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79 INDUSTRIAL DESIGN AS AN INNOVATIVE ELEMENT IN ENGINEERING EDUCATION

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ABSTRACT

This paper describes how the Copenhagen University College of Engineering (IHK), in our continuing effort to innovate the engineering study programs, have introduced strong industrial design elements in the 210 ECTS Bachelor of Mechanical Engineering program as well as the 30 ECTS International Design Semester and the 10 ECTS Summer School in International Design and Development. The paper describes how implementation of novel industrial design subject areas requires the creation of new laboratory and workshop facilities in order to combine traditional engineering design disciplines with creative design as a driver of innovation. With a practical and problem based learning approach at IHK the students are asked to work closely together with companies to come up with engineering solutions that are sustainable from both an engineering and a design perspective.

Keywords: Industrial Design, Innovation, Engineering Education.

1 INTRODUCTION

Appointed by the Danish government, the Danish Design 2020 Committee published its report in June 2011 on how design can be strengthened and used in order to contribute to growth, productivity, and innovation [1]. Building on a strong Danish tradition the Committee envisioned that, in 2020, Denmark will be known worldwide as the design society which, at all levels and in a responsible way, has integrated the use of design to improve the quality of people's lives, create economic value for businesses, and make the public sector better and more efficient. A central prerequisite to the realization of this ambitious vision is the further development of design and creative competencies at all levels of education. Stimulating the students' creative talents through design work is challenging: Engineering students often prefer the exactness and predictable nature of science-based problem solving. It is demonstrated that by encouraging students to leave the classroom and the computer for a while enhances their ability to solve real world problems.

The Design Committee has a vision of Denmark as a society in which people and institutions are influenced by and are a part of the unique Danish design tradition – with the courage to experiment with innovative solutions [1]:

- Design and creative competencies are an integral part of education at all levels, from primary to tertiary education
- Denmark is a frontrunner in educating "T-shaped" designers with a combination of highly specialized skills and general competencies such as creative problem solving, a global outlook, and the ability to work in cross disciplinary teams
- A substantial number of graduates from the social, natural, and technical sciences, especially engineering and business, have competencies in design related problem solving
- The Danish design schools have enhanced their solid Scandinavian grounding through material- and form-based design …
- Danish design graduates appreciate the need for design to permeate into the broader society, and they have a global outlook, international experience, and are internationally competitive
- Danish design programs attract highly qualified, international design students, staff, and researchers

IHK has decided to contribute to the realization of the Design Committee's ambitions. This decision goes together with the strategic transformation process of IHK [2] and the intention to develop IHK into an innovative center of sustainable development in cooperation between students, industry and public authorities [3].

2 TOWARDS A DESIGN-BASED ENGINEERING EDUCATION

Our present world is characterized by rapid and ongoing developments in every field of science and technology. These developments have led to an ever-increasing specialization of factual knowledge, tools and techniques in all areas of professional engineering. Many of the traditional tasks and skills expected of professional engineers have been replaced and/or changed by the introduction of computer and information technology-based methods such as Computer-Aided Design and Manufacturing (CAD/CAM) and Finite Element Analysis (FEA). While a solid foundation of engineering science knowledge, a good understanding of physical and mathematical principles and practice in the application of a range of fundamental algorithms, procedures and equations to solve common problems in particular engineering disciplines are still basic prerequisites of professional engineering work in practice, there is more and more emphasis today on interdisciplinary collaboration, use of external knowledge sources and skills in open-ended complex problem solving.

These changes have influenced the demands made of engineering graduates by businesses that employ professional engineers as well as by professional organizations like the Danish Society of Engineers (IDA) and The European Society for Engineering Education (SEFI). In fact, experience reveals that although a good grasp of engineering science principles is still a fundamental expectation to modern engineers, some of the most important requirements now are the ability to communicate effectively, the ability to work independently as well as in a team, and the ability to think both critically and creatively.

Many educational institutions have reacted on these changes and have adjusted their engineering curricula accordingly; an overview is presented in [4]. In this process it has become increasingly clear that the teaching of engineering design plays a key role in the development of the attributes mentioned above. For example, IHK has recognized this by requiring that mechanical engineering students be prepared for professional practice by including a major design experience in their final project. This must be based on the knowledge and skills acquired in their coursework, and should incorporate engineering standards and realistic constraints such as manufacturability, sustainability, and environmental, economic, political, social and ethical issues. As a consequence, design has gradually developed to become the core of engineering curriculum in many colleges and universities worldwide, including the Center of Energy and Product Design (CEP) at IHK.

Giving design such a leading role in engineering education requires the consideration of a number of important issues. These include the requirement of consistency between design and traditional engineering courses in the different semesters of the curriculum in order to provide students with a coherent and realistic framework of professional design activities. Other import aspects are the challenge of project based learning and running team based design projects, in particular the creation of realistic but manageable design scenarios, and issues around project assessment and team work.

3 THE ROLE OF DESIGN IN THE ENGINEERING CURRICULUM

Most subjects in the Bachelor of Mechanical Engineering curriculum such as materials, mechanics, thermodynamics, and mechatronics are science or technology based with a relatively clear emphasis on a specific area of technological knowledge. Engineering design encompasses a much broader range of topics than most other subjects covered in the engineering curriculum. A modern design oriented engineering syllabus should include the following subjects:

- Design theory and process
- Design tools, techniques, methodologies
- Design communication: drawing, sketching, report writing, oral presentation
- CAD modeling and applications
- Design projects
- Design teamwork and project management

The nature of the first three elements of this syllabus, i.e., design theory, process, tools, techniques and methodologies, and design communication is similar to that of other engineering subjects. These topics are introduced in the first semester of the syllabus and can be covered using a traditional lecture/assignment approach. It includes basic drawing and other communication skills that are necessary for students to present their ideas in a format that has become one of the "musts" of the engineering profession. The purpose is to equip students with the fundamental theoretical knowledge and skills to understand the nature of the engineering design process and to start performing basic design tasks. Of course, it will be necessary to review some of these elements, and also cover more complex material as the needs arise at a later stage.

Computer-Aided Design (CAD) plays a leading role in modern mechanical engineering and therefore requires careful consideration. Many students in the first year of an engineering degree have little experience of engineering graphics and need to be made aware of the importance of clear, accurate technical and design communication within an engineering organization. This means that they must be able to modify or redesign existing products, and for new projects draw "what is in their mind" quickly and accurately. To achieve this, students must be able to utilize the full range of industrial techniques – from sketching and drawing orthographic views using conventional manual drawing techniques as well as CAD software for design and analysis.

It is important to make students realize that a CAD system is not an end in itself. Rather, it should be regarded as a tool to achieve design goals. Students must be asked to consider their current and future use of CAD tools in the broader context of product design, modification, analysis and production. To achieve this they need to be advised to consider CAD as being able to assist them in the following functions:

- The replacement of manual drawing techniques, and in particular to rapidly amend CAD-generated orthographic drawings
- The production of 3D models for visualization and analysis and to enable designers to investigate quickly more design alternatives than is generally possible with manual graphical, technical and/or solid models
- The optimization of design processes by incorporating advanced Computer Aided Engineering (CAE) tools such as FEA, Computer Aided Manufacturing (CAM) and computational fluid dynamics (CFD)

4 RELEVANCE OF DESIGN PROJECTS

Design projects play a vital role in providing students with a crucial attribute desired by industry for a newly graduated engineer: The ability to identify and define a problem, develop and evaluate alternative solutions, and develop one or more designs to solve the problem. It is generally agreed that this attribute can only be developed by exposing students to the experience of open-ended problem solving which includes linking engineering science knowledge to complex, real-life design problems. Apart from the "hardcore" engineering and technical issues, these problem solving activities should include a range of extra-disciplinary and "soft" factors, such as economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political considerations.

It is obvious that this type of problem based learning can only be achieved by using quite complex project scenarios, and therefore requires careful planning and integration into the rest of the curriculum in order to prevent students from being seriously overburdened and confused. As in other complex and challenging subject areas, it is important to structure the contents of the design curriculum carefully and introduce new topics and aspects in a logical and consistent way. Due to the large amount and variety of material and considerations which need to be covered, design project work should ideally span over the whole curriculum. They should lead towards and culminate in a capstone experience that is as realistic as possible, include a broad range of the considerations mentioned above, and be typical of the problems faced by professional engineers in their particular area of discipline.

An important aspect that needs to be considered is the relationship between design work and the material presented in the various engineering science courses. Projects in the design-based courses in different semesters should be offered by different individuals who are from the main specialist teaching groups in the institution in order to create realistic scenarios and provide competent support for the students during their project work. However, this arrangement presents a challenge in maintaining an important common thread in the courses. Failing to recognize and address this issue can result in a disjointed and sometimes even confusing design-oriented curriculum, where certain topic areas may be unnecessarily repeated or unknowingly omitted. Students may also fail to appreciate the progressive nature of knowledge accumulation in design during their curriculum, or be overburdened by design tasks that are too complex for their current level of understanding. It is therefore important to have a consistent design framework for the whole undergraduate degree program.

The framework should include all topic areas and aspects of design that need to be covered in the curriculum. Guidelines should be provided for the introduction, application and review of the different concepts. These guidelines then provide help for course organizers when a design course or project is planned. Likewise, the design guidelines serve as a focal point for the students who are able to see the curriculum in its entirety as well as a collection of discrete subjects and projects offered in different years. To achieve these objectives IHK has recently endorsed an integration of different courses in its undergraduate degree program. For example, the course "CAD and Industrial Design" covers the topics of design processes, communication in design along with the basics of CAD, and "Design of Mechatronic Systems" covers the topics integrated design and design of (mixed) engineering systems.

5 INNOVATION WITH A STRUCTURED APPROACH

For many people, design is the essence of professional engineering work. It combines the principles of engineering science with creative aspects, thus bridging the gap between the function and the structure of an artifact. However, many engineers regard creativity as a vague concept that does not fit well the precise quantitative engineering world. Whereas a traditional engineering science-based course is often not perceived to be creative, design courses with large projects have the potential to develop the creative talents of students greatly, but they also have the potential to greatly inhibit creativity. The outcome depends upon the academic leadership and their understanding of the creative problem-solving process.

Stimulating the students' creative talents through design work is challenging. Engineering students often prefer the exactness and predictable nature of science-based problem solving. This trend is reinforced through common teaching and examination practices in the majority of courses in the undergraduate curriculum. For example, it is relatively straightforward to prepare for an examination on the basis of problem sheets containing standard textbook questions. Open-ended, creativity-based problem solving as required in design projects is sometimes perceived as uncomfortable, and as a major threat to achieving a good examination result.

Brainstorming is generally the most commonly used creative method in design teaching. At IHK, it is introduced in a first semester course, and applied extensively in conceptual design projects throughout the curriculum. Other methods that combine creativity with systematic approaches are also introduced in lectures for the various conceptual design projects throughout the curriculum. These methods include function analysis, objective trees, and morphological analysis.

Project supervisors must be aware that students often try to shortcut the creative process by coming up with one "great idea" for the solution of a given design problem, and trying to include an artificial process around it in order to justify their approach and satisfy the project requirements. To avoid this, students at IHK are required to use morphological analysis that documents the evolutionary nature of their design work.

The idea of design as a series of interrelated tasks within a systematic design process is also emphasized. This makes it easier for students to appreciate the relevance of creativity in the process, in particular when additional, more structured techniques such as function analysis and morphological analysis are also introduced. These tools also help students to organize and structure their work in open-ended design projects.

At CEP, design has always played an important role in its undergraduate curriculum, and a project based learning approach has been adopted in its study programs since early 2000. Over the years, virtually all academic staff members of CEP have participated in various design projects, and there have been several occasions when the strategy of design teaching has been discussed in special meetings, and subsequently formulated as a general policy. Engineering design now accounts for about 25% of the overall teaching content of the first four semesters, and there is a design project in every semester of the undergraduate degree course, the vast majority of them organized as project based learning experiences in cooperation with industrial companies.

6 DEVELOPMENT OF DESIGN STUDIO AND FACILITIES

Practice-oriented teaching at CEP has, over the years, implemented a number of methodologies in the laboratory environment. The digital opportunities are a central focus point for this development. In the developed Design Studio the focus has been to facilitate many subject lines and gain use from the very fast development in computer aided technologies. The competitions between digital outcome and physical outcome have to be controlled carefully. Design and innovation in cooperation with companies and in the motivation of the students strongly linked to physical outcomes - things you can use, test, showcase, etc. This experience has helped to develop a concept Design Studio. The Design Studio is a multifunctional workshop linking IT tools (3D scanning, CAD, multimedia and simulations), along with physical manufacturing techniques. Via the Design Studio we offer an integrated creative facility where students, teachers and external users can meet and create visualizations, physical models and prototypes in product development processes using a variety of methods and technologies. The pictures in Fig. 1 show an example of a Bachelor's project work in the Design Studio, where the starting point was to dimension the spokes of a new carbon fiber automobile wheel. A scan of an approved wheel with spokes was used as the input in a FEM simulation. A new design in new materials fulfilling the equivalent mechanical specifications was subsequently developed.

FIGURE 1. *Upper left: carbon fiber rim. Upper right: 3D scanning of wheel. Lower left: FEM simulation. Lower right: the final spoke design. On courtesy of Mr. Steffen Vagt-Andersen.*

7 CONCLUSIONS

IHK is undergoing a transformation process towards becoming a center of innovation and entrepreneurship based on collaboration with students, enterprises and public authorities. Design is seen as a powerful driver of innovation and growth and steps have been taken towards integrating design processes in all educational programs. With the creation of the Design Studio and other facilities a number of methodologies have been implemented in laboratories and workshops that enable students and companies to carry out innovative processes in a realistic industrial environment. Design driven innovation can complement technology driven innovation and significantly increase company productivity and differentiation in competitive international markets. It should be emphasized that easy and frequent access to laboratories and workshops for students and companies are crucial to support innovation and entrepreneurship in a practical down-to-earth manner. Although this paper has focused on industrial design it is expected that the design approach will also be increasingly used to develop better and more efficient public services and solutions.

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82 STUDENT ACHIEVEMENTS IN SOLVING PROBLEMS USING MODELS IN ELECTRONICS

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ABSTRACT

The article presents the results of a two-semester research, which examined student achievements in problem solving using engineering models in electronics. The research aimed at investigating the effect of the following variables on student achievements: studied model, student learning experience, and the lecturer educational background. A quantitative research methodology was applied. An achievement test, based on a mixture of Bloom's and a problem-solving taxonomy, was developed for two models of electronic devices: an ideal amplifier and practical model of diode, and were offered to students as a part of the final test. 336 students, studying mechanical and electronics engineering, and four lecturers participated in the study. T-tests for the independent variables with two groups (model and lecturer background) and one-way analysis of variance for the independent variable with the number of groups (learning experience) were performed. The results indicate the grades of students educated by lecturers with an academic degree in technology and science education are significantly higher in each taxonomy level of problem solving than the grades of students taught by lecturers without a pedagogical academic degree. Additionally, it was obtained that the mean of knowledge level is higher than the mean of routine level and the latter is higher than the mean of interpretation level.

Keywords: Student achievements, solving problems, engineering models, knowledge, routine, interpretation.

1 INTRODUCTION

It is well established that models play a central role in the process of scientific enquiry [1]. There are varied definitions of the "model concept" in the scientific literature. One of them describes a model in science as "a representation of phenomenon initially produced for a specific purpose" [2, p.11]. Other definitions emphasize simplicity of model representation that focuses attention on a particular aspect of the observable fact, and analogy or imitative relationship to some real–world phenomenon [2, 3]. An engineering view on the model concept is expressed as follows: "Modeling, in the broadest sense, is the cost-effective use of something in place something else for some cognitive purpose. It allows us to use something that is simpler, safer or cheaper than reality instead of reality for some purpose... This allows us to deal with the world in a simplified manner, avoiding the complexity, danger and irreversibility of reality" [3, p. 75]. This definition highlights an engineering approach: the engineer uses an engineering model for finding a cost-effective way of problem solving by simplification of reality. So, we must use the same approach in engineering education as well.

