** learning
- visualization of otherwise **invisible** processes
- new modes of human-machine-interaction
- **presence, immersion** and **flow** (based on e.g. NUI)

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Immersion, Presence and Flow

→ Presence
Spatial sense in a mediated environment.

„Key constructs for the learning success in Industry 4.0 “

→ Immersion
Immersion is a metaphorical term derived from the *physical experience* of being *submerged in water* (...) the sensation of *being surrounded by a completely other reality*, as different as water is from air that takes over all of our attention, our *whole perceptual apparatus.*” Murray, 1997

→ Flow
“One of the *most universal and distinctive features* of optimal experience is the *people* become so involved in what they are *doing* that the activity becomes *spontaneous, almost automatic*; they stop being aware of themselves as separate from the actions they are performing. It often requires strenous physical exertion, or highly disciplined mental activity to enter a continuous flow.”

Csikszentmihalyi et al. 1990
Exemplary Research Questions

1. To what extend, support/distract NUI factors of cognitive performance (e.g. retention rates)?

2. Are virtual worlds limited to self-directed learning processes? How can teaching activities take place?

3. How can collaborative (interdisciplinary) problem solving processes be trained?

4. ...
Performance in virtual worlds

Performing in Virtual Worlds

Investigation of the hardware influence on participants performance and the key constructs presence, flow and immersion

Task: Participants explore a maze and try to remember positions of objects

Further research: Impact of habituation, virtual collaboration, Teacher’s role within the virtual learning environment, impact of improved hardware
Teaching in virtual worlds

Study About the Teachers Perspective

For the VLE, the Open World / Sandbox Game „Minecraft“ was chosen. The participants’ spatial behavior was assessed with a screen capture tool. After the experiment, a structured interview was conducted. The average age was 40.7 with n=2 females. The aim was (a) to learn the basics as trainee and (b) to instruct the confederate to solve an issue.

Higher age means difficulties with hand-cursor coordination (habituation in 60 sec.); the trainers are open-minded for the usage of VLE; positive for the trainers is the adaptability of VLEs.
Collaboration in Virtual Worlds

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<th>➔ Collaborative Problem Solving</th>
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<td>Investigation of the impact and effects of collaboration within VLEs: Two participants should solve an issue; one participant alone cannot solve it because the necessary items are randomly distributed across both.</td>
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| ➔ | Inform | At the begin of the experiment each participant got a training in the VLE to attain the necessarily knowledge of the control mechanism. After the training two learners, who were unknown to each other, enter the learning scenario to solve a technical problem together. Learners were seated in separated rooms, communication took part over headphones. |

| ➔ | Note | The first period of the study took place in late July 2015 with 48 participants over 5 days and yielded about 8 hours of interviews, 28 hours video material and 127,000 coordinates about the movements of the participants. The data analysis is still ongoing. |
(Preliminary) Results

1. The screening of the gathered video data indicates that age and online-gaming experience were shown to be related to participants’ spatial coordination within the virtual learning environments.

2. It was shown that participants who reported higher sensations of immersion, got used to the virtual world faster, as seen by their objective behavior (e.g. number of gaze fixations, fluency of movement). To which extend this is a consequence of participants precondition and mixed reality devices needs further investigation.

3. Participants who documented their course of action out loud performed more efficiently; hence they finished the sub-goals faster and showed a better transfer of knowledge into the physical world.
From Virtual Worlds to Mixed Reality

Connection of multiple platforms

Virtual Cooperation

Technical Developments

Integration of all senses

Industry

practice-oriented transfer of knowledge

Didactics

contextual aware problem solving

Embedded Assessment

Next Level Mixed Reality

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Conclusion

1. Results show that VLE bear a promising potential for successful implementation within higher education. But it is going to be a new challenge for teachers and users to teach, learn and work in the virtual world. It has to be figured out to what extend classical didactical concepts of higher education can be transferred into VR-based education.

2. Tomorrow, trainers have to be able to prepare virtual learning environment as they prepare presentations and handouts today. For the successful usage of mixed reality virtual learning environments for everyday teaching, training and learning for suitable topics, VLE must be provided which can be created without deep knowledge in computer science.

3. This studies showed the potential of nowadays-recent progress regarding the ongoing digitalization, but it is necessary to take care that everyone can be involved in this developments. Therefore, continuing this kind of research and further improvement of the technology is an important contribution towards tomorrow’s proliferous and digitalized world for everyone.
Thank you for your attention!

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