MODULAR EDUCATION MODEL: A PROCESS OF VIRTUAL ENVIRONMENT IMPLEMENTATION TO IMPROVE STUDENTS MOBILITY

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Abstract

This paper describes a research project of the design and implementation of modular education model for effective virtual environment support of technical faculty students key competences improvement that involves intentions of the University of Zilina, a science, education and research institution. The research works respond to the outputs of project supported by the Nation Cultural and Education Agency (Slovakia) as an arm that guides the mission for research support of the Ministry of Education. Improving the faculty education environment, particularly those that are engineering-performing includes requirements that are effectively adopted to assess targeted goals for 21st century technical graduates’ key competences. Underlying basis of the research project, the continuous improvement of the education model addresses key students career-ready competences supporting the challenges faced by the education and industry area attempting to scale up educational innovations fulfilling targets such as improving teachers high-order competences and attending to the organizational context in which improvements are to be enacted. At the core of the project’s work in the period of 2016-2018 presented in this article is an implementation process to bring to scale practices that have been shown to improve support of students’ mobility achievement in three core competences: activity, innovation, cooperation. This research focused upon qualitative synthesis methods to investigate faculty experiences with modular teaching/learning concept implementation. In particular, the study used virtual education environment and an interpretive approach to synthesize findings from 9 experimental pilot students groups conducted by 7 researchers involving teachers-practitioners to modules review, students’ learning outcomes portfolio assessments and interviews with 100 faculty students with modular teaching/learning experiences. In this article, the author identifies handful research results of innovative modular education concept in virtual environment that can help to achieve the goal that all graduates from technical faculty are well-prepared for further long-life learning, successful careers, and flexible adaptation in the society. First, a modular education model is built to reflect the core elements of engineering education programs and practices that have been shown to be effective in students pilot groups engaged in perspective study programs (mechatronics, electronics, autotronics). Second, modules design-cycle testing is used to allow the modules to be revised in ways that adapt it to a particular engineering learning content in specific technical skills implementing support of activity, innovation and cooperation. Third, a project researchers and education practitioners partnership is employed that strives to both take advantage of and build faculty didactics knowledge management ownership and teachers expertise. The paper explains the theories that drive this technical faculty improvement model, reviews evidence of their effectiveness to date, and suggests what it will take to make them work well. The results stress that students’ activity, innovation and cooperation improvement approaches can ensure the success of the faculty. The reasons for higher performances are complex and determined by synergy of multiple factors: personal, organizational, technological; these factors have very real consequences for education improvement with much more challenges. Finally, the article concludes with a set of recommendations for faculty management, teachers, industry representatives and researchers to enhance the evidence base and increase the knowledge of how faculties’ success outcomes can improve over time.

Keywords: Engineering education, student’s mobility, modular concept, virtual environment, key competences, activity, innovation, cooperation.

1 INTRODUCTION TO MODULAR CONCEPT

Technical faculties are high-expectation users and creative innovators when it comes to modular technology concept adoption. Today, research, education and production networks connect faculty teachers, researchers and students for innovative projects that require extensive graduates’ mobility in activity, innovation, cooperation and transfer of enormous knowledge and skills volumes [1]. Behind the scenes, faculty and research group who specialize in education environment explore how to
advance the virtual environment implementation with new design procedure concepts and technologies massive support [2]. To solve the challenge for more flexible networking of faculty, industry and social area, the research project is focusing on a new teaching/learning concept: modular education model and virtual environment implementation to support of faculty students mobility in graduates’ career ready professional hard skills and personnel soft skills in activity, innovation cooperation domain [3]. The research team is actively involved in encouraging development of modular education model with virtual technologies support, both through classroom innovative projects with students’ engagement and participation in the national Cultural and Education Agency (KEGA) infrastructure support. The projects teachers and students working groups’ involvement across the nation are already realizing the many advantages that project results offer [4], [5]. Yet meeting the diverse and growing needs of the academic members is a challenge for faculty workplace. With the fixed design and configuration, traditional workplace simply cannot support the unpredictable and dynamic mobility required for emerging types of applications, advanced levels of collaboration and increasing speeds of engineering skills growth. This is the perfect time for the project initiatives because the whole modular model with virtual environment support is going through a big inflection point for industry and academia.