In the educational process, an individual's mental activity causes the formation of a mental model. The results of this activity, or expressed models, can be conveyed by student explaining or problem solving, and can be tested by teachers. Models make a major contribution to science education because building of mental models and representation of expressed models are central to the development of phenomenon understanding [2]. Therefore, models expressed by students allow assessment of educational outcomes. Generally, the assessment is based on the use of some kind of taxonomy. The most popular taxonomy of educational objectives was proposed by Bloom [4]. Bloom divided educational objectives in the cognitive domain into six levels: knowledge; comprehension; application; analysis; synthesis; and evaluation or making judgments. The taxonomy of problem solving activity (PST- Problem Solving Taxonomy) [5] is especially appropriate for use as a complexity characteristic [6] in the field of engineering education. As stated by PST, problem-solving activities can be divided into five levels: routines, diagnosis, strategy, interpretation, and generation. Routines are those operations which afford no opportunity for decision but proceed by consecutive mathematical steps to a unique solution. Diagnosis is the selection of correct routines from incorrect routines. Strategy is the choice of a particular routine for the solution of a problem which may be solved by several routines. Interpretation is the reduction of a real-world situation to data which can be used in a routine, and the expansion of a problem solution to determine its implications in the real world. Generation is the development of new routines.

It is well known that outcomes of the educational process depend on teaching and teachers. Scientific and engineering research plays the main role in academic institutions. Very few professors have the ability and the time to excel at both activities: research and education, and most give priority to the most respected disciplinary research. The quality of both teaching and research consequently suffers [7]. Most professors learn to teach by doing in the process of their educational career, and base their educational approach on their own experience [8]. The suggestion to educate future professors in pedagogy is not a new recommendation. The American Society for Engineering Education (ASEE) report [9] from 1955 stated: "It is essential that those selected to teach be trained properly for this function." But this recommendation up to date has not yet come to fruition. The report of the National Research Council [10] from 2003 asserts: "The committee found that most faculty who teach undergraduates in the STEM disciplines have received little formal training in teaching techniques ".

The purpose of the current study is to examine student achievements in problem solving using engineering models in electronics. The research aimed to investigate the effect of the following variables on student achievements: studied model, student learning experience, and the lecturer educational background. In what follows, we present our research method, results, and discussion.

2 METHOD

The study applies a quantitative research methodology. Students learning electronics from departments of mechanical and electric and electronic engineering at an academic college participated in the study. In the first stage, 122 students and three lecturers and in the second stage, 214 students and four lecturers participated in the research. The students studied four different courses during one full semester. All the courses included topics which present the operational principles of different electronic components –ideal amplifier and diode - by their engineering models. Student achievements in problem solving using two different models were analyzed.

The research question was: What is the effect of the model, student learning experience (semester of learning), and lecturer background, on students' problem solving using models in electronics?

2.1 Design of achievement tests

The main research tool – an achievement test – was developed for each model and was incorporated as part of the final test of the appropriate course.

The design of all achievement tests relied on three dimension design array that specified the content of every question, its taxonomy and difficulty level. This way insures appropriate sampling of the learned material and attains content validity of the achievement tests. The scheme of question design is presented in Figure 1.

To ensure expert validity, the design arrays and the questionnaires were validated by three senior lecturers of electric and electronics engineering who agreed about the content and formulation of the questions, at least two of them had M.Sc. and Ph.D. degrees in technology and science education (TSE).

The taxonomy dimension was based on a mixture of two taxonomies – Bloom taxonomy [1] and taxonomy of problem-solving activities or PST [2]. We proposed three levels of problem solving activities: (1) knowledge according to Bloom's taxonomy, (2) routine, and (3) interpretation according to PST. Even though the PST is the most appropriate taxonomy for the studied field [6], we used the mixture of the two taxonomies since the PST lacks the knowledge level which is important to diagnose whether the students recognize the model role in electronics. Each problem in the achievement test was divided into six to seven open questions. Each question referred to specific content of the learning model, belonged of the appropriate level of taxonomy and classified into two degrees of difficulty.

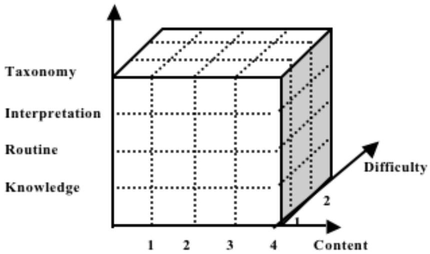

FIGURE 1. *Scheme of question design in achievement test.*

All the completed questionnaires were graded by two experts using an agreed rubric for grading. In case of disagreement on a certain grade, there was a discussion till conformity was achieved. All the answers graded starting with first answer of all the examinees then the second answer and so on until the end. The completed questionnaires of all the students were anonymous (only identification numbers was marked) and they were graded in a random order.

2.2 Research stages

The pilot questionnaire for practical model of diode was designed and tested in mid-term exam in November 2010. Subsequently, the questionnaire was reformulated using the conclusions revealed from the analysis of the obtained results. Two succeeding questionnaires for ideal amplifier and practical model of diode were designed according to these conclusions. After the first stage of the research, January – February 2011, research population was broadened. In the second stage of research, July-August 2011, students learned four different courses and solved the problems using models of ideal amplifier and diode.

TABLE 1. *Research stages, number of participants, and models of the study.*

Stage	Number of students	Number of lecturers	Model
First	84	2	Ideal amplifier
	38	2	Practical model of diode
Total- First Stage	122	3*	
Second	121	2	Ideal amplifier
	93	3	Practical model of diode
Total- Second Stage	214	4*	
Total	336	4*	

* One lecturer taught two models

2.3 Research variables

The independent variables were: studied model, student learning experience (the serial number of the semester, from beginning of the learning program), and the lecturer background (with and without academic degree in TSE).

The dependent variables were student grades in every taxonomy level (knowledge, routine, interpretation) and overall grade.

2.4 Hypotheses

1) The GPA of the students who were taught by the lecturers without TSE is 93, while the GPA of the students who were taught by the lecturers with TSE is 88, therefore we assumed that the grades in solving problems using models of the students who were taught by the lecturers without TSE would be higher than the grades of those who were taught by the lecturers with TSE.
2) The grades of the experienced students would be higher than the grades of the freshmen.
3) The grades of knowledge level would be higher than the grades of routine level, and the latter would be higher than the grades of interpretation level.

2.5 Data analysis

The grade was between 0 and 10. All the questions of knowledge and interpretation levels had only one degree of difficulty, while the questions of routine level had two degrees of difficulty. Therefore, the grades of the knowledge and interpretation levels were calculated as simple average of student grades, whereas the routine grade was calculated as 40% of the grade of low difficulty degree plus 60% of the grade of high difficulty. The overall grade was calculated as the average of the knowledge, routine and interpretation grades.

T-tests for the independent variables with two groups (model and lecturer background) and one-way analysis of variance (ANOVA) for the independent variable with the number of groups (learning experience) were performed. In addition, descriptive analysis of the grades according to the three taxonomy levels was carried out.

TABLE 2. *Comparison of means, standard deviations (SD) and t-test results for the model variable.*

	Model				
	Ideal Amplifier (n=171)		Diode (n=165)		
Level	Mean	SD	Mean	SD	t
Knowledge	7.35	2.95	6.43	3.08	2.797**
Routine	6.75	3.38	6.82	3.31	-0.194
Interpretation	6.82	3.31	4.11	3.17	4.339***
Total	6.59	2.71	5.78	2.41	2.878**

Note: $^{**}p < 0.01$, $^{***}p < 0.001$

Table 3 shows that there was a significant difference according to the learning experience variable between all students' grades, but it contradicted our second hypothesis: the mean of all the levels decreased when the learning experience increased.

TABLE 3. *Comparison of means, standard deviations (SD) and ANOVA test results for the learning experience (semester) variable.*

	Learning experience = Semester								
	2 (n=146)		3 (n=62)		4 (n=68)		5 (n=60)		
Level	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F
Knowledge	7.81	2.61	6.37	3.21	6.05	3.30	6.20	3.03	8.31***
Routine	7.16	3.28	7.48	2.86	6.82	2.83	5.14	3.98	6.66***
Interpretation	6.01	3.37	4.65	2.74	4.45	3.35	3.04	3.26	12.87***
Total	6.99	2.50	6.16	2.32	6.16	2.31	6.19	2.60	12.08***

Note: $^{***}p < 0.001$

Table 4 displays that the most significant difference in all the taxonomy levels was found between the grades of students who were taught by the lecturers without TSE degree, and those who were taught by lecturers with a TSE academic degree. These results contradicted our first hypothesis that students with higher GPA will gain higher grades.

TABLE 4. *Comparison of means, standard deviations (SD) and t-test results for the lecturer background variable.*

	Lecturer Background				
	Without TSE degree (n=128)		With TSE degree (n=208)		
Level	Mean	SD	Mean	SD	t
Knowledge	6.11	3.16	7.38	2.88	-3.758***
Routine	6.03	3.38	7.25	3.16	-3.673***
Interpretation	3.79	3.37	5.60	3.25	-4.906***
Total	5.31	2.56	6.74	2.47	-5.087***

Note: ***p < 0.001

Table 5 presents descriptive statistics results of all research participants according to three taxonomy levels. It is obvious that the mean of knowledge level is higher than the mean of routine level and the latter is higher than the mean of interpretation level. The results presented in table 5 support our third hypothesis, that the grades of knowledge level would be higher than the grades of routine level, and the latter would be higher than the grades of interpretation level.

TABLE 5. *Comparison of means and standard deviations (SD) of students' grades according to the taxonomy level.*

Level	Mean	SD
Knowledge	7.23	3.20
Routine	6.79	3.34
Interpretation	4.91	3.41

4 DISCUSSION

The results refute two of our hypotheses: (1) the achievements of the students with higher GPAs would be greater than the achievements of the students with lower GPAs; (2) the grades of the more experienced students would be higher than the grades of the first and second year students. The results show that the grades of students who were taught by the lecturers with a TSE are significantly higher than the grades of those who were taught by lecturers without a TSE degree. The refutation of our first two hypotheses stems from the fact that the students with lower GPAs were taught by lecturers with a TSE in semesters 2 and 3, while the students with higher GPAs were taught by lecturers without a TSE in semesters 4 and 5. This means that lecturer teaching skills affect student achievements more significantly than individual cognitive abilities and learning experience. Therefore, we assert that teaching methods of the lecturers with a TSE lead to higher student achievements on all taxonomy levels. Obviously, teacher mastery depends not only on his or her educational background. Therefore, we tried to neutralize such additional factors as teaching experience – all the lecturers who participated in the study teach in the academy for more than 10 years; all of them are engineers and have high professional reputation. Pedagogical education is the salient factor that distinguishes between them. So we can claim that educational background is an important component of the teacher mastery, which contributes significantly to high student achievements.

The results support our third hypothesis that the grades of knowledge level would be higher than the grades of routine level, and the two would be higher than the grades of interpretation level. The more complicated taxonomy level of problem solving demands more developed cognitive skills; therefore, the average student achievements are lower and the scattering of results is higher. The results are consistent with the assertion of researchers [5] who claim that the freshman engineering students are essentially specialist in routines, but their interpretation skills are rudimentary. According to [5], in the two last learning years, students' attention is focused more and more on the real-world implications of their work; therefore, interpretation begins to be of considerable importance. Accordingly, in advanced stages of the learning process students might solve real engineering problems more efficiently.

Still, the results of the study indicate significant differences in student achievements of two engineering models. The fact that students' grades, concerning the ideal amplifier model, were significantly higher than the grades related to the diode model, especially in interpretation level of taxonomy, may indicate that understanding of diode model requires higher level of abstraction and more developed cognitive skills. Exchanging the methods of models' teaching between the lecturers may help all of them to enhance their pedagogical techniques as well as student achievements. Namely, the engineering faculty needs to continue learning new approaches to teaching and to develop their pedagogical skills.

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83 A STUDY ON HEALTH INFORMATICS EDUCATION IN FINLAND

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ABSTRACT

Governments and health authorities in many countries have recognised the urgent need for highly educated and trained workforce in information management in health care. This paper presents an overview of health informatics programmes and courses in Finnish higher education. This empirical study is descriptive and the data collection contained interviews with health informatics experts. The results show that health informatics education is quite new in higher education in Finland. Health informatics is an independent degree programme in five universities of applied sciences. Furthermore, many other universities and universities of applied sciences provide courses and modules focusing on health informatics. In addition, the results show that different universities and universities of applied sciences have different focus areas. The interviewees emphasised many possibilities of health informatics in society. The importance and need of health informatics education was confirmed in the interviews. Especially, multidisciplinary knowledge and skills were emphasised in order to answer the challenges of modern society.

Keywords: Health Informatics, Higher Education, Finland.

1 INTRODUCTION

Governments and health authorities in many countries have recognised the urgent need for highly educated and trained workforce in information management in health care. The challenges rise among others from the ageing population, advances in health care and technological developments. Furthermore, during the past two decades, several types of information systems have emerged in the field of healthcare [1, 2]. Technological and business processes offer a new type of possibility to view healthcare. There is also increasing evidence that information technology improves health, health care and public health [3-5]. However, new expertise is needed in order to answer the challenges in hospital and healthcare. There is a need for specialists that understand both the field of information systems and the special characteristics of health care [6].

All the above was recognised in Turku University of Applied Sciences (TUAS), too, and a novel engineering degree programme in Health Informatics was designed at Turku University of Applied Sciences [7]. We defined health informatics as the application of information and communication technologies (ICTs) in healthcare (as a field of science and practice). In 2011, the first students graduated from the Information Technology (B.Eng.) programme with a Health Informatics specialisation. In addition to starting this new education we started Innowell Network project [8] to build a network of actors and operators in this field. The project was started in 2009 and one of the project phases was to study the overall situation of Health Informatics education in Finland. In this paper we introduce the results of this phase of the project. We report the situation of the health informatics education in Finland in general, not only in the engineering education. Similar reports have been published, for example one focusing on British programmes [9], and website [10] listing educational programmes in health informatics have been created.

The Finnish higher education system contains two sectors, according to a so called dual model (Figure 1): science universities and universities of applied sciences. The universities focus on research and research-based education. They confer Bachelor's, Master's, Licentiate and Doctoral degrees. The universities of applied sciences are usually regional higher education institutions that provide tuition in subjects from several sectors, and which emphasise the connection with working life. The degrees they provide (Bachelor's and Master's degrees) are higher education degrees with a professional emphasis. The idea of universities of applied sciences is to work in close co-operation with one's region and to answer to the needs of working life. The above mentioned Health Informatics programme is a good example of this relevance to working life.

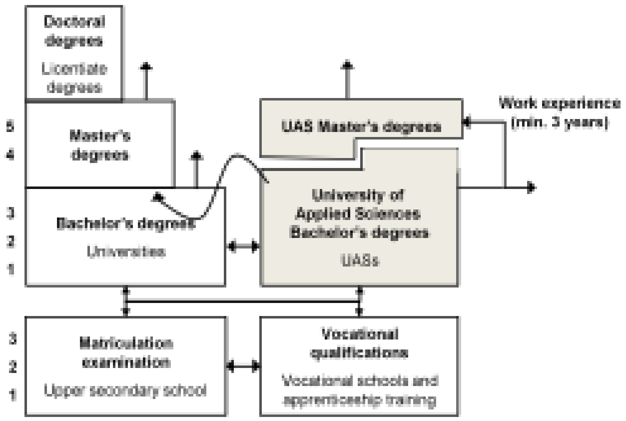

FIGURE 1. *Higher education system in Finland.*

The main aim of this research was to describe the current situation in health informatics education in Finnish higher education. Furthermore, this research aimed at showing the existing networks and collaboration possibilities in health informatics education.

