EXPERIENTIAL LEARNING OF MECHATRONICS IN A MIXED REALITY LEARNING SPACE

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Introduction

In modern vocational training and education, integrated learning scenarios where e-learning is linked with the world of work play an important role. The current generation of e-learning environments does not provide an integrated solution able to meet these requirements in vocational training of mechatronics yet [3]. The European project "Virtual Laboratory in Mechatronics: Access to Remote and Virtual E-Learning" (MARVEL) deals with the above mentioned requirements. The objective of this paper is to discuss some key ideas of the MARVEL project. First we outline the background of MARVEL, followed by a brief discussion of its pedagogical concept. Then we will introduce our approach of a *mixed reality learning space* which compromises a taxonomy of learning media, places and activities. Before concluding, some learning scenarios are presented to illustrate the proposed approach in practice.

The MARVEL Approach

MARVEL is an education and training project funded by the European Leonardo da Vinci programme. The project focuses on learning arrangements allowing remote and distributed working with laboratories, workshops and real working-places in the field of mechatronics [6]. A major goal of the MARVEL project is the usage of real worlds in virtual learning environments in order to support work-process-oriented learning with real-life systems from different learning locations. Telematics, remote and mixed reality techniques are used cooperatively within a network that includes colleges, industry partners, and national bodies dealing with certification and standardisation issues. Thus the project has an organisational development goal, which is the co-ordination of learning facilities in different institutions and countries to form a transnational learning network of remote laboratories and distributed workshops. Currently the MARVEL project consists of seven member institutions as shown in figure 1.

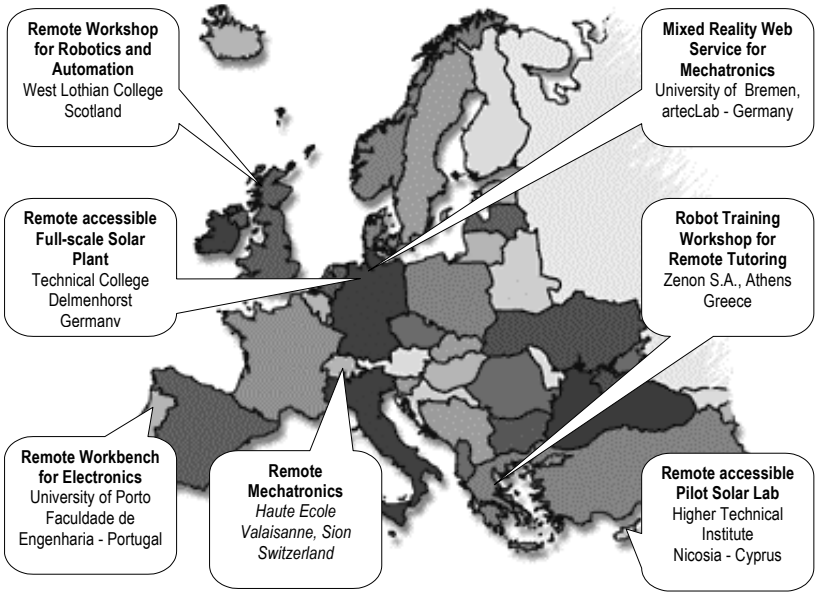

Figure 1: The MARVEL network of distributed labs and workshop facilities

The MARVEL project evaluates and makes available working examples of remotely accessible practical environments, including e-learning and student assessment materials for various application fields and use cases. In relation to real work tasks, the training of non-technical skills such as teamwork, the ability to communicate in foreign languages, intercultural competence and customer orientation, will be an important goal in the MARVEL learning scenarios. Working with remote work assignments, experiments, collaboration in distributed teams and communication in a foreign language with students from a partner college may help to develop and train these soft skills.

Pedagogical concept

In our approach we try to combine simulation training, remote lab experimentation and learning-by-doing on real-life systems to reduce knowledge transfer problems between virtual and real systems. The MARVEL project follows an innovative paradigm in engineering education and vocational training by supporting local and distributed learning based on merging virtual and real labs and workshop facilities. Mixing tangible objects of real work spaces with the digital representation of information spaces, is an approach that witnessed an increasing interest during the last decade [6,1]. This concept – also known as Mixed Reality – provides an interesting idea which comes close to our requirements.

In relation to the MARVEL project our research is less focused on technical issues[1] of Mixed Reality and more on the question of how to organize and arrange learning spaces for distributed learning and working along the *reality-virtuality continuum*. Thus the approach in MARVEL, which is presented in this paper, describes an organisational concept, in terms of learning scenarios and their implementation into learning and/or working processes. It is based on the idea of a mixed reality learning space that spans the reality-virtual continuum and integrates the local and remote as well as different learning activities. Figure 2 illustrates the dimensions of the mixed reality learning space and shows the range of choices available and the possible interaction among the various technological alternatives.