2 STUDENTS MOBILITY IMPROVEMENT METHODOLOGY

Employers in an industry want employees graduated in technical faculty who are self-motivated [6] and able to effectively interact with others in changing situation. These skills are also very hard to teach, so employers want to know that job candidates already have the soft skills that enable them to be successful in the real workplaces. Soft skills are the personal attributes graduates need to succeed in the workplace. These are often related to how employee works with others, in other words, these are individual people characteristics for further engagement of graduate mobility in workplace. Soft skills are different from hard skills, which are directly relevant to the professional job to which employees are applying. These are often more quantifiable, and easier to learn. A hard skill for a technology control module operation, for example, might be the ability to design, tuning and operate production machines, maintenance procedure and use diagnostics tools. Regardless of the job to which students are applying, we need at least some soft skills. In order to succeed at work, all graduates must get along well with all the people with whom students interact, including managers, co-workers, clients, vendors, customers, and anyone else graduates communicate with while on the job.

2.1 Mobility enhancement: Soft skills for activity, innovation, cooperation

Modular concept with virtual technology brings a new level of students mobility support in dynamic interaction to the technology classroom by digital mimicking technical laboratories in a realistic way so that students’ acquisition of the hard and soft competences necessary in the real world may be assessed, measured and graded through the use of a simulated virtual instrumentation environment in each of learning content modules [7]. Since many attempts and different approaches are used during the module filling, several sources of evidence are collected during a task which increase the validity of the knowledge and skills achievement claims made from the tasks results assessment. To maximize the potential of modular concept in virtual instrumentation environment as a tool to measure students’ professional hard and soft competences for problem solving, project filling and technical inquiry, it is important to properly prepare students for the set of assessment methodology and criteria [8]. Since selected education modules are designed to emulate traditional hands-on laboratory tasks, some of the tools that are used to prepare students for traditional laboratory tasks may also benefit them when they use virtual laboratory tasks. Traditional laboratory tasks utilize a pre-laboratory activities and training to cognitively and affectively prepare students before starting the experiment in a virtual instrumentation environment introducing students to better prepare them for the module tasks completion assessment. Principal traditional laboratory activities enhance students’ performances in their prior experiences and exposing the knowledge and skills they are struggling with ahead of the virtual laboratory environment.

2.2 Mobility support: Virtual education environment

Virtual digital education environment laboratory assessments are gaining popularity as a technology educational assessment tool that can measure students’ competences such as problem solving and scientific inquiry within classroom technology environments and learning content. Competences are a combination of learning content knowledge and processing skills with individual soft skills level that
lead to the practices and culture of learning engineering graduates’ competences by doing it, which require assessments that measure and grade teaching/learning process effectiveness. Virtual instrumentations, which are computer programs modules and specific hardware modules that contain models of hands-on technology laboratories, may provide the environment needed to measure students’ process-based competences [9]. Virtualized laboratory education concept provide students with a digital design, modelling and simulation support to mimic the activities, innovation and cooperation that take place during hands-on technology laboratory, the latter of which may sometimes include elements that are considered unusable, non-practical, poor-functioned, or impossible to run in a technology classroom practical projects’ procedure. Fig. 1 presents a modelling of thermal model of power electronics devices and active simulation processing of how virtual instruments works in real electronics module [10]. There are two channels of learning process - cognitive model channel for processing knowledge of learning content and visual channel for processing pictorial interpretation that enhanced activity and innovation for students mobility improvement adding visualization to word-based theory lessons to improve students’ understanding of learning content and to form higher order competence.

2.3 Mobility improvement: Interactive simulation approach

Interactive simulations are frequently used in classroom education modules as a supplement to traditional hands-on students’ experimental laboratory experiences. They have been shown to improve students’ knowledge integration skills, which in turn facilitate a deeper understanding of complex topics and have been shown to contribute to conceptual change by placing greater focus on higher-level thinking processes instead of technical skills normally required in a traditional hands-on laboratory. While these virtual environment laboratories have been shown to be an effective teaching and learning tool, it is important to extend the potential of these modelling and simulations so that they may be assessment and grading tools, as well. For example, design and implementation of 8 selected education modules principal for targeted study program reflects an extension of digital simulation laboratory environment because they include the evidence knowledge, skills and critical decisions capture features in students’ mobility enhancement resulting evidence mobility improvement. This evidence-based capture features in virtual education environment allows the tracking of students’ activity, innovation and cooperation improvement on an approach of processing data in complex individual student’s interactions captured during the tasks solution in each of education module to be collected and analysed as evidence of students’ output acquisition of key competences related to graduates career-ready mobility needs. To illustrate the output of virtual education environments from a modelling and simulation training module in modular concept, we describe the thermal modelling design of the power semiconductor device, followed by simulation of two modified device construction. In the model there are also defined boundaries conditions, such as thermal or electrical insulation. Student’s in individual activity identifies addition boundaries, material transition and thermal conductivity as a set of real devices parameters. Hard engineering skills are concentrated to power electronics module theory followed by innovative approach to examine the real physical samples in cooperation with real devices producers’ environment to choose operation parameters of the area under the chip warped by a solder with a relatively high thermal conductivity value to evaluate and compare conductivity to the top surface of the silicon-coated chip. To illustrate students mobility improvement in the targeted competences output, Fig. 2 and Fig. 3 present a simulating of thermal model of power electronics devices in alternatives simulation processing and innovation principle of how virtual instruments works in mental representing electronics module for different design is...