2 METHOD

We used purposive sampling to select the study participants who would be able to provide the necessary data [11, 12]. The use of the purposive sampling method relies on the researchers' knowledge about the study environment. The idea is to choose sample members [11], in such way that in-depth knowledge can be achieved with the chosen members [13]. In total, 16 experts from universities of applied sciences, science universities and stakeholder organisations related to health informatics in Finland were invited to participate in the study. The identified experts had long experience in health informatics either in higher education or in stakeholder organisations.

The identified experts were contacted with an email and those who were willing to participate in the study were asked to reply to the researcher's email. In total, 11 out of 16 possible experts chose to participate in the study. The data were collected through theme interviews [11]. The interview themes were the following: health informatics in Finnish higher education and the possibilities to share health informatics expertise among Finnish higher education institutes.

Before the interviews, the respondents gave a permission to record the interviews. The times and locations of the interviews were chosen based on the needs of the informants. One of the authors (NL) conducted the interviews. The data was collected in autumn 2011. The length of the interviews varied from 40 to 65 minutes.

The data were analysed inductively with content analysis [11]. The collected data were at first transcribed. One researcher (NL) read the answers several times in their entirety to become immersed in the data. Interview transcripts were coded and analysed using content analysis to identify categories and themes regarding health informatics in Finnish higher education and the possibilities to share health informatics expertise among Finnish higher education institutes.

3 RESULTS

Based on the interviews and websites of the universities and universities of applied sciences, health informatics education in Finnish higher education is organised in many different ways (TABLE 1). In some institutes health informatics is its own degree programme, in some it is a specialisation line and in some only separate courses on health informatics are offered.

Three universities of applied sciences have an own degree programme in health informatics. These programmes lead to a Bachelor of Engineering degree. In two universities of applied sciences, health informatics is a specialisation within the Degree Programme of Information Technology and the students graduate as Bachelors of Engineering. Furthermore, many institutes provide single courses on these topics, such as health care technology at Tampere University of Applied Sciences.

At the moment only two universities of applied sciences provide master level education in health informatics. In Kuopio, the programme is a cross-sectional programme in the field of health care, leading to several different master's degrees. In Pori, the programme can be studied either with the healthcare or engineering focus and the master's degree is similarly either Master of Nursing or Master of Engineering.

In science universities, the variety of studies in health informatics is as wide as in universities of applied sciences – from single courses to master's degrees. In Oulu health informatics is a master programme in the Faculty of Medicine. In Tampere, health informatics is a specialisation of medical technology in the Degree Programme in Electrical Engineering in bachelor level. In master level, medical informatics is a specialisation in the Degree Programme in Information

Technology. Furthermore, Tampere University of Technology has a separate unit focusing on human-centred technology. The Unit is part of the Department of Software Systems. The unit focuses on investigating user needs, values and requirements as a basis for better technical systems. In Jyväskylä, health informatics related topics are provided in the Department of Biology of Physical Activity as a master programme. The University of Eastern Finland provides a master programme in Health and Human Services Informatics. At the University of Turku, a single course is provided in health technology.

Health informatics studies in universities of applied sciences and science universities are mostly implemented in multidisciplinary way. These studies connect different courses and packages among different disciplines such as engineering, wellbeing and healthcare.

TABLE 1. *Health informatics education in Finnish higher education.*

Institute	*Faculty/department*	*ECTS*	*Type of education (Programme, Specialisation, Course)*	*Notes*
Oulu UAS	Faculty of Engineering/Degree Programme in Health Informatics	240	Programme	Bachelor of Engineering
Jyväskylä UAS	Faculty of Engineering/Degree Programme in Health Informatics	240	Programme	Bachelor of Engineering
Metropolia UAS, Helsinki	Faculty of Engineering/Degree Programme in Health Informatics	240	Programme	Bachelor of Engineering
Savonia UAS, Kuopio	Faculty of healthcare/ Degree Programme in Health Informatics	90	Programme	Master of some specific healthcare sector
Oulu UAS	Faculty of Engineering/Degree Programme in Information Technology	30	Specialisation	Bachelor of Engineering
Satakunta UAS, Pori	Faculty of Engineering & Faculty of Healthcare/Degree Programme in Health Informatics	60 90	Programme Programme	Master of Engineering Master of Nursing
Turku UAS	Faculty of Telecommunication and e-business/Degree Programme in Information Technology/Health Informatics	68	Specialisation	Bachelor of Engineering
University of Oulu	Faculty of Medication, Medical and Wellness Technology	300	Programme	Master of Health Sciences
University of Tampere	School of Health Science, Health technology	5	Course	
University of Tampere	Department of Information Sciences	300	Programme	Master of Science
University of Jyväskylä	Department of Biology of Physical Activity, Wellness technology	120	Programme	Master of Sport and Health Sciences

Table 1. continues.

Institute	*Faculty/department*	*ECTS*	*Type of education (Programme, Specialisation, Course)*	*Notes*
Tampere University of Technology	Department of Software engineering	44	Specialisation	Master of Science (technology)
University of Turku	Faculty of Medicine/Department of Nursing Sciences/Course on Health technology	8	Course	
University of Eastern Finland	Health and Human Services Informatics	120	Programme	Master of Health Science or Social Sciences

The interviews showed that health informatics is difficult to define as a separate discipline. Still, it is a specific topic in many universities of applied sciences as well as in science universities. However, as Table 1 shows, health informatics is provided in various faculties and as a cross-scientific subject. Even though the concept health informatics is not an easy one to define, the interviewees agreed on the need of education in this field.

The results also show that answering to the challenges in society requires experts in health informatics that have multiprofessional skills and knowledge. However, the field of health informatics is young and thus it is constantly developing, which sets additional challenges to the education providers. The requirement of a multi-skilled person was a shared wish among the interviewees. The education should produce students with a coherent understanding of health care and its' developments.

The universities applied sciences and science universities do some collaboration in arranging health informatics education. In addition, representatives from health informatics industries participate education as guest lecturers. Education collaboration between HEIs and industry exists in thesis process as well. The invisible barriers between universities applied sciences and science universities throw some challenges to versatile collaboration. The barriers are based on different roles of the HEI sectors and partly also from the competition between the sectors.

One big challenge in sharing the knowledge is how to connect the experts in the health informatics field and how to make them communicate with each other. At the moment this happens through different consortiums, clusters and value chains such as the Wellbeing cluster of central Finland, HYVITE project, IKITIK cluster, OSKE Wellbeing cluster, Kuopio Innovation, MediMerc, FiHTA, Finnish e-health, Society of Telemedicine, and the European Mobile Media Association. Other possible partners for higher education institutes in the health informatics field are National Institute for Health and Welfare, the Technical Research Center of Finland, Academy of Finland, the Finnish Innovation Found Sitra, the Finnish Funding Agency for Technology and Innovation and the Finnish Work Environment Fund.

4 DISCUSSION

Our study showed that health informatics education exists in many HEIs in Finland. The many different ways to organize health informatics education show that the field is not stabilized. Health informatics is a multidisciplinary concept and it can be approached from many different viewpoints. This is also how the field of education showed in this study. The health informatics education was offered by various departments from various fields of education. Furthermore the programs, specialisations and courses in health informatics are quite new education field. This confirms that the urgent need for highly educated and trained experts has been recognized in Finnish higher education and HEIs are responding to the demands of working life where information technology facilitates information management, knowledge sharing, and the creation of new knowledge in organizations [14].

Healthcare organizations are already using information systems for clinical purposes to improve patient care [3, 15, 16]. Furthermore, several other types of healthcare information systems have been developed such as order entry systems, patient flow systems, patient records systems, administrative information system, pharmacy and materials management information systems, human resources management information system, personnel presence card system, financial and cost accounting information systems, patient relationship management systems, picture archiving and communication systems, laboratory information systems, operation theatre systems, e-procurement system of medical supplies, telemedicine systems, e-learning systems, and web-based supply chain management information systems. [1, 2]. Technological and business processes offer a new way to view healthcare and HEIs are responding to this challenge with the health informatics education. The need to take a more technological and business process oriented view of healthcare delivery and to identify the appropriate organizational and information infrastructures to support these processes is one of the focus areas of the studied health informatics education solutions. The IMIA recommendation offers a more general definition of the needed dimensions of health informatics education [17].

At the moment universities of applied sciences and science universities do some regional collaboration in providing education in health informatics. However, the activity of collaboration varies regionally [18]. In Tampere, there is a long tradition of collaboration between the university, university of technology and university of applied sciences. The collaboration has realised in the HYVITE project [19]. In Turku, too, the collaboration has started well and some courses and projects have been already provided. Visiting lecturers from the industry also participate in the education to some extent. A typical collaboration form is students' theses that are often real life assignments from the industry. Despite all the collaboration the interviewed experts call for more collaboration. The aim should be from regional collaboration to national collaboration [20]. A concrete proposal made by the experts was annual meetings of the health informatics stakeholders. This proposal was targeted especially at the existing parent organisations such as FiHTA, the National Institute for Health and Welfare or the Technical Research Center of Finland. There is both aspiration and will to share experiences and starting common research programmes. Another concrete proposal was to create a pool of experts from where one could search and ask necessary experts to research and education activities.

While sharing experiences the multidisciplinary networks, groups and teams create new information on health informatics. Universities of applied sciences collaborate with working life and strengthen their networking and multidisciplinary role in this way. The collaboration is especially active in applied and multidisciplinary research and development projects. The different roles and aims of universities and universities of applied sciences enable new forms of collaboration in the field of health informatics [21]. The collaboration between different organisations is important for the development of health informatics. One of the key issues in the development of health informatics itself and education of it is that regional actors and their processes are recognised. Health informatics is a new field and innovations belong there substantially [22].

5 CONCLUSION

The health informatics education is quite new field of education, but the need for health informatics experts in working life is evident. The collaboration between different stakeholders in health informatics field should be further promoted although some good examples already exist. In the future more focus is needed on knowledge sharing in this large and multidisciplinary field of health informatics.

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85 THE USE OF STREAMING VIDEO TO SUPPORT ENGINEERING STUDENT'S LEARNING IN ENERGY TOPICS

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ABSTRACT

Nowadays there is great interest in education about 'streaming media' in all branches of education because the enormous potential of video dissemination through the information and communication technologies. At present, video can be considered as a powerful medium that, first, can provide narrative visualization, and second, can engage multiple senses of learners simultaneously. This paper presents a review of design criteria for developing streaming video teaching materials for engineering education within the frame of active, deep approaches to learning. The approach taken consists in the consideration of general good teaching practices in higher education. The paper also presents a review on video teaching materials on renewable energy topics, mainly solar energy. The search has been performed on common websites such as YouTube and Vimeo, but also in relevant Educational Digital Libraries such as NEEDS or MERLOT, where streaming video could be considered within the general category of digital courseware.

Keywords: streaming video, active learning, renewable energy.

1 INTRODUCTION

The applications and potential benefits of the use of video in teaching and learning started with the analogue videotapes in the early seventies [1, 2]. In some cases, video technology was used to improve practical teaching by developing simulated laboratory sessions [3]. In others, video-taped lectures were used in distance courses as a substitute of traditional lectures [4]. At present, with the broad use of digital technology, video can be considered as a powerful medium that, first, can provide narrative visualization, and second, can engage multiple senses of learners simultaneously. Educational applications incorporating videotapes, digital video and on-line video can be found in discipline as diverse as management, language teaching, physics and mathematical sciences, medical education and engineering.

With the advent of digital video, video resources can be distributed to students via CD-ROM or DVD, on-line via the Internet, and embedded within other computer-based learning resources. Compared to traditional forms of video which are viewed primarily in a linear sequence, digital video permits more effective interactivity and control, as video elements can be quickly selected by the user, or controlled by a computer program, in any desired sequence. Although, while the technical requirements for digital video production may now be less demanding, the production of quality learning content still requires appropriate expertise [5, 6].

This paper presents a review of design criteria for developing streaming video teaching materials for engineering education within the frame of active, deep approaches to learning. The approach taken consists in the consideration of general good teaching practices in higher education. The paper also presents a review on video teaching materials on renewable energy topics, mainly solar energy. The search has been performed on common websites such as YouTube and Vimeo, but mostly in relevant Educational Digital Libraries such as NEEDS, MERLOT or ERIC, where streaming video could be considered within the general category of digital courseware. The review has been performed with the aim of using the founded digital materials in introductory courses on mechanical and electrical engineering at the University of Burgos, but can be also of value for any interested reader of any other Faculty of Engineering.

2 REVIEW OF STREAMING VIDEO CRITERIA DESIGN IN HIGHER EDUCATION

Streaming video can be defined as video which can be played by means of an Internet data stream, directly on a web site, in real time, without having to download previously. Accessing streamed video is therefore a similar process to accessing video 'over the internet' by downloading video files; but it is much faster for the user because the video does not need to be downloaded as a discrete file. Streamed video is also different from CD-based or DVD-based video. Individual CDs or DVDs need to be produced and distributed to each user; not so for the streamed video. Viewers need access to the Internet with reasonable bandwidth and they need to be using a computer with a media-player and related software compatible with the streamed video. Viewers also need to know to expect delays and some interruptions and to not, necessarily, interpret these as faults. Video streams can be made available to students in a wide variety of ways. It is not necessary for a student to 'go' to the website from which the video is streamed. A text-based, or image-based, hyperlink can easily be inserted into any on-line learning resource, such as a web-page or page in a VLE (Virtual Learning Environment) and simply click to open the necessary link to the streamed video and run the required software.

Educational evaluation of instructional courseware is a complex topic, even with simple learning resources. Evaluation in higher education is a difficult process and rarely is it possible to extend the evaluation process to specific learning resources used within a taught program. 'To what extent did the students learn from the video or from any number of additional resources?' is a common and difficult question for the educational evaluator. Instructional courseware materials are highly subjective since they depend on the goals of the designer and the context of use. However, previous references on evaluation models for instructional courseware should be considered, within the context of educational approaches to learning.

A well recognized guide for good teaching practices in higher education is the one proposed by Chickering and Gamson [7], widely used in US and Canada over the years. It is based on an underlying view of education as active, cooperative, and demanding task. The authors have first, identified practices, policies, and conditions that would result in a powerful and enduring undergraduate education, and second, offered a set of seven research-based principles that would help, sustain, debate and action regarding undergraduate learning. The seven principles proposed are as follows:

1. Encourage contacts between students and faculty.
2. Develop reciprocity and cooperation among students.
3. Use active learning techniques.
4. Give prompt feedback.
5. Emphasize time on task.
6. Communicate high expectations.
7. Respect diverse talents and ways of learning.

As far as the ICT have become major resources for teaching and learning in higher education, an updated version of this guide was published considering the appropriate ways to use computers, video and ICT [8]. The authors address the teacher's how, not the subject-matter what, of good practice in undergraduate education, recognizing that content and pedagogy interact in complex ways. Moreover, the authors point out that, in contrast to the long history of research in teaching and learning, there is little research on the college curriculum. This task is yet to be done, and it is the aim of this work.

Which are the connections of video teaching with this set of good teaching principles? Streaming video is directly related to the seventh principle and indirectly connected to principles 3 and 6, depending on the video delivering media.