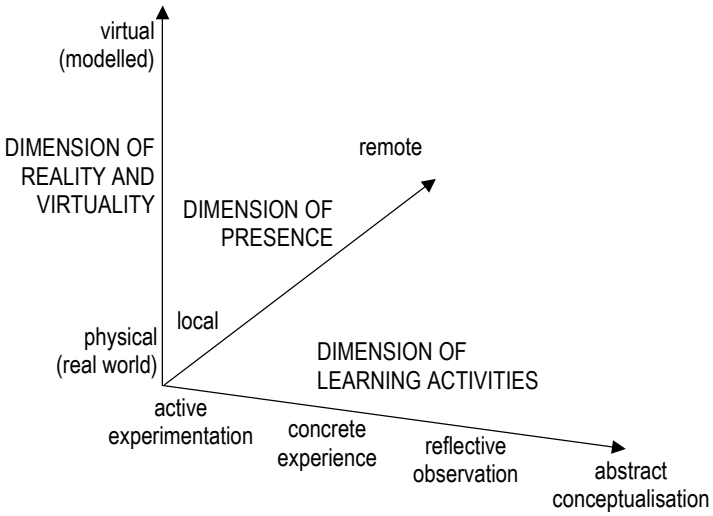

Figure 2: Mixed Reality Learning Space

There are three motivations behind this taxonomy. First it allows to explore the didactical impact of virtual as well as real (physical) learning media and tools in the learning process. Second, such a taxonomy may identify which learning activity requires which tools. Third, producing a clear taxonomy helps to build a *rich* learning environment, which has the capability to support different learning modes and styles. To illustrate the practical use of this taxonomy, the three dimensions will be explained more in detail:

1. Dimension of reality and virtuality: The dimension of reality and virtuality (reality-virtuality continuum) concerns the extent to which a learning media/tool is either totally virtual or is based on

[1] More about our technical approaches in connection with Mixed Reality see BRUNS [2].

the physical world. This spans the extremes from fully virtual environments (e.g. virtual lab, computer-based simulation, digital worlds) to wholly physical environments (e.g. work-based learning, on-site training).

2. Dimension of presence: The dimension of presence concerns the extent to which a learner or a group of learners is acting in their local space 'the sense of being there' or interacting from remote. This spans face-to-face on the one side and distance education on the other. Face-to-face learning still plays a major role in education and training. The advantages of classroom learning, because of the direct contact, both in and out of class, can engage students in thinking and interaction through questioning, discussion, small-group presentation, role play, and case studies. In practices, the advantages of face-to-face and distance learning methods might complement each other.

3. Dimension of learning activities: This dimension covers different learning modes. In line with the theory of experiential learning [4], which is the educational concept behind MARVEL, there are several underlining modes that characterize a learning activity: action, experience, reflection, and conceptualisation. As the learning process is not identical for all people, different learning styles can be distinguished as well. Preference for one or more modes over others indicates a preferred learning style. But learning styles are also context-dependent. Depending on the learning task, the experience with the learning subject, and the point in time when learning takes place different learners will adopt different learning styles for the same task, and a single learner may change learning styles from one situation to another. Consequently, an appropriate environment that accommodates various learning styles is essential for effective learning [8].

Learning scenarios

The learning scenarios considered in MARVEL address various mechatronic systems and use cases, but concentrate initially on process control, robotic systems and computer integrated manufacturing and electronics. A brief characterisation of these learning scenarios is presented in the table below.

Learning scenarios	Settings and course trials
1. Distributed process monitoring, control and maintenance of a solar plant	Classroom-only and various types of mixed classroom-workplace learning settings, including remote experiments and teaching sessions with teams from partner colleges in different countries.
2. Configuration and programming of a robot with support by a tele-tutor	
3. Distributed diagnosis and maintenance of a modular production system	
4. Exercises in remote engineering and mechatronics	
5. Remote experiments in electronic circuit design	

Table 1: MARVEL learning scenarios

Various experiments have already been evaluated in a local setting with students [7,5]. Distributed learning settings will also be evaluated, where students will access virtual and physical laboratories and workbenches from a remote partner institution. A teacher, assuming the role of a tele-tutor, will support these learning sessions via Internet. In further course trials distributed learning groups will collaborate via Internet and solve a typical maintenance task, requiring them to program and/or configure a real mechatronic system. For safety reasons, their ability to modify parameters remotely is limited, and the learning task will be supervised by an instructor at each site. As a complementary action to distributed settings, teachers will hold a joint teaching session with the partner colleges, using their local lab facilities.

An important aspect within MARVEL is that concepts and examples for real working and learning are developed and accessed virtually through remote processes. These concepts support the social aspects of learning, as learning is necessarily integrated in communication processes, among different learning groups while working at the same machine. Because learning by experience in a real and social context is more and more restricted in pure virtual environments, our taxonomy of a Mixed Reality Learning Space might help to make the appropriate didactical decisions.

Conclusion

This paper outlines some key ideas of the MARVEL project. The approach, which is presented here, describes an organisational concept, in terms of learning scenarios and their implementation into learning and/or working processes. It is based on the idea of a *mixed reality learning space* that spans the reality-virtual continuum and integrates the local and remote and different learning modes. This can be achieved by learning arrangements where e-learning with simulations and remote laboratories is combined ('mixed') with experiential learning in real laboratories and at the workplace. Our approach is seen as a step for realizing the concept of "Virtual-reality e-learning" within a particular subject field of mechatronics. E-learning or even Blended Learning – in the classical sense characterized as web-based training – is limited in scope because learning experiences are restricted to working within virtual situations. That is why a learning concept following the idea of mixed reality could promise new learning perspectives and could go further than Blended Learning.

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