Figure 1. Thermal model – definition of domain and borders for 9 bonds (2+3) matrix layout).
activated resulting in a meaningful learning long-term outcomes. The temperature distribution on the power module surface has, among other factors, a major impact on its life. When designing bonds placement, we try to make the difference between the maximum and minimum temperature on the chip face as small as possible. The high current peaks resistance of power semiconductor devices is important for predicting the reliability and performances of power electronics modules and ensuring their safe operation. The effect of exceeding the rated maximum safe bonding junction temperature can range from a change of electrical characteristics of the power module to terrible failure.

Thus, this knowledge is critical for power modules reliability and performance prediction, and as a higher order of electrical engineer subtends as a key competence. A simulation and modelling virtual environment program can help student to improve mobility by means of activity, innovation, cooperation. In the following simulations, student can monitor the chip temperature distribution for different bonds arrangement and the alternative construction.
3 STUDENTS MOBILITY IMPROVEMENT RESEARCH DESIGN

Identifying students’ areas of hard and soft competences strengths and weaknesses before engaging with the virtual laboratory ensures students have an opportunity to acquire basic understanding of the knowledge and skills need for the laboratory. All of students than has opportunity to use individual learning style and improve the less-preferred learning style depending on specific learning content and key competences required [11]. The recognition of knowledge readiness level serves to enhance student focus on the process of acquiring new learning content knowledge and application hard and soft skills during the laboratory exercises. Virtual instruments that help prepare students for a laboratory may be especially relevant for simulated environments where students become easily distracted and confused by the electronic circuits graphics and digital interactions of the activity. We investigated digital virtual laboratory impact to administer education modules prior to the modelling and simulation procedure because the modelling and simulation are often not the main real world activity; modelling and simulation procedure is used as a supplement to a traditional hands-on education, research and development laboratory. Since modules aim to mimic real-life laboratory environments, by means of investigating the efficacy of virtual instrumentation in a modular concept in enhancing students’ performance during the laboratory we confirm evidently improved their effectiveness in career-ready knowledge and skills adoption. At the core of the project’s research work in the period of 2016-2018 is an implementation process to bring to scale practices that have been shown to improve support of students’ mobility achievement in three core competences: activity, innovation, cooperation. This research focused upon qualitative synthesis methods to investigate faculty experiences with modular teaching/learning concept implementation. In particular, the study used virtual education environment and an interpretive approach to synthesize findings from 9 experimental pilot students groups conducted by 7 researchers involving teachers-practitioners to modules review, students’ learning outcomes portfolio assessments and regular interviews with 100 faculty students with modular teaching/learning experiences.

3.1 Mobility assessment: Individual portfolio

The complex students’ activity, innovation and cooperation improvement interactions are continuously collected into individual student’s portfolio-file that captures every tasks action during completion of the education module milestones. The portfolio-files of each student are analysed to help teachers understand the procedure how a student arrived to the task solution and to give them individual student’s mind map overview to concluded specific activity goals (Fig.4).

![Figure 4. Monitoring concepts and tools in virtual education environment (proportional).](image)

Since these portfolio-files capture the fine-grained actions students use to solve a module specific task, virtual education environment may have the potential of providing valuable feedback on process-based competences such as technology problem solving, project management and scientific inquiry.
These process-based key competences are often associated with the use of diverse ways to approach a specific task in education module. The tasks assessment allows students to use different approaches related to student’s individual knowledge model and learning style and explains the didactic theories that drive the technical faculty teaching-learning improvement model and reviews evidence of the educational institution effectiveness to date.

4 MODULAR CONCEPT RESULTS

We identify handful research results of innovative modular education concept in virtual environment that can help to achieve the goal that all graduates from technical faculty are well-prepared for further long-life learning, successful careers, and flexible adaptation in the society.