The use of streaming video is directly related to the seventh principle of the proposed set, respecting the student's way of learning. Students bring different styles of learning to college and need the opportunity to learn in ways that work for them. Learning styles, which can be defined as the characteristic strengths and preferences in the ways the students take in and process information, have been a topic of interest in higher education research from long ago, and have been widely used in engineering education [9-14]. The cited literature references state several categories or indexes to classify the learning abilities. Amongst them, the model of Felder-Silverman [13] propose a visual versus verbal learners category directly related with the use of video for teaching purposes (Visual learners remember best what they see--pictures, diagrams, flow charts, films. Verbal learners get more out of words--written and spoken explanations). As most engineering students are visual learners [15], the use of video as teaching tool can help students learn in ways they find most effective and broaden their repertoires for learning. A video that includes real pictures and films, animated diagrams and flow charts, dynamic explanation texts, etc., constitutes a strong narrative lecture reinforced by the audio explanations of the speaker, and addresses both visual and verbal learners. Moreover, those students with high performance in both learning styles pair, visual and verbal, are fully empowered. Though for business topics, reference [16] shows the positive impact of streaming video on Chickering and Gamson's principles of good teaching practice, particularly on item 7, respect diverse talents and ways of learning.

By the way, streaming video can communicate high expectations explicitly and efficiently. Significant real-life problems can be easily presented when showing real devices, industry applications, technological processes, etc. and can set powerful learning challenges that drive students to not only acquire information but sharpen their cognitive skills of analysis, synthesis, application, and evaluation. Many often, video presentations are used by industry and companies to present structured information about scientific and technological processes in a more effective and safe manner than even a true visit to real plants.

Streaming video could be considered within the general category of digital courseware. Some relevant Educational Digital Libraries [17, 18] have already criteria for the evaluation of engineering courseware. Following the structure suggested in NEEDS [19], the criteria are divided into three main categories: instructional design, software design and engineering content. Each category is described by a set of components.

The instructional design deals with the question of if the multimedia enhances learning. Will students learn from courseware? Four essential components must be revised:

- Learning objectives are clearly stated and are appropriate. These objectives could be stated in the software or in an instructor's guide or page. The learners are aware of learning objectives as they are using the multimedia. A clear method of measuring achievement of learning objectives is provided.
- Multimedia interactivity. That means that the learner is actively involved in the learning process. The choices that students make are meaningful and not just not for the sake of making choices. The students can decide in what order to learn and how deeply they want to concentrate on specific topics.
- The content is well chosen and structured. The scope of the multimedia content is appropriate for the intended learning objectives and intended audience. The multimedia is not ambiguous or is not likely to be misinterpreted by the students.
- Instructions or an instructor's guide clearly explains how the multimedia should be used or the operation is self-evident. Help functions and guides are provided. Sufficient time is allowed for students to master the multimedia for arriving at the point at which learning really starts.

These are general criteria that can be also applied to specific streaming video teaching materials. Additional and more detailed criteria for the design of streaming video for teaching purposes are proposed by the Click and Go Video Decision Tool [20], that a simple tool in order to help the teacher to make some key decisions when designing streaming media. The tool takes the form of a check list that focus on four main aspects: (i) the educational purpose; (ii) the educational focus on image and sound, interactivity or integration; (iii) technical and implementation issues; (iv) comparison of practical and educational requirements. Table 1 presents a summary of the checklist.

TABLE 1. *Summary of the design criteria (i) to (iii) of Click and Go Video Decision Tool.*

(i). The educational purpose
Why do you want to use video and audio as a medium?
What learning outcome(s) do you want to achieve using video and audio
Who is your audience and what are their accessibility requirements?
Why do you want to stream video and audio on the web (rather than on CD for example)?
(ii). The educational focus on image and sound, interactivity or integration
Image and Sound: It is important to you that the media captures image and sound as close as possible to the real thing. This will involve the production of a detailed storyboard, a high quality camera and microphone, appropriate lighting and careful compression.
Interaction: On-demand availability of the media resources is more important to you than quality. The focus here is the provision of user control and non-restricted access to a library of images and sounds.
Integration: You find it important to link the video and audio to other media and course tools. Video and audio in this case is meant to be part of a wider learning environment, possibly embedded within your university's virtual learning environment or to support face-to- face lectures.
(iii). Technical and implementation issues
Some of my students will be accessing the video and audio from home
Some of my students will be accessing the media on campus computers
Some of my students will be accessing the video and audio from work
My students have a diverse range of connection speeds
I am unsure which media player to choose
All my students use the same Internet browser
My students use a variety of Internet browsers
Some of my students might not be able to hear sound
My video and audio will be broadcast live
I do not have access to a server that can 'stream'
I intend for more than 10 students to access the video and audio simultaneously
I do not have a camera, lights or a microphone
I do not have the equipment to turn the video on a camera into streaming media on the web
I have one or more students with a disability
I am a busy person

3 STREAMING VIDEO ON THERMAL SOLAR ENERGY TOPICS: A SHORT REVIEW

Developing one's own teaching streaming video could be an expensive and time consuming task, while using already available video could be easier and inexpensive. When searching for video clips for teaching purposes, following the criteria stated in the previous section, you can consider television broadcaster on-line resources, or websites such as YouTube, Vimeo or TeacherTube, which can be very useful. For engineering education purposes, it could be useful to search in relevant Educational Digital Libraries such as NEEDS or MERLOT, where streaming video could be considered within the general category of digital courseware. However, high level technical and/or educational videos at these websites are very scarce.

As an example, we present a short review on educational streaming video that can be used as teaching materials for thermal solar energy courses. To limit the scope of the search, only thermal solar systems for the production of domestic hot water or space heating have been considered. Contents cover solar system descriptions, lectures, maintenance topics, self-made solar collectors, commercial videos and professional items. Table 2 presents a summary of the search, performed on April, 10th 2012. Consider that URLs could change along time.

TABLE 2. *Review on educational streaming video for thermal solar energy courses.*

Repository	Title	type	url
MERLOT	Description of a low temperature solar thermal system for domestic hot water supply in buildings	Technical video	http://www.merlot.org/merlot/viewMaterial.htm?id=489884
Learners TV	Solar Thermal Energy Conversion	Lecture	http://www.learnerstv.com/video/Free-video-Lecture-5814-Engineering.htm
Florida Solar Energy Center	Inside Energy - Episode 7 - Solar Hot Water Systems	Technical video	http://vimeo.com/1975763
Florida Solar Energy Center	Solar Thermal Inspection - Part 4 - Indoor Inspection	Video-slides	http://vimeo.com/10285485
Florida Solar Energy Center	Solar Thermal Inspection - Part 3 - Outdoor Inspection	Technical video	http://vimeo.com/10066576
Hawaii Energy	Understanding Your Solar Water Heater Timer	Animation	http://vimeo.com/29448909
Solartron Energy	Solar Hot Water System - Technological Marvel	Technical video	http://vimeo.com/17567700
Unknown	Brief Introduction Solar Thermal and Solar Hot Water	Video-slides	http://www.youtube.com/watch?v=L0fxmyXOevU&feature=fvsr
Eurotherm	Euroterm Solar Thermal Collectors Production	Technical video	http://www.youtube.com/watch?v=CZIvbqWtLKU
Coastal Solar	Solar Evacuated Glass Tube Replacement	Technical video	http://www.youtube.com/watch?v=nGzerlVFhg8
Unknown	Hot Air Collector	Practical video	http://www.youtube.com/watch?v=oVsYVTyvBoA

These videos can be directly streamed from the URL, but their great advantage is that they are easily embedded in Learning Management Systems, as those used frequently by Universities or Higher Education institutions for both blended learning or e-learning teaching approaches. This facility empowers strongly the use of streaming video as an additional resource to other teaching materials instead of the replacement of the same.

4 CONCLUSION

A review of design criteria for developing streaming video teaching materials for engineering education within the frame of active, deep approaches to learning has been presented. As most engineering students are visual learners, the use of video as teaching tool can help students learn in ways they find most effective and broaden their repertoires for learning. In addition, a short review on video teaching materials on solar energy for water or space heating serves as an example of addressing engineering and professional learning outcomes when used for educational purposes.

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86 A STUDY ON THE DEVELOPMENT OF PROGRAM OUTCOMES ASSESSMENT TOOL USING REFLECTION JOURNAL

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ABSTRACT

The main purpose of this study was to develop a program outcomes assessment tool using reflection journal. Reflection journal has recently comes to gain more attention from school as an alternative assessment tool. Although numerous studies reconfirmed the education importance and value of reflection journal as an assessment tool, research on the assessment tool of the engineering accreditation, based on education view is scarce. After literature review about the case studies on the program outcomes assessment, this study, to analyse the current assessment tools, and then, examined the educational implications of reflection journal as a program outcomes assessment tool. As a result, this study suggested the assessment tool using reflection journal for PO6(teamwork), one of the most important assessment items in engineering accreditation. In this study, we used the performance criteria, assessment criteria, rubrics, and closed the loop to measure the teamwork and engineering ethics.

Keywords: Reflection Journal, Program outcomes assessment tool.

1 INTRODUCTION

Accreditation of engineering education reflects the paradigm shift of education, and emphasizes the perspective of learning and performance.[1] [2] The educational paradigm moved away from traditional teacher-centered, lecture-oriented, textbook-centered learning environment to emphasize the importance of learner-centered, problem-based learning environment. [3] Moreover, it also means that the perspective moves away from concentrating on what a teacher teaches to focusing more on what a learner learns or is capable of.[4] The central role of accreditation of engineering education is to evaluate the achievement of educational objectives and learning outcomes through education system including education curriculum, and to induce the qualitative improvement of education as the assessment results will be reflected in the management of curriculum. The outcomes assessment tool evaluates students who completed the program in terms of their abilities and qualifications as engineers, the results of which provide evidence necessary in improving the program. Therefore, the program outcomes assessment tool is an important component in realizing outcomes-based education for it measures not just the learner's understanding of concepts, but the ability to analyze, understand and apply concepts learned to solving real-life problems.[5]

Despite the increasing number of research on the program outcomes assessment tool, the accreditation criteria on program outcomes are perceived as a quite difficult standard in terms of the quantitative aspect of an education executor or evaluator due to a lack of understanding the components of assessment system and the validity of assessment tool. In this research, we suggest developing the program outcomes assessment tool using reflection journal to solve the previously discussed problems. Program outcomes assessment focuses on the reflection of learner's performance and the future plan for learner's performance from the learner's point of view.[6] [7] [8] Like so, in order to evaluate the learner's reflection on experience and performance gained from the curriculum, not only the acquisition of academic concept, but also the learning procedure and the achievement of critical thinking which will lead to practical behavior as learning outcomes should be assessed. Moreover, as reflectional journal is increasingly being used as a standard assessment tool in constructivism.[6] The educational applicability of reflectional journal as the program outcomes assessment tool to monitor the student's learning procedure is very high.

The purpose of this research is to develop an effective program outcomes assessment tool using reflection journal. To fulfill the purpose and to understand the program outcomes assessment, the literature review was conducted. Particularly, it was attempted to establish logical grounds for the program outcomes assessment tool by reviewing the case study of using reflection journal. The elements with which the program outcomes assessment tool should be equipped are also identified.

2 THEORICAL BACKGROUND

2.1 The implication of program outcomes assessment system

Outcome-based education is the fundamental philosophy of the accreditation of engineering education. The educational objectives and outcomes of the program can be achieved by the completion of regular curriculum and by such extra curriculum as seminar, internship, club activity, team activity, and training abroad. Therefore, the accreditation of engineering education defines outcomes collectively to include all kinds of activities where a student may learn, and emphasizes evaluating outcomes comprehensively.[9]

In other words, the accreditation of engineering education based on outcomes-based education establishes a variety of performance criteria including assessment of student's completed courses. It also requires that students achieve objectives, which are defined before the start of the program, by the time they graduate. Moreover, it demands the system of Continuous Quality Improvement.[10]

Program learning outcomes refer to knowledge, thinking skills, and performance skills that a student must acquire upon the completion of curriculum.[11] Program outcomes, therefore, can be defined as the overall abilities to be obtained by an engineer, which can be developed consistently and comprehensively through the completion of education curriculum.

Previous research on program outcomes assessment system involved such assessment tools as capstone design, portfolio, and graduation thesis. Particularly, capstone design appeared to be one of the most effective assessment tool used in many education programs. There were two major reasons for such effectiveness. The first is the adequate time of when the assessment is implemented. The decision on when to carry out the assessment is critical in comprehensively assessing the learning outcomes as KEC2005 defines learning outcome as the competency to be acquired by the time of graduation and ABET also defines it as "what students are expected to know and be able to do by the time of graduation".[12] Based on the accreditation criteria 3, capstone design course can be implemented as the final course. Then, the capstone design can accurately represent the characteristics of learner outcomes and will be effective as the program outcomes assessment tool with combination of proper rubric.[1] Secondly, the program outcomes assessment utilizes the characteristics of capstone design. Capstone design offers a way to represent comprehensive knowledge and capability related to concept, skills, and attitudes, and can be used effectively as an assessment tool. In addition, portfolio is also widely used as the program outcomes assessment tool as it demonstrates the student's writing, think, and research skills better than test scores.[13] Graduation thesis paper is effective in program outcomes assessment as it includes a student's direct experience, and helps evaluating comprehensive abilities like experimental and logical thinking skill.[14]

The program outcomes assessment tool previously discussed aims to evaluate learning outcomes by the time of graduation in a comprehensive manner, and utilizes the assessment tool based on its appropriateness.[4][15]

2.2 The educational implication of reflection journal

With recently growing emphasis on learner-centered learning environment, assessment tools are also becoming to include not only the learning outcomes, but also the learning process.[16] In this context, reflectional journal is applied in elementary school and secondary school, as well as in college education as the typical alternative or complementary assessment tool to measure both learning outcomes and procedure.[3] [17] [18] [19] [20] Also, reflection journal has important educational implication as it can facilitate the management system of autonomous improvement of educational effectiveness, including enhancing teaching activities, and promote learner's own management and evaluation of learning outcomes. Especially when considering the characteristics of learning outcomes of the accreditation of engineering education, using reflection journal as a assessment tool seems suitable as it can demonstrate knowledge, skills and attitudes gained through learning procedure.

Reflection journal, as a tool evaluating introspective thought or activity, can be defined as explicit manifestation and specific action plan of introspective thought. [17] [21] [22] [23] [24] [25] Introspective thought or activity refers to synthetic thought which heavily influences the behavior after gaining understanding, experience, and knowledge from self-examination of learning experience.[21] Like so, as a means to express the introspective thought and activity, reflection journal can promote both cognitive and affective aspects of self-examination, and engraft constructivist theory.[21] [22] [23]

Moreover, reflection journal provides direction to solve educational task as an assessment tool, and has educational value as creative result. Reflection journal records learning activities experienced by an individual. For it involves writing out the learner's thinking process of completing the learning task, it is possible with reflection journal to assess the meta-cognition skills which help the learner understand his own shortcomings and find ways to improve. At the same time, it helps to create dynamic and productive learning outcomes by improving self-regulation skills and thinking ability. [17] [19] [26] [27] [28]

Taking all the research together, reflection journal has significant educational implications as an instrumentation of review of learning experience by providing opportunities to objectify self-reflection and analysis.[29] Allowing learners to express what they have thought and felt during the learning process, reflection journal can also be expected to function as a formative evaluation to advance education curriculum.[30]

3 CASE STUDY OF DEVELOPMENT OF PROGRAM OUTCOMES ASSESSMENT SYSTEM AT HANYANG UNIVERSITY

The second general criteria of the accreditation of engineering education states the program must establish performance criteria to review periodically that its program educational objectives are met. This criteria signifies the need for building an assessment system which includes specific performance criteria, grading criteria, assessment tool, subject, periodic time, analysis, and public release. To fulfill the criteria, preparation of appropriate outcomes assessment system that will include comprehensive evaluation of learner's acquired ability is essential.