- modular education model reflects the learning content core elements of engineering education programs and practices that have been shown to be effective in students pilot groups engaged in perspective study programs (mechatronics, electronics, autotronics),
- modules design-cycle testing allows the modules to be periodically revised in ways that adapt it to a particular engineering learning content in specific technical skills implementing parallel support of activity, innovation and cooperation,
- project researchers and education practitioners partnership strives to both to take advantage of and builds faculty didactics knowledge management ownership and teachers expertise in higher order of pedagogical competences.

4.1 Mobility improvement: Category of Activity, Innovation, Cooperation

Students in an initial period of semester were not be accustomed to the virtual laboratory environment in which multiple trials were expected to be conducted so that previous trials informed and influenced later attempts. Hence, there may be a need to explicitly educate students regarding process-based competences and the necessity of approaching problems using different teaching methods and repeating experimental trials. One reason for conducting repeated experimental trials is to learn from previous trials, or errors, to inform necessary changes to subsequent trials. This part of research focused upon activity, innovation, cooperation as a preference to students’ mobility to investigate teachers/students experiences with modular teaching/learning concept implementation in virtual education environment. Interpretive approach to summarize findings from 9 experimental pilot students groups conducted by 7 researchers involving teachers-practitioners to hierarchy category design and assessment, students’ preferences outcomes assessments and regular survey addressing 100 faculty students with modular teaching/learning experiences is summarized in Tab 1.

<table>
<thead>
<tr>
<th>Hierarchy</th>
<th>Experts</th>
<th>Category</th>
<th>Preferences - Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>acquisition of new information</td>
<td>14.29</td>
<td>57.14</td>
</tr>
<tr>
<td>2</td>
<td>forming of general insight on issues</td>
<td>14.29</td>
<td>85.71</td>
</tr>
<tr>
<td>3</td>
<td>adoption of methods to foster creativity</td>
<td>71.43</td>
<td>28.57</td>
</tr>
<tr>
<td>4</td>
<td>support skills in computer programs</td>
<td>14.29</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>generation of new ideas</td>
<td>28.57</td>
<td>71.43</td>
</tr>
<tr>
<td>6</td>
<td>improvement of knowledge expression</td>
<td>42.86</td>
<td>28.57</td>
</tr>
<tr>
<td>7</td>
<td>acquisition of the insight in the field</td>
<td>28.57</td>
<td>57.14</td>
</tr>
<tr>
<td>8</td>
<td>implementation of knowledge into practice</td>
<td>0</td>
<td>28.57</td>
</tr>
<tr>
<td>9</td>
<td>ability to decide to the right choice</td>
<td>14.29</td>
<td>14.29</td>
</tr>
<tr>
<td>10</td>
<td>attractiveness of the results presentation</td>
<td>0</td>
<td>14.29</td>
</tr>
</tbody>
</table>

The category of activity, innovation, cooperation role to improve mobility findings of 100 respondents in pilot groups of students engaged in modular concept with virtual environment are summarized in a series of reports in aggregate numbers of relative units (%). As an example, following results of one of
11 students’ experimental groups and 7 experts it is possible to see category hierarchy preferences highlighted in 3 different colours: red – high, yellow – middle, green – small.

The activity, innovation, cooperation skills research in pilot groups during experimental didactic cycle explains the engineering an pedagogy theories that drive the technical faculty improvement model, reviews evidence of their effectiveness to date, and suggests what it will take to make them work well. Virtual instruments in education environment for teachers/students mobility improvement are designed to:

- operate the parametric models mimicking real-life laboratories,
- strength in allowing students to conduct several trials during an experiment to create an iterative didactic cycle, which is an essential aspect of process-based competences such as specific module problem solving.

4.2 Mobility improvement: Learning outcomes

Modular concept to mobility improvement as this paper is attempting to demonstrate (Fig. 4) is offering a wide range of possibilities and is very diverse in nature to individual soft-skills, learning styles, and activity, innovation, cooperation approach of each of student resulting:

- increasing diversity in teachers/students education methodology,
- increasing higher-order knowledge and hard-skills of individual students,
- promoting student-centred approach,
- improving cooperation procedure,
- enhancing creativity output and innovation in research projects,
- improving individual activity,
- accessing new environment,
- solving problem in different situations.

This study have focused on the modular concept in virtual education environment and technology enhance pedagogy to accommodate changing student educational needs, and experiential learning can be promoted by adaptive teaching methods as presented in Fig. 5, which conforms to the requirements of the industry to engage students through innovative pedagogy concepts.