This research developed the program outcomes assessment tool using reflection journal that also meet the criteria of the accreditation of engineering education. Considering the characteristics of reflection journal and the content of learning outcomes, the assessment tool can provide evaluations for program outcomes 5, 6, 8, 10, 11, and 12. Nonetheless, the current research will provide the assessment system for the program outcome 6 on the ability to function as a member of multidisciplinary team.

3.1 Components of program outcomes assessment system

The program outcomes assessment system suggested by the accreditation of engineering education is a system which guarantees CQI in regards to performance criteria and assessment tool's objectives. The program outcomes assessment system using reflection journal includes all of holistic rubric, closed loop, assessment form, and analytic rubric in order to evaluate the achievement level of program outcomes comprehensively and analytically from a variety of aspects. The program outcomes assessment system should include assessment of learning outcomes with performance criteria and overall criteria and assessment of assessment tool with performance criteria, analytic rubric, and assessment tool.

3.2 The educational implication of reflection journal

Reflection journal items should be composed to provide opportunities to express not only knowledge acquired, but also personal thoughts, affects, and experiences. As shown in Table 3, the analytic rubric can be used to assess the knowledge gained from team activity, contribution to the team, shortcomings, and future improvement plans.

Not only does the program outcomes assessment tool using reflection journal raise awareness of the importance of learner-centered curriculum, but it also evaluates the outcomes from various aspects by taking into account both cognitive and affective aspects of leaner. Moreover, establishing specific assessment item helps identify the problems of curriculum and organize educational improvement.

TABLE 1. *Assessment system of reflection journal PO 6.*

6	Ability to complete the role as a member of multidisciplinary team	
Performance criteria	The student can perform self-examination of his own role as a member of multidisciplinary team, and reflect on possibl improvements.	
Assessment method	Assessment using reflection journal	
Rubrics	Degree of self-reflection on one's own role as a member of multidisciplinary team	
	Good	As a member of multidisciplinary team, the student adequately reflects on his own role and identifie plans to improve. (Achievement score 4 ~ 5)
	Fair	As a member of multidisciplinary team, the student reflects somewhat on his own role and identifie some ways to improve. (Achievement score 2~3)
	Poor	As a member of multidisciplinary team, the student does not reflect on his own role and does not identif ways to improve. (Achievement score 0 ~ 1)
Closed Loop	Objective	The entire ABEEK graduate students are members of multidisciplinary team, and their level of self reflection and self-improvement is above average.
	Implementation	Students are encouraged to display good teamwork required by classes that involve group project. The are also encouraged to engage in club activities.
	Assessment	The subcommittee of program assessment evaluates the achievement of learning outcome abilities of graduation candidate students.
	Revision	Using program CQI, the program committee analyzes the problem and opinion of those students who did not meet the achievement criteria. The committee increases the portion of subjects necessary to improve their capacities. The committee revises the program to achieve its objectives by reviewing the system of design courses, or the management and content of design courses. Based on the review of analysis, revisions are made to performance criteria, achievement level, education curriculum, rubric, and assessment tool if necessary.
	Disclosure	The assessment results will be released publically annually on the website. The assessment committee will hold annual meeting to discuss the improvement plans which will then be presented to the affiliated professors as program CQI report.

Learning Outcome 6.
Describe what you learned from the team activity.
Describe the level of your contribution to the team.
Describe your own deficiency and how you will improve.

Assessment item	**Learning through team activity**	**Contribution as a team member**	**Self-improvement and reflection**	Score	
				Total	Mean
Score					

Criteria	Performance Criteria					
	0	1	2	3	4	5

4 CONCLUSION

This research devised the assessment tool using reflection journal to effectively evaluate the program outcomes of the accreditation of engineering education. As the accreditation of engineering education demands assessing the program outcomes in terms of both cognitive skills and affective domain, reflection journal appears to be a quite efficient tool to be used for the program outcomes assessment tool.

Furthermore, the realization of outcomes-based education that is critical to the accreditation of engineering education requires the possible utilization of assessment results in improving curriculum. The program outcomes assessment underscores the construction of system that guarantees achievement of educational objectives and dedicates to improving education. In these respects, reflection journal is sufficient to analyze and correct the problem of curriculum since it provides a chance to reflect and examine the content and procedure of learning. Learners can also identify and make up for their shortcomings by writing reflection journal. Such reflection is expected to consistently improve the learner's learning ability.

This research suggested performance criteria, rubric, closed loop, and assessment item for the program outcome item 6. The most important evaluation components when establishing assessment system were logically identified. To increase the objectivity and validity, a rubric for assessment items were developed.

For further research, assessment criteria and rubric to evaluate from various aspects, which will take into consideration the characteristics of program outcomes are to be explored more in depth.

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87 A NEW EMBEDDED SYSTEM PROTOTYPING SERVICE FOR TAIWAN ACADEMIA

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ABSTRACT

For helping researchers in the academia of Taiwan to speedup their implementation and verification of innovative system designs, The National Chip Implementation Center (CIC) provides a new service program named MorPACK. The MorPACK platform is highly modulized and flexible in contrast to present prototyping systems, by adopting three concepts: substrate-level modulizion, three-dimensional module stack, and components reuse. MorPACK helps professors and students to concentrate their efforts on their own functional module(s), and easily reuse existing modules like playing bricks, which greatly reduces the developing cycle of an embedded system. CIC also have prepared an Linux-based operating system, a virtual platform simulator, a plenty of user manuals, reference designs, and training courses. In this paper, we will introduce the general situation of the two-year prior run of MorPACK program, including the concurrent engineering model between CIC and research groups form universities, project accomplishment status, and participant feedbacks. For further planning, CIC will revise the design-flow arrangement, hardware/software specification, documentation, and training and consultation services, to provide the MorPACK as a regular prototyping service for Taiwan Academia.

Keywords: three-dimensional, modulized, prototyping, service.

1 INTRODUCTION

For verifying the functional correctness of an embedded design, a critical issue is to implement the function through a prototyping platform before taping-out. The current state-of-the-art platforms include FPGA-based prototyping [1], hybrid prototyping [2], virtual prototyping [3], and full custom prototyping [4]. The FPGA-based prototyping provides short prototyping periods, parallel processing, and simple user-friendly interfaces. However, the defects of FPGA-based prototyping are the low performance and the difficulty to integrate hard IPs. For hybrid prototyping such as ARM Versatile, it is based on an ARM real chip and a large FPGA that implements the bus infrastructure and can be used to prototype custom AMBA peripherals; however, the inflexibility and low performance are still critical issues. The virtual prototyping is an electronic design methodology, which simulate a hardware design by a software simulator, written by high-level language such as C/C++ or SystemC. However, the virtual prototyping is mainly suitable for system software developing, due to the conflict between the timing accuracy and simulation speed. The full custom prototyping is implemented based on users' requirements. Currently, three methods are available for full custom prototyping: SoC [5], system in package (SiP) [6], and 3D IC [7]. These methods can achieve the integration of heterogeneous system, but have high cost fabrication and time complexity.

National Chip Implementation Center (CIC) has been serving the academic and industrial societies in Taiwan for more than 15 years. The main objective of CIC is to provide highly qualified IP design and implementation services to the academia of Taiwan. We continuously introduce advanced IC/system design technology to the campus, provide design environment, assist professors and students to implement their innovative works, and play the role as a bridge between academic and industrial societies. For helping researchers in the academia of Taiwan to implement and verify their innovative designs, CIC sustains to develop new prototyping techniques which benefit the users. In 2005, we proposed the Multi-Project SoC program [8], in which several IPs from individual research projects were implemented in a single SoC by sharing a common platform. In 2007, another program named CONCORD [9] was brought up to provide a fully modulized, board-level prototyping platform. The Multi-Project SoC took benefits from reduced tape-out cost of a single project and optimized performance of a SoC chip, but also took deficiencies from yield, heterogeneous integration, and reusability of components. Otherwise, the Concord platform is fully flexible by composing the main-board and various functional sub-boards, but the performance is limited due to it board-level architecture. To combine the advantages of the Multi-Project SoC and Concord platform, we now present a new substrate-level, modulized and stackable prototyping platform named MorPACK (i.e. Morphing Package). The MorPACK platform is highly modulized and flexible, easy to integrate heterogeneous components into a system, yet retain high performance.

2 MORPACK SPECIFICATION BRIEF

To provide an effective and user-friendly prototyping system, we adopt three techniques for MorPACK platform: substrate-level modulizion, three-dimensional module stack, and components reuse, to fulfil following main objectives:

1. Heterogeneous integration: The prototyping system should be composed of components from different process.
2. Variety: The prototyping system should be highly flexible. To build a platform is like to play bricks.
3. High performance: One of the main design goals of the prototyping system is to shorten the distance of signal transmission and raise the performance.
4. Rapid developing cycle: The developers do not need to re-design and re-produce the main parts of the target system.

5. Low cost: The recycling of functional modules reduces the use of resources, thus decreases the development price and the impact to the environment.

The MorPACK platform is composed of these components:

1. Substrate-level functional modules: A functional module is a small substrate with the die(s) of individual functional IP(s) attached on it. These IPs comprise an ARM926 processor, a north-bridge including the AHB, ROM, SRAM, VGA, NOR flash, SDRAM, and various type of memory controllers, a south-bridge including the APB, and various peripherals such as UART and interrupt controller, and other customized functional IPs. Figure 1 illustrates the CPU module as an example.
2. Stack mechanism: Multiple modules can be easily mounted and dismounted to be a stack, as shown in Figure 2. The tri-state interface and signal transmission mechanism between function modules is also included. For flexibility and configurability, the modules can be stacked by any order.
3. Carrier board: The carrier board contains a base to connect the module stack, and other connectors, electronic components, switches, and buttons which can not be placed on a function module. Figure 3 demonstrates a digital photo frame system implemented by the carrier board, respective modules, and a LCD panel.

CIC have prepared an operating system for the MorPACK platform, which is based on Linux kernel 2.6.33. Boot code including power on self test software for peripherals is provided to the users for further reference. We also provide a virtual platform created by ARM Fast Model tool, a plenty of user manuals, reference designs, and training courses.

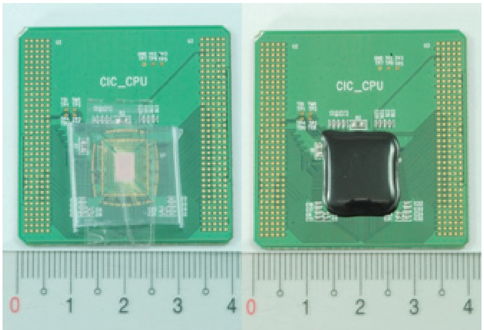

FIGURE 1. *CPU module. Left: before packaging; right: after packaging.*

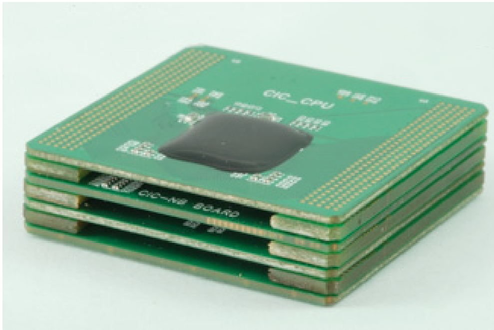

FIGURE 2. *Module stack.*

FIGURE 3. *Digital photo frame demo system by MorPACK.*

3 MORPACK PROGRAM STATUS

Since 2010, six professors and their research groups have joined the MorPACK program. Their respective projects are:

1. Eigen-based signal processing engine IP design for biomedical ultrasound systems, by Prof. A. Y. Wu from National Taiwan University,
2. ECG signal processor for mobile healthcare monitoring, by Prof. C.Y. Lee from National Chiao Tung University,
3. Low complexity and high throughput lossless image compression system, by Prof. Y. T. Huang from National Chung Hsing University,
4. H.264 video encoder with low memory bandwidth, by Prof. J. Y. Guo from National Chung Cheng University,
5. Object detection system development and multi-pixel parallel image labeling IP design, by Prof. M. H. Sheu from National Yunlin University of Science and Technology, and
6. Test architecture & hardware debug platform, by Prof. K. J. Lee from National Cheng Kung University.

The design-flow of MorPACK program is divided into two front-end and four back-end stages. CIC and the staff of individual research groups have to complete their respective objectives at the scheduled checkpoint of each stage. CIC mainly provides training courses, design/verification environments, hardware/software of MorPACK platform, and technical support; researchers have to attend courses, study manuals, design their IP(s) and perform necessary verifications, and keep contact with CIC. Table 1 and Table 2 are the front-end and back-end objectives and for CIC and the individual research groups.

The program began in July 2010. By December 2010, CIC had provided a series of training courses and set up the design environment. All the research groups had finished their synthesis/gate-level simulation works before March 2011, and taped-out their respective customized IPs in June 2011. Until January 2012, CIC has readily prepared the MorPACK components including the carrier board, processor, NOR flash, SDRAM, north-bridge and south-bridge modules. Professors and students are now testing the functionality of their IP packages for further system integration. The object detection system by Prof. Sheu and his crew members [10] is the first completed project which passed all the verification steps and achieved the specification requirements, as shown in Figure 4.

FIGURE 4. *The object detection system by Prof. Sheu and his crew members.*

4 CONCLUSION

The MorPACK platform is highly flexible, easy to integrate heterogeneous components into a system, yet retain high performance. By using the techniques of substrate-level modulizion, three-dimensional module stack, and components reuse, system developers can concentrate their minds to design the customized IP(s), by reusing the ready-made modules to construct the rest of the target system.

In this paper, we introduced the general situation of the two-year prior run of MorPACK program, including the concurrent engineering model between CIC and research groups form universities, and accomplishment status of research projects. For further planning, CIC will revise the MorPACK design-flow arrangement, upgrade hardware/software specification such as advanced processor and bus types, flexible arbitration scheme, high-speed die-to-die I/O scheme, and provide documentation, training and consultation services as a regular prototyping service for Taiwan Academia.

TABLE 1. *Front-end objectives of MorPACK design flow.*

Stage		CIC	Research groups from universities
Virtual prototyping		1. Provide MorPACK virtual platform 2. Provide MorPACK virtual platform user manual 3. Provide technical consultation	1. Prepare LISA/SystemC IP model(s) 2. Integrate IP model(s) into MorPACK virtual platform and perform simulation 3. Hand over IP model(s) and simulation report
Logic implementation	RTL Design	1. Provide MorPACK encrypted RTL/gate-level Verilog platform, Encrypted RTL/ Gate-level netlist, tri-state AHB wrapper example, SDF timing data, Software example, and SDRAM/NOR Flash simulation model 2. Provide platform introduction (memory map, peripherals, etc.) 3. Provide verification IP environment for bus protocol 4. Provide IP integration/verification guide 5. Provide training courses and technical consultation	1. Attend CIC training courses 2. Apply Verilog IP design (including tri-state AHB wrapper) 3. Verify IP protocol by VIP environment 4. Integrate Verilog IP into MorPACK Verilog platform and perform simulation 5. Hand over Verilog IP and whole system simulation/VIP verification reports
	Rapid prototyping	1. Provide MorPACK rapid prototyping platform 2. Provide MorPACK rapid prototyping platform user manual, including NOR Flash burning program and manual, PROM/FPGA burning manual, DCT/LCD Controller example, and boot code software example 3. Provide training courses and technical consultation	1. Attend CIC training courses 2. Download Verilog IP to MorPACK rapid prototyping platform and perform whole system rapid prototyping 3. Hand over rapid prototyping report
	Synthesis	1. Provide coding style check rule, front end cell library, and design delivery form 2. Provide technical consultation 3. Verify coding style rule check result 4. Perform early design performance evaluation and provide result 5. Perform design synthesis 6. Provide post-synthesis gate-level netlist	1. Perform Verilog IP coding style rule check 2. Hand over coding style rule check result 3. Perform Verilog IP early synthesis 4. Integrate gate-level Verilog IP into MorPACK Verilog platform and perform simulation 5. Fill design delivery form 6. Perform post-synthesis gate-level netlist simulation

TABLE 2. *Back-end objectives of MorPACK design flow.*

Stage	CIC	Research groups from universities
Physical implementation	1. Perform back-end layout, place and route 2. Perform and provide back-end layout verification and provide result 3. Provide post-layout gate-level netlist 4. Provide back-end performance evaluation result	1. Perform post-layout gate-level netlist simulation
Tape-out	1. Integrate all tape-out dies 2. Dummy metal/poly insertion 3. Whole block DRC verification 4. TSMC tape-out flow	
Bare die Measurement	1. Design and manufacture substrates for university bare dies 2. Perform wire bonding for bare dies 3. Configure carrier board settings 4. Configure ATE settings	1. Prepare test bench 2. Perform test 3. Provide test result
Substrate Assembly	1. Assembly for MorPACK common platform and university substrate 2. Provide MorPACK system module and test debug carrier board	1. Perform MorPACK System Module verification 2. Hand over MorPACK System Module verification report

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88 THE LAB OF COURAGE: STUDENT PARTICIPATION IN BUSINESS PROJECTS

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ABSTRACT

Anna Sulkakoski is a biotechnology engineering student completing her fourth year of studies at the Turku University of Applied Sciences (TUAS). For a year and a half Anna has been working as a project assistant in a business commissioned project which aims at producing the adiponectin protein in yeast cells. The project's progress is steered by the commissioning company's needs and timetable. Since the project plan is protected by NDA, the chain of information in the project is highly structured: the R&D Manager acts as the project supervisor and is in contact with the company, sharing only the information necessary for the execution of the project with the Project Manager and the student assistant.

Although Anna has become an expert both in protein production processes and especially the adiponectin, she claims the true value of project work for her lies in gaining the courage. For Anna, the most significant pedagogical innovation behind project work is learning through trial and error: courage is born out of the realisation that one survives the failure. What is more, projects are a rich environment for developing engineering skills, which are cemented by repetition: the more laboratory work a student can get her hands on, the better.

Keywords: Protein production, learning-by-doing, laboratory skills.

1 INTRODUCTION

Adiponectin (Synonyms; Acrp30, AdipoQ, GBP-28, APM-1, ACDC) is a protein hormone secreted by fat cells, and is connected to metabolic processes [1]. The lack of adiponectin in humans has been linked to gaining weight, diabetes and cardiovascular diseases [2-4]. The ACR30 project aims at developing a production system for adiponectin in yeast cells, more specifically the Pichia pastoris species. The benefit of applying this particular species is that its post-translational modifications are closer to mammalian protein modification than that of e.g. S. cerevisiae [5]. Other benefits include its strong inducible promoter and the scarcity of secreted homologous proteins which makes the downstream-processing less intricate [5-6].

1.1 General project pipeline

The concrete framework for realising the ACR30 project at the Turku University of Applied Sciences was defined by the commissioning company and by the laboratory facilities available. In this project, the process of knowledge and communication flow assumed a unique arrangement following a student – engineer – supervisor - company representative pipeline. This pipeline was formed already in the initial phases of the project.

The first phase of the project involved modifying the gene that encodes the ACR30 protein to be suitable for S. cerevisiae protein production. This careful study included planning of the genetic sequences and insertion of genetic elements into the ACR-encoding gene and further on into a carrier vector [7]. Meanwhile, a similar system was designed for another yeast species, Pichia pastoris [7]. This part of the work was a team effort of the student-engineer-supervisor-company collaboration.

1.1 Engineer (Project Manager) perspective: project pipeline

Much of the work of the Project Manager in this particular project involved orchestrating the different actors of the project and their schedules. Because the project is carried out in a teaching laboratory, it has to be carefully scheduled around laboratory courses. Another critical factor was supervising and instructing the student assistants in their work. Accommodating the hours that the students spent on the project with their course load proved a major challenge. The obligatory attendance policy of many of their courses made it considerably difficult for the student assistants to participate in the project.

The different phases of the project lasted several days, and the students should have had the opportunity to work with the project in consecutive days at a given time. This, however, often proved impossible, and in practise the various stages of the same task were actually conducted by several different people. This made it difficult for the students to get a proper overall picture on the entire process.

In the beginning, the Project Manager planned all the practical work tasks and their schedules. The student assistants only came in to complete the tasks planned and scheduled for them. When a new assistant started with the project, a lot of time was obviously spent on familiarising him/her to the work plan. If a student was working on the project for the first time, they completed practically all of the work stages together with the Project Manager. On one hand, it was crucial to complete the tasks in order to attain the results needed for continuing with the project – on the other hand, it was impossible to predict the level of instruction needed by each new student at the laboratory. When the students became more familiar with the processes, they had more and more opportunities to work independently.

As the project progressed, the Project Manager was able to focus more on planning the upcoming stages as the students conducted most of the practical tasks. As the skills of the students improved, they were also able to assume more responsibility in the planning of the work tasks and of their own schedules. Towards the end of the project there were many discussions on what the next step in the project would be and how to solve problems that had arisen. This way the students were introduced to a more proactive view on their work and were motivated by being able to have an impact on the project. However, the final decisions and the responsibility remained with the Project Manager. It was clear that this added to the students' interest and commitment to the project.

The communication between the Project Manager and the students occurred mostly while working and planning in the lab. We had a small project team, so it was not necessary to hold regular meetings. Those involved in the project knew what the others were doing and what the next step would be. Problems were solved as they arose and the following work stages were agreed upon without a hitch while working in the lab. Throughout the project, the R&D Manager, who acted as the project supervisor, was in charge of communication with the client company. The Project Manager and students had no contact with the client company.

It was rewarding to observe how the skills of the students increased as the project went along. From the initial learning of the basic skills, we were able to make joint decisions. In the beginning of the project, the students completed simple work stages; in the end, they were able to plan and carry out complex work tasks independently. If there was room for further improvement, it might have to do with the students being able to plan their own schedules even more than they did, since managing schedules proved a critical skill even in a project of a relatively small scale like this one. However, this was almost impossible because of their strict course attendance requirements.

For the Project Manager, the initial challenge was to reconcile two sets of objectives: those of the commissioning company and those of the university. There was a dual responsibility, which, from time to time, almost seemed contradictory – ultimately the aim had to be on completing the project and producing the results required by the commissioning company. On the other hand, treating the project as a learning environment for students required extra time dedicated to producing certain learning competences first. Quite soon, however, one comes to realise that in order to attain the first objective the other one must be achieved to the best possible level. This, in turn, acts as a motivating factor for discovering the best methods of teaching in order to achieve the best possible level of learning. What is more, when we reached the level where the Project Manager no longer had the knowledge to act as a teacher, it became apparent that the students took the responsibility for their own learning. Indeed, the best learning results came from us tackling a new problem together as a team.

1.2 The student perspective: project pipeline

Carrying out all three mandatory practical work periods during two summers at the university laboratories created certain know-how and routine to laboratory work. However, the third period, working for the ACR30 project, again introduced completely new tasks which required quite a lot of practicing. Some days brought on nothing but questions but little by little both knowledge and confidence increased under the watchful and patient eye of the Project Manager.

Practical work turned into part-time work when the school started again in September. Both the equipment needed for this project and the tasks started to be familiar, which added to the ability to carry through routine tasks independently. As time went by it was motivating to notice a change in one's position and level of impact in the project group. It seemed that the gained trust proved liberating also for the Project Manager as he now had someone he could run his ideas by.

Working and carrying the course load required some adaptive skills since the project timetables varied every week. Since a work day in a laboratory is usually carried out in several smaller tasks, it is possible, with persistence, to even carry out some parts during free periods between classes. However, juggling with laboratory schedules and course work differs quite a bit from a normal 8-hour working day. As the project tasks were more scattered and there is no continuity in carrying out the consecutive phases of a process, they actually took more time to complete: the feeling of losing one's train of thought become quite familiar in these circumstances.

The second summer working as a full-time project assistant in the same project gained more perspective and more responsibility. The role of the student became that of the supervisor for three new student trainees. The four of us handled the majority of the practical laboratory work which allowed the Project Manager to dedicate more time to planning the upcoming tasks as well as reporting. This, in turn, offered him a broader view on the entire project's progress and helped him plan our work ahead.

Working in this project has provided priceless experience in general laboratory work and the routine gained through different laboratory courses now seems quite limited. Completing tasks which we have only gone through in theory in class also crystallised many topics.

The initial thoughts when entering a new project as an inexperienced trainee are "what if something breaks" and "what if everything is ruined by my mistakes". One of the most important lessons was that mistakes are inevitable especially when the end result is not known exactly. The second lesson involved scheduling and planning. Especially this type of explorative research project needs a comprehensive understanding over what has already been done and what is going to happen in the future. Sometime this requires stepping further away from the hectic practical work. The thing to accept in research work is also that the goals set are not always met. This can be really discouraging in the beginning but the key is to see that you never walk away from a project empty-handed. The goals are usually reset as the work carries on and new things, sometimes even dead ends, should be welcomed with curiosity.

1.3 Supervisor's view

The project supervisors' role was emphasised in the beginning and at the end of the project. At first, the role was to negotiate with the commissioning company. This included technical specifications needed in the project as well as monetary aspects and human resources – especially the role of students working in the project.

The other task was to combine the student work with the curriculum and timetables of the Degree Programme of Bio and Food Technology. This was probably the most challenging part of the process. It is noted that the TUAS curriculum is quite flexible. However, projects like the ACR30, which require a rapid launch dictated by the company's schedule are not easily fitted into the university's pace. We avoided major hindrances by incorporating student work via practical work periods and free-choice studies.

A business-commissioned project is not ideal for allowing a free and unobstructed space for the student to construct her knowledge through experience [8]. However, a clear, target-oriented project with fixed parameters allowed for efficient learning of laboratory routine, equipment handling and in-depth knowledge on protein production methodology.

Mills and Treagust (2003) [9] summarise the critical issues to be addressed in engineering education. They recognise a clear demand for more industrial practice, but also draw attention to the need for more experience in design tasks and developing communication and team work skills. In the ACR30 project the student perspective developed in scope because of the consecutive working periods which started already at the beginning of the project. Also, keeping the project organization small and communication regular and open added to her ability to participate in strategic and management aspects of the project. Both the Project Manager and the student learned the importance of planning and managing of schedules.

The supervisor's role as a gatekeeper and a messenger between the company and the project aimed at providing the project enough breathing room to concentrate on the practical work. Supervising the project was easy due to engineer presence. The Project Manager executed the project in terms of planning and overseeing routine lab work and supervising students. Discussing project results and innovating new approaches was part of the supervisor's weekly meetings with the Project Manager and the student assistant.

There are certain key moments in terms of learning in the project's lifetime that are worth noticing. The project began with somewhat a hierarchical project organisation: the supervisor negotiated with the company and communicated the information back to the Project Manager, who in turn broke this information into even smaller pieces for the student. Once the student reached her independent position in carrying out the laboratory work and started to participate in problem-solving and even in strategic planning, a chain of command turned into a collaborative effort. From a supervisor's perspective, it was imminent that both the Project Manager's growing trust in the student assistant and the student's growing confidence in her abilities to master the laboratory work produced a key turning point in the roles they played in the project. A close working relationship between the supervisor, Project Manager and the student facilitated the process by which a hierarchy built into a partnership.

2 CONCLUSION

Projects, which are directly linked to companies and their commercial aspects, are clearly pipelined by TUAS. This means that process flows from careful planning towards results and reporting to company. There is always a risk involved when a project involves student participation – the risk has to do with sharing confidential information and with the execution of the project as efficiently as possible. Therefore, we concluded that student-engineer-supervisor model is a good way to minimise such risks that companies want to avoid. We also conclude that project participation must have a solid linkage to student curriculum and study frame. In this case we were lucky enough to find an optimal student for this process and we were also granted enough freedom to implement many consecutive practical working periods into the project. A flexible curriculum that would better allow integration of project work into studies and which would identify those valuable students more effectively is definitely worth more exploring.

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89 SUSBIO – DEVELOPING THE BIOGAS PROCESS FOR FUTURE ENGINEERS

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ABSTRACT

Energy consumption is growing rapidly throughout the world and increased energy prices are well documented. For example, the U.S. Energy Information Administration (EIA) noted that as of 2008, the spot price for a barrel of crude oil has increased by 53% over the past year [1]. Rising energy costs increase agricultural production input costs as well as logistics costs. These costs are passed on to consumers in the form of higher food prices. This is not the only reason to develop and adopt renewable energy sources which can reduce the dependence on fossil oil and temper global warming. Used energy is directly related to material produced for everyday life.

Currently in the SUSBIO project tools are developed for material efficiency combined to food value chain. The aim is to create new methods to utilize biowaste material as well as to produce biogas from various low value sources. The focus is in optimizing biogas processes in pilot scale and nutrient recovery processes in laboratory scale by implementing experiments conducted by students in different stages of the process. The students are learning project-type working and they are producing crucial information to the project at the same time. This type of learning is discussed in more detail from student and project manager (teacher) perspective in this paper.

Keywords: Biogas, biowaste, project-learning skills

1 INTRODUCTION

The strategic plan at the Turku University of Applied Sciences (TUAS) is targeting to increase the number of R&D projects. For the university this target generates various problems that are often related to self-financing, recruiting the right personnel and ensuring that learning in projects integrated into study curricula. We have therefore invested a lot of effort into planning the integration of learning and projects, as well as integrating personnel, both students and teachers, into the R&D projects. This is furthermore linked to our way of teaching. This process has been on going in universities for decades but not to the extent that we are aspiring for. It is common practice that some practical courses are linked to externally funded research projects, as it is also known that students' training periods are commonly linked to R&D projects in universities. However, these project-linked learning platforms are mainly short (under 6 months) and do not encourage students' commitment in the scale that would be desirable.

The project SUSBIO (Sustainable utilization of waste and industrial non-core materials) was designed with a close link to teaching and learning procedures. This is not only hands-on doing in the laboratory but also communication with other project partners, i.e. industry and other universities and institutes.

The technical collaboration required by the project defines the level of communication with industrial partners. The SUSBIO project targets to an increased material efficiency in the food value chain by adding to sustainability and re-cycling of organic materials. This target is achieved by developing laboratory level procedures and pilot scale activities at TUAS and by linking these activities to full scale industrial operations. At the university the laboratory experiments and the pilot testing are largely carried out by engineering students. The SUSBIO pilot unit, a 4 m3 bioreactor (Fig. 1), has been placed on the site of a major local biogas producer in Turku. This secures a direct link between the people and the operations at the university and bioenergy industry.

FIGURE 1. *Pilot scale bioreactor at TUAS.*

In investing into laboratory equipment the project has considered not only the state-of-the-art systems but also the methods currently applied in other regional universities and research laboratories. This ensures comparability of results. A key criterion for the pilot unit was an up-scalable technology. The same technical solutions have been applied to new industrial biogas plants in Sweden [2]. Therefore the SUSBIO project results will be directly applicable to industrial operations in biogas plants in Finland, too.

In the Turku region a large "cluster" of professional schools offering opportunities to cooperation has been created. As an example, the Livia college in its Tuorla agricultural school has been producing biodiesel for its own agro machineries and is now commencing a smaller scale biogas plant of Finnish construction. Thus it has been natural that close cooperation between the SUSBIO project and Tuorla has been established.