![Figure 5. Mobility promoted by adaptive teaching methods.](image)

Teachers in bachelor and engineering study programs reported positive experiences on student’s engagement. Also, the virtual instrumentation transition had a positive influence on students who reported higher soft-skills perceptions of activity, innovation, cooperation care in their key competences in hard-skills domain formation. Reflecting on the university-industry partnership
process, we found that responding promptly to the concerns of partners helped establish technical education credibility and trust. Open and frequent communication was also essential to maintain focus, sustain commitment, and ensure the longevity of the partnership.

4.3 Mobility improvement: Modular concept benefits

The tailored modular courses with key competencies formation structure give students easy access to the valuable learning techniques obviously used by experts in science and technology, and other assets related to modular concept is derived from didactics. The data of knowledge pre-test and post-test, as well final exams and individual innovative project results were analysed quantitatively by reporting correlation coefficient and personal evaluation report prepared by experts engaged in the modular concept research. The interpretation and use of Pearson's correlation coefficient varies based on the context and purpose of the study of didactic tests data calculation (selected preferred items related to activity, innovation, cooperation). The modular concept and virtual education environment brings benefits in improving overall teachers/students mobility in the pilot groups. In each module all of students has opportunity to use individual learning style and improve the less-preferred learning style depending on specific learning content and key competences required. Teacher experiences derived from didactic cycle assessment generated following benefits. Most of students in modular concept have:

- active transfer theories and pre-laboratory learning content,
- skills to use basic specific virtual technology,
- adequate technology skills for study program specific software technology,
- looking for teacher/student technology support and cooperation in small groups,
- ask for technology use to enhance individual mobility in learning for practice from external real environment.

To combine the research project outcomes with the commonly accepted forgetting curve, which states that people forget about 75% of what they learn in a formal setting within a week, it is easy to conclude that technical faculties spend far too much time, finances and human resources on formal learning. The good news confirmed in the project results are that virtual instrumentation technologies and modular learning content greatly enhanced a faculty’s ability to deliver other types of teaching/learning methodology and concepts of virtual environment technology used to dictate how students learn active, innovative, cooperative; now it can be leveraged to empower engineering students to learn in more natural ways to improve individual mobility to achieve the goal that all graduates from technical faculty are well-prepared for further long-life learning, successful careers, and flexible adaptation in the society. This work was born on the University of Zilina, Slovakia experts team experiences with Student Learning mobility programmes and European Credit Transfer System (ECTS) environment related to the Erasmus+ courses design, evaluation and assessment to equip students with variety of effective tools and information that they will need to be a flexible part of the total EU marketplace, and help to ensure that learning content and modular concept are consistent, and consistently excellent [12]. The faculty team’s beneficial goals in learning content evaluation and assessment: be successful in developing strategic relationships and deliver quality services to education. Every action we take in Erasmus+ mobility is focused on contributing to the success of students’ competences and for consistently going beyond learning content boundaries.

5 CONCLUSIONS

We have discovered benefits of modular education concept for students and teachers from the inputs about becoming members of a project team enhancement on activity, innovation, cooperation and thus we value teachers-students unique perspective as we explore ways to enhance our offerings in perspective study programs. We hope to gain a better understanding of what benefits students and teachers are aware and faculty would like to see in the future. Modular concept in virtual education environment allows multiple approaches to be captured, measured and assessed because the student’s actions associated with each task aim and learning process are collected in the portfolio-files, analysed as a group, and used as evidence of students’ acquisition of targeted key competences. Education modules in virtual education environment allow individual student to conduct several trials during an experiment so that the results of previous trials and errors open an activity in later attempts, creating an iterative didactic cycle, which is also related to graduates career-ready
mobility in key competences such as problem solving, project design and technology inquiry. This, then, is job newcomers’ great challenge to respond to the crippling refrains of cultural consumerism with thoughtful and firm decisions, with research, knowledge and sharing. We want to state clearly that young people mobility themselves is agent of youth activity, innovation and cooperation ministry. Certainly they need to be helped and guided, but at the same time it is important to left student's free mobility to develop new approaches with activity, innovation, cooperation and a certain audacity. So the paper will not attempt here to propose a kind of manual of youth ministry or a practical guide to reproduce competences. The aim of the project is more concerned with helping young people in technology education environment to use their individual insight, ingenuity and knowledge to address the issues and concerns of the society development. Education makes graduates raise questions, keeps them from being anesthetized by banality, populism and impels them to pursue meaning in life of the possibility of contributing to the development of society. Finally, we conclude for faculties management, teachers, industry representatitives and researchers to enhance the evidence increase the knowledge of how faculties’ success outcomes can improve over time career-ready technical faculty’s graduates mobility as a source of engineering services, system solutions, software support and related jobs all over the world.

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REFERENCES