The SUSBIO project has already helped in establishing further research cooperation on the national level. The Finnish Game and Fisheries Research Institute (RKTL) has been working for the utilization of the less-valuable fish species. Tekes – the Finnish Funding Agency for

Technology and Innovation - is now funding the joint project between RKTL and TUAS. In this cooperation the SUSBIO project is separating protein from less-valuable fish which is caught and pre-processed by RKTL, and the remains will be utilized in biogas production, first in small scale in the SUSBIO pilot reactor.

Industrial biogas production still is quite new and relatively small a business in Finland. Also the legislation on the field is underdeveloped. The EU waste directive, 2008/98/EC, was implemented into the Finnish legislation as a new waste law which came into force in May, 2012. The country level target to the increased the use of renewable energy causes continuous pressure for changes in rules and regulations as well as in subsidising policy which needs to be taken into consideration in the future developments.

Considering all these aspects, the SUSBIO project provides an ideal basis to teachers and students to gain ground breaking knowledge.

The general idea of having research or development projects at universities of applied sciences is to generate and collect knowledge in close contact with the industry and to distribute this knowledge to students. The distribution of the knowledge is effectively performed by student participation in research projects. The participation in project activities such as planned work, scheduled meetings, seminars and industry visits, give students a model of how industrial projects are run.

Practicing research and development project activities in an educational institution is an important learning method for students and also for teachers. By participating in projects the teachers can keep their technical knowledge up-to-date.

A major research project like SUSBIO is run at TUAS by two part-time project leaders, who also are teachers, three recently graduated engineers and a varying number of students. The project is implemented in close contact with the research partners and the local industry. A major part of the practical work in the research project is conducted by TUAS students. The project has been active for two years and already now has had more than 20 students participating the project.

In the SUSBIO project, there are three options for student participation (Figure 2).

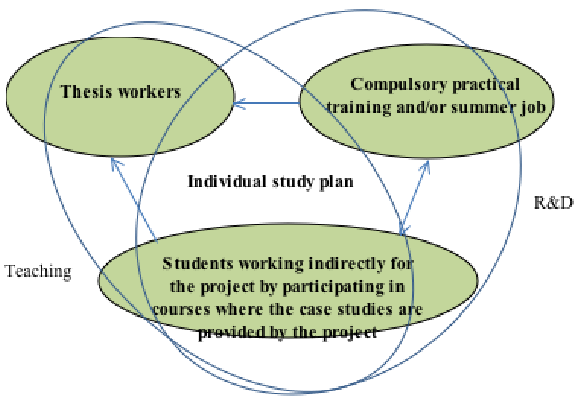

FIGURE 2. *Student participation in the SUSBIO project.*

These types of participation are directly related to curricula and generate study points. The students receive a clear, well defined work description and they perform the work in the laboratory accordingly. After the work they finalise a laboratory report with results, comments and preliminary conclusions. The comments are highly related to the student level of knowledge.

One additional type of student participation can still be identified. Students are also recruited to work for the project on a contractual basis. They naturally receive a monthly payment. These types of engagements are mainly applied for more advanced students and entail a larger responsibility within the project. The way these students work in the project is very close to the normal business and industrial work. This includes managing one's tasks, timetables and reporting results.

In order to run the project effectively and to assure that the information is distributed to all participants, weekly project meetings are held. These are attended by the project employees, teachers, students and project leaders, who report the status of their tasks. This is also the forum where possible project related problems are discussed.

Occasional problems relate to the lack of student dedication to the project. By lack of dedication is meant issues related to keeping agreed deadlines and doing the planned work in the scheduled timeframe. We have tried to maximize the student dedication by integrating the students as a part of the project team as much and as early as possible. All students, no matter what kind of a relationship they have to the project, are invited to these weekly project meetings.

Students obtain learning experiences by participating in the research projects. This has also been noticed in several other studies [3-4]. Working within a project which includes a continuously running bioreactor provides students with practical challenges without existing correct answers from supervisors. They have to solve problems as they work. This is typically made by searches in the literature and bench-marking studies. The naturally formed way of working in the project is close to the well-known teaching method Problem Based Learning, where students learn by solving problems related to the context. This is made by close combination of theory and practice. The skills students need to master as they enter the industry have changed during the time. The key idea in PBL is that the learning and the supervision of the work is strongly anchored to the problems originating from the working life. [5] As project team members students obviously learn teamwork and communication. Both are extremely important employee qualities in business and industry. Students also learn about the project as part of their courses. The learning material in these courses has been collected during the preparation period of the project application. This material is continuously complemented by new information gained during the project

The project personnel consist of three recently graduated young engineers. Their responsibilities grow as a continuous process while working in the project. They manage the everyday work in the project including minor purchases, reparations as well as instructing students working in the project. They work as the everyday connection between the students and the project leaders. A significant part of these young engineers' responsibilities is the daily maintenance of the biogas pilot. This is a pilot scale production unit, which requires daily care. This can only been managed by strict planning of work tasks and holding the timetables.

The research project work is integrated in the Bio and Food Technology Degree Programme curriculum through several courses and teachers. This is commonly implemented by teachers participating in the project meetings, discussing the coming courses and collecting possible tasks or sub-projects which can be realized as student laboratory work. These sub-projects have for example involved developing of analysis methods, conducting residual analyses from the biogas pilot digestate etc. The students thus analyze real material and develop real analysis methods. This is a point that has made the laboratory tasks more interesting and clearly increased the student motivation. The analysis reports are delivered to the project team and are used by the project. Methods developed by students and run by students are for the moment used for quality assurance of an industrial project partner.

2 CONCLUSIONS

R&D projects are integrated in the methods of teaching at TUAS. The integration is considered as an opportunity to create new courses and competencies that will meet new and sometimes unexpected industrial needs. Moreover, projects have been welcomed by the students as a more effective way of learning than class room teaching. The distribution of the knowledge is effectively performed by student participation in research projects. Skills important in working life are achieved in research projects. It is also noticed that a higher level of commitment for learning and doing is achieved amongst the teachers. Involving teachers in the project planning and execution has been found extremely important. In the beginning of SUSBIO, some practical problems occurred because the project managers were recruited from industry and they did not have teaching duties parallel to project management. This, however, was not a question of skills or teaching capability, but was rather due to the curriculum structure which was not flexible enough at those days.

3 ACKNOWLEDGEMENTS

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90 THE "KNOWS" AND "DOING" IN ENGINEERING EDUCATION

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ABSTRACT

The skills required by Engineers are diverse and ever changing. These skills can broadly be classified into four areas, namely, Science, General Knowledge, Communication and Engineering. A curriculum for an engineering degree has to accommodate all these requirements with teaching input from different sources. The degree programme is however dominated by Science and Engineering and the methods of teaching and research are different for the two disciplines. Science is inductive and is taught as laws and procedures which the students have to know ("knows") while engineering is deductive, requiring visualisation of the problem before deciding on the "knowledge" required to solve it ("doing"). The development of a first year Electric Circuits course, designed to develop conceptual thinking, engineering problem solving and improve the students' ability to succeed in subsequent years is presented. Methods that were introduced to change the students' study habits, including the requirement to pass all the knowledge areas in the course, are discussed.

Keywords: Curriculum development, Assessment, Engineering education.

1 INTRODUCTION

Engineering practitioners are required to master a large variety of skills to succeed in the workplace. The required skills have been recorded in international agreements, such as the Washington, and subsequent accords, and have become legally required outcomes of accredited engineering degree programmes in many countries [1]. The skills can be divided into four distinct areas: Science, General Knowledge, Communication and Engineering. These diverse requirements make the training of engineers complex, requiring teaching input from different sources. In an engineering degree programme Science subjects (presented by scientists) dominate the early years with Engineering subjects dominating the final two years of study. The science subjects presented to our students in first year are Mathematics, Physics, Mechanics and Chemistry.

The research and teaching methods of the two disciplines is different. Science is inductive [2], starting with an observation, and is normally taught as laws and procedures which the students have to know ("knows"). Engineering is deductive [2], requiring conceptualisation of the problem before deciding on the "knowledge" required to solve it. This is the "doing" type of training required in an engineering degree programme and, as the students come from a "know" school education, it is important that engineering students are exposed to the "doing" requirements in the early years of study.

In this paper the evolution of a first year Electric Circuits course, designed to develop conceptual thinking and engineering problem solving, is presented. The special measures used to change the students' mindset, including the requirement to pass all the knowledge areas in the course, to improve their ability to succeed in subsequent years, are discussed and results presented.

2 BACKGROUND

Since 1986 the Faculty of Engineering at the University of the Witwatersrand has had various support programmes for students struggling with the transition from a secondary education to a tertiary education system [3]. These included the Pre-University Bursary Scheme (PBS) [4], College of Science [5] and the Faculty of Engineering Foundation Programme. These programmes had varying degrees of success. The most successful was the PBS, with students "hand-picked" by the industry sponsors and the least successful being the College of Science programme. The College of Science programme was run by the Faculty of Science and students, continuing with a science degree, seemed to cope with science degree programmes. This was not the case for students entering an engineering degree programme with only one student graduating.

In 2007 the Faculty stopped all foundation programmes, requiring extra years of study, and replaced them with a "mainstream" academic development system of extra tutorials for students who felt they required the extra support. Students identified as "at risk", from their first set of test results, were encouraged to participate. Unfortunately this change also coincided with a major curriculum change in secondary education making it very difficult to analyse the success or failure of the extra support given to the students. Results [6] indicate, for the School of Electrical and Information, the pass rate for first time students was 57% in 2007 dropping to a low of 33% in 2009, the intake from the first year of the new secondary school curriculum, with a pass rate of 46% in 2011. The Faculty of Engineering also relaxed the rule allowing students to repeat their first year of study. Analysing their results indicate an improved success rate, for repeating students, from 65% in 2007 to 92% in 2011.

The main concern of the author is not the success of the students in first year but the subsequent success in their following years of study [7]. In addition to the changes to student support by the Faculty of Engineering, changes have also been implemented in the Electric Circuits course, the only "traditional" engineering course in the first year of study. The other course, Engineering Design, consists of English literature and project based learning. The changes in the Electric Circuits course have been evolving since 2003 [7] [8]. Although these changes have appeared to have improved the pass rate in second year [7], the success rate for non-repeating students in second and third year are, in the author's opinion, still unacceptably low. The possible reasons for this and solutions will be discussed in subsequent sections in this paper.

3 THE DIFFERENCES BETWEEN SCIENCE AND ENGINEERING

3.1 Research differences

The author is also involved with biological research, investigating electric fields in sea water related to the electrosensors of sharks. Publishing in biological based publications is a challenge as the style and basic requirements are very different from the requirements and style required by engineering publications. A book, Biology for Engineers by A. T. Johnson [2] published in 2011 explains the fundamental differences between the research methods used by scientists and engineers. Johnson states that the differences fall into three categories, namely phylogeny, motivation and methods.

He states phylogeny, or the evolution of technology, can be divided into four phases,

1. Phenomena are observed
2. Relationships are established
3. Dependencies are given numerical values (quantitative)
4. Control (modelling and predictive equations)

with the first two belonging in the field of science, control, clearly, in the domain of engineering, with both disciplines participating in the quantitative phase.

Scientists are mainly motivated by interest in what they are studying, trying to find as much information as they can on their subject. Engineers, much like artists, are motivated by the products they create.

The fundamental difference between engineering and science is in the methods they use in their research and publications.

Johnson concludes that:

- Science is inductive: Scientific facts accumulate until an overall unifying concept emerges as irrefutable. Scientific papers very rarely have any surprises and normally incrementally extend the knowledge in a particular area.
- Engineering is deductive: Engineers generally try to conceptualise first and fit facts within this established framework.

3.1 Teaching differences

As most of the subjects presented in first year, in most engineering curricula, are science subjects the bulk of the academic support for our students have come from the science community. These programmes are often criticised by engineering lecturers when there is no apparent improvement in the success rate of students in subsequent years of study. The question that results from this criticism is “What do you want from your students?” The answer to this is not easy and only became clear to the author after reading Johnson’s book.

As science is inductive the material is normally presented as laws and procedures which the students have to know (“knows”). There is nothing wrong with this approach, in the scientific field, as the knowledge is obtained incrementally and the students need to know the established laws and be able to solve procedural problems before pushing the boundaries of science. This is also acceptable for engineering as we do not want them "meddling" with the established laws but rather know the laws of science and be competent in implementing scientific procedures.

Engineering courses in the early years of study have to introduce the students to deductive approach (the "doing") required by students to successfully complete the degree programme and have a successful career in engineering. The students' learning methods have to change from procedural to conceptual. McCormick [9] defines conceptual learning as: understanding the relationship between items of knowledge. This is not an easy task [7] as the students come from a rote learning and procedural background from school which is reinforced by the science subjects requiring the same skills. It is difficult for them to understand why a different mindset is required for just one subject in first year. Engineering students need the ability to be competent in both procedural and conceptual learning.

This difference in philosophy also explains why the students attending the College of Science did well in the sciences and extremely poorly in the engineering programmes.

4 THOUGHTS ON A COMMON FIRST YEAR

The faculty has for a number of years been considering a common first year for all engineering students, with the students deciding on which engineering discipline to follow after successfully completing first year. As a web search will confirm, this is in-line with a number of universities worldwide. The common first year normally covers the basic science and mathematics courses with an introductory (fun and marketing) course for one or more of the engineering disciplines. For engineering academics this would be desirable, as the "bad" students will be "weeded out" and our throughput would increase!

The results of the first-time students in the 2009 intake in electrical and biomedical engineering were analysed in terms of the subjects passed the first time they were attempted. The science subjects chosen for the analysis were Physics, Mathematics and Mechanics (Science subjects). The students' results were then analysed in terms of students passing all the science subjects and their Electric Circuits (engineering) results (see Table 1).

TABLE 1. *Students results for "Engineering" and "Science".*

Results	Number of Students
Passed Science Subjects and Circuits	27
Failed Science Subjects, passed Circuits	16
Passed Science, failed Circuits	26

Of the 53 students that passed the science subjects only 27 also passed Electric Circuits. If there was only a requirement to pass the science subjects (a common first year) the results would imply that 49% of the students would fail engineering subjects in the second year of study. This may also indicate that some of the students' natural abilities (aptitude) may make them more comfortable with the methods and procedures of science rather than those of engineering. A good scientist does not necessarily make a good engineer and vice versa. This natural preference should be established early in the degree programme, with the courses structured in such a way that students, who feel that engineering was the wrong choice, can get credits for the science courses and pursue an alternative career in science.

5 TEACHING THE "DOING" OF ENGINEERING

5.1 2004 to 2011

Since 2004 the Electric Circuits course at the School of Electrical and Information at the University of the Witwatersrand has been evolving to introduce the first year students to the methods and philosophy of engineering. The changes have been documented in a number of iNEER publications with a review in the proceedings of the 2010 ASEE Annual Conference [7]. The changes for 2004 to 2008 can be summarised as follows:

- Extended course with less contact time
- A "critical thinking" lecture (no formal Circuits)
- No formal tutorials
- Individual laboratory tasks (play and do)
- Self-evaluation tests.

This resulted in an improved pass rate from 65% (2003) to 74% (2009). Unfortunately this did not translate into an improved performance for first time students in their second year of study. It became clear, from analysing the exam scripts, that the students were optimising their learning by leaving out AC theory and operational amplifiers, essential material for success in second year.

The results of first time students in first year in 2008 and their second year results in 2009 were analysed in terms of four knowledge areas in the circuits course, namely:

- Basic Concepts
- Analysis Techniques
- Laboratory Concepts
- Complex real circuits.

The analysis showed that 79% of the students who would have failed one or more of the Electric Circuits' knowledge areas failed one or more second year subject. This failure rate was reduced to 42% for students who passed all the knowledge areas.

As a result of the analysis and to prevent this selective learning the students are now required to pass all four knowledge areas to pass the course, irrespective of the final mark. The pass rate in 2011 was 68% with this requirement applied and would have been 81% if it had not been considered, compared with 74% in 2009. This indicates that the students are selectively studying less than they did previously.

Open book tests and exam were also introduced in 2010 to negate the necessity for rote learning just before the exam. Students are allowed to bring a text book, of their choice, and an A4 folder with anything they feel they need. No changes were necessary in the style and type of test and exam questions as, since 2004, the tests and examinations have tested the "doing" and not the "knowing".

5.2 Changes in 2012

5.2.1 In the classroom

With a better understanding of the differences between Science and Engineering, changes to how Electric Circuits is presented have been implemented in 2012. The emphasis is now on the "doing" of engineering. Unfortunately there are some "knows" required in an introductory course, but this is presented as information discovered while exploring the basics of current flow and voltage drops. This is the "global learning" or best teaching practice as defined by Felder and Silverman [10] [11].

An example of this style of presentation was the presentation of Kirchhoff's current and voltage laws. Discussions with the class on what current is, an imaginary concept developed to explain scientific observations, led to what did the students think would happen with current entering a node. Consensus was that what went into the node must come out (nowhere else to go), which is Kirchhoff's current law, developed by our students and not by Kirchhoff! Kirchhoff's voltage law was also developed in this manner. Operational amplifier circuits were also "discovered" using this method of presentation.

One possible negative outcome is that three quarters of the course content has been completed in the first quarter using this exploration approach to learning. This may not be a bad thing as there will be more time for the students to assimilate both the material and conceptual learning process.

5.2.1 In the laboratory

The concept of laboratory exercises was first introduced in 2011 and extended in 2012. Laboratory exercises are ad hoc small exercises to supplement the discussions in the lectures, where the students are having trouble visualising a topic. These are in addition to the formal laboratory tasks that have to be undertaken by the students. Participation in all the laboratory tasks and exercises are ensured as they are satisfactory performance requirements (SP) for the course. Two exercises used in the first quarter this year were:

1. Choosing components from your kits, or from the laboratory, build the circuit shown in the figure 1 to prove both Kirchhoff's current and voltage laws. Demonstrate your experiment and results to a Laboratory Demonstrator using both a multimeter and an oscilloscope to take the readings.

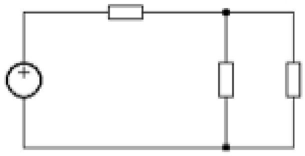

FIGURE 1. *A four component circuit.*

2. Using four resistors demonstrate that a bench power supply can be used as an "ideal" voltage source and as an "ideal" current source.

This type of exercise reinforces the "doing" skills and will also develop the exploration and experimental mindset essential for engineers.

6 CONCLUSION

The differences between the research and teaching methods in the disciplines of Science and Engineering have an impact on the teaching process in engineering degree programmes. Engineering students must be able to cope with the demands of both procedural (inductive science) and conceptual (deductive engineering) learning methods. As most of the subjects in the early part of the degree programme are science based it is vitally important that the engineering subjects concentrate on the development of the conceptual and deductive skills required by students in their later years of study, and in their professional life as engineers. For engineering just knowing is not enough as engineers also have to do.

7 ACKNOWLEDGEMENTS

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91 "MY BEST COURSE IN ENGINEERING" – DEVELOPING A COURSE IN PROJECT PLANNING AND REQUIREMENTS ENGINEERING FOR UNDERGRADUATE STUDENTS

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ABSTRACT

Fourth-year engineering students specializing in ICT at the Turku University of Applied Sciences (TUAS) were offered an optional 6-credit course in Project Planning and Requirements Engineering with the focus on the initial phases of ICT projects. The aim of this practitioner's report is to describe the planning and implementation of the first course in 2010, and its further development on the basis of student experiences in 2011. Problem based learning (PBL) and concurrent case-oriented work on product definition and project planning were the guiding pedagogical principles.

One of the challenges in teaching project management is the creation and simulation of a 'real' project environment. The students were encouraged to invent and define an exciting product of their own, to specify the requirements for it, and to plan the development project based on the product definition. In order to simulate the project environment in a product-oriented company, a full-day session was arranged for the purpose of playing a business simulation game, ProDesim, developed at the TUAS. During the two courses, feedback was collected from the students. The results indicate that the PBL approach both inspired the students and gave them a wider view on how to utilize the specific ICT engineering skills in practice.

Keywords: Project planning, Requirements analysis, Business Simulation, Problem Based Learning.

1 INTRODUCTION

The founding of Helsinki Polytechnic School (today the Aalto University) in 1849 started the modern form of disciplined engineering education in Finland [1]. However, it took a long time before project management courses became commonplace in engineering education, for example, in 1979, the Students' Study Guide of Tampere University of Technology did not include a single course in project management [2].

On the other hand, starting in the 1960's, industry gradually adopted newly developed 'scientific' project and systems management methods, such as PERT (Program Evaluation and Review Technique), CPM (Critical Path Method), QFD (Quality Function Deployment), and DfSS (Design for SixSigma), and by the late 1970's, many leading high technology companies utilized them in everyday business and even had internal handbooks for project management and NPI (New Product Introduction) processes [3].

Developing disciplined project management and systems engineering processes was a necessity especially for companies developing embedded systems and products. The complexity of such systems, which included hardware electronics, embedded software, and complicated mechanics with motor and servo controls, evidently caused the projects developing such systems to become seemingly complex, too. In today's competitive business environment, the initial planning of any complex product takes place concurrently with the planning of the product development program realizing and introducing the product to markets.

As a response to the aforementioned industry demands, Turku University of Applied Sciences (TUAS) has been offering to the fourth-year ICT engineering students an optional 6-credit course in Project Planning and Requirements Engineering with the focus on the initial phases of ICT projects. The aim of this practitioner's report is to describe the initial course planning, execution, collected student experiences, and the improvements to the course in 2010 and 2011 in TUAS.

The initial course objectives were defined quite generally, thus leaving for the teacher margins to implement and focus. Long experience in project management has convinced the author that real project work can only be learned in practice, although basic principles and methods are well adoptable from text books and lectures. However, one of the big challenges in teaching project management is the creation and simulation of a 'real' project environment where the project work and management can be trained in practice.

Problem based learning (PBL) and case oriented working on concurrent product definition and project planning were the guiding pedagogical principles used in the course. PBL is a special case of inquiry-learning, and it represents an obvious solution for teaching project management, since it includes many of the elements of real life projects, and emphasizes their collaborative team work nature [4]. In PBL, the students voluntarily form teams, which self-organize, start to tackle 'ill-defined' problems by gathering information, set goals, share and report interim results, and do practically everything what is typically done in any project [5]. Furthermore, PBL has been used in some elementary courses at TUAS, and students were familiar with its principles.

For creating meaningful and motivating business cases, the study groups were encouraged to invent their own exciting products, define the requirements for them, and then plan the development project for implementing the product on the basis of the product definitions. The only prerequisite was that the product should be reasonable to implement by the team with support from outsourced resources and subcontractors. Finally, in order to further simulate the project environment in a product oriented company, a special full day session was arranged for the purpose of playing a business simulation game, ProDesim, developed at TUAS [6].

2 IMPLEMENTATION OF THE 2010 COURSE

2.1 Study topics

Basic understanding of systems engineering is a necessity for every engineer, but for specialists involved in product definition and project planning work, the main system engineering methods have to be part of their daily toolkit. A good common sense definition of systems engineering is formulated by Nobel laureate Simon Ramo [7]:

"Systems engineering is a branch of engineering that concentrates on the design and application of the whole as distinct from the parts ... looking at a problem in its entirety, taking account all the facets and all the variables and linking the social to the technical aspects."

Systems engineering is thus a wider topic, which includes both the requirements engineering (RE) [8], project planning and execution, and product life cycle management (PLM) for the product to be developed. Therefore, the students were introduced to all these aspects, although the emphases were in product requirements definition, product system (block) level design, and project planning based on the 'frozen' product requirements, i.e., requirements under formal change management. Basics in market and customer segmentations, market analysis, 'the voice of the customer' (Kano model), and product investment calculus (break-even point, net present value) were also included to facilitate the product definition work.

The QFD, the House of Quality, was developed by Yoji Akao in 1966 in Japan for "transforming user demands into design quality, for deploying the functions forming quality, and for deploying methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process." [9].

The author has successfully used the method for defining telecommunication products, and based on these experiences, the QFD was one of the topics taught in the course. The Design for Six Sigma (DfSS) methods include several useful tools (including QFD) for designing high quality products that meet the defined requirements, especially in mass production. In true Six Sigma (SS) quality, only four out of one million produced units do not meet the specification. The basic concept of SS was introduced in the course, and some of the system level design tools were briefly discussed. However, the course was not intended to go into DfSS details.

On the project management side, the students were introduced to a typical NPI process and project life cycle with the main phases of planning, conceptual development, system level design, detailed design, testing, and production ramp-up. However, since the main focus of the course was on the first three phases, such topics as project scope management, work break down structure (WBS), time scheduling, cost management, risk analysis, and documentation management were emphasized. The framework for the project management part of relevant study topics was drawn from the IPMA (International Project Management Association) and PMI (Project Management Institute) competence descriptions [10,11].

The NPI simulation game, ProDesim, is a business model based board game, which has a conventional playing board with a computer interface. The play team is sitting around a 'real-life' managerial board, which is equipped with a specific chart indicating the project flow and the main phases, and with decision-making play cards and resource pawns, both containing

RFID tags (Radio Frequency IDs). When the relevant cards and pawns are moved through the RF reader, the computer model identifies the decisions made and calculates the next move. As the board of directors, the players make decisions on new, existing and exiting products according to the market situation and competition; what kind of products, when to launch, how much to allocate R&D resources, at what cost and price, how to handle the logistics and stock, and so on. In a way, the game jumps one managerial level upwards from the product development project, but nevertheless, it gives an excellent idea about the project environment in a company.

The main deliverables required from the project teams were

a) the preparation of a concise but detailed enough preliminary project plan for a simulated go/no-go decision to be made at the end of the course by the project owner (which was represented by the teacher), and
b) the preparation of a well defined product requirements document, which is attached to the project plan and fulfils the assessment criteria, in other words, is complete, clear, precise, implementable, traceable, and testable (validation and verification).

The main deliverables required from the individual students were

a) an acceptable amount of completed home assignments: 80% (24/30)
b) a report of the ProDesim simulation game session
c) a personal reflection report (2-3 pages) on the project team work (given template)
d) a passed examination.

2.2 Time schedule and workloads

The 2010 course in Project Planning and Requirements Engineering was implemented in the first autumn period, from 1 September to 30 October, with two consecutive full days of teaching and practicing every week. This time schedule caused certain pedagogical challenges; how to make the course interesting for the students even in the late afternoon hours, and how to distribute the students' work load evenly. The concurrent nature of system planning and product definition work along with the project planning work represented one obvious solution: one day per week for requirements analysis and the other for project planning would make the topics varying enough.

The daily timetable followed the scheme where morning sessions were devoted to theory, with instruction in the old-school classroom manner (2-3 lessons; 1 lesson = 45 minutes), followed by a collaborative review of assignments (1-2 lessons), and the afternoon sessions were reserved for group work (3 lessons), totalling in six lessons each day. The assignments for the following week were given during the two days, and delivered through the Optima [12] intranet based learning environment that is in use at the TUAS. Optima was also used for making course announcements, providing background materials, and preparing and saving group works.

The 6-credit course corresponded computationally with 162 hours of student work, which were allocated as follows:

a) lectures: 40 hours
b) guided classroom work (review of assignments and group work): 40 hours
c) (individual) home assignments: 20 hours
d) independent group work: 40 hours
e) preparation of the individual reflection report: 10 hours
f) examination (including preparing and review of results): 10 hours
g) presentation of group works: 2 hours

The guided classroom work also included the ProDesim simulation game (one full day), and the demonstration of Caliber Requirements Management tool by a Borland representative (one afternoon) [13].

2.3 Course implementation and feedback

The implementation of the 2010 course was the first for the author, and the entire course pre-planning phase took place in a two-week period preceding the actual course. Many details had to be planned ad hoc between the sessions, and at the end, the course did not appear quite the same as in the initial plans. For example, instead of preparing informative slideshows for the lessons, it became evident in the very beginning that the use of a white board was preferable for two reasons; there was not enough time for making the slides, and the long slide presentations made the students apparently passive and sleepy.

Another example was the high demand (80 %) of approved home assignments; it became soon unrealistic for some students to achieve it, and they had to be given extra exercises.

Two PBL project teams were formed during the first two days based on voluntary 'recruiting' to the following roles: a project manager (PM), a chief system engineer (SE), and optionally, a hardware engineer, software engineer, test engineer, or product manager. The PMs and SEs were in charge of coordinating the tasks so that the expected deliverables will be ready in time. Otherwise the roles were up to the PBL teams. It was also allowed (but not required) to change the roles during the project. To invent the case products caused some pain for one of the groups, but during the second week both two groups had a product: 1) a general purpose remote controller, and 2) a new generation palm game console. The project work could then begin with the market analysis and customer segmentations.

The students focused on their daily group work eagerly, and also organized themselves and allocated the WBS tasks in order to keep the demanding time schedule of two months. This is reflected in their daily work log notes:

"We first analysed and discussed in the group what segments can be found for the remote controller, and then initially determined 4-6 main segments. Then we started to share the tasks: I got the construction of the project file structure and the planning of IDs."

"Initially I took the role of SE, but since N.N. soon indicated that he would prefer some other role, I replaced him as PM in order to get things forward."

Feedback was collected at three occasions during the course: after five sessions, after the ProDesim gaming session, and at the end of the course. Only four out of 10 students returned the first inquiry. The feedback did not indicate anything alarming, and the general satisfaction to teaching was 3.6 (on scale 0-5). The teacher's decision to use the white-board instead of slides was appreciated, and more effort would be needed to elevate the students' motivation. The ProDesim inquiry responses indicated that the young generation students really enjoyed the game (mean score 4.1), and everyone wanted another chance for it. However, the game principles and goals were not that clear for all (mean score 3.4).

The last feedback inquiry (N=6) revealed that the general grade for the course was good (mean 4.0, variation 3-5), and in the free comment part, the course was described as good, interesting, informative, and useful: "The course was the most interesting after a long time because of the way it was carried out". Students further regarded that they had learned useful professional skills (mean 3.7, variation 2-5), and the course as a whole corresponded with their expectations (mean 4.0, variation 3-5). The main comments and suggestions for further development were as follows:

a) The teacher supposed the initial competence level of the students too high.
b) The course should extend over a whole semester, not just one period, because of the high workload.
c) Too high an acceptance level (80%) for completed home assignments, and also some simpler exercises would be needed.
d) Better guidance for exercises and group working.

Table 1 presents a summary of the preferred learning methods for the 2010 and 2011 implementations. As can be seen from the table, the students still regarded the "old school" methods of lecturing and home assignments as the most suitable modes of learning the study topics.

TABLE 1. *Preferred learning methods used in the 2010 and 2011 course implementation. Numbers are mean values of individual preferences from 1-6 (1=most preferred, 6=least preferred).*

Method	2010 (N=6)	2011 (N=10)
Lectures	2.3	2.5
Exercises	2.6	2.6
Group work	3.2	1.5
Examination	4.0	4.9
ProDesim	3.3	3.7
Caliber demo	5.5	5.8

3 DEVELOPMENTS IN THE 2011 COURSE

No big adjustments were made in the contents of the 2011 course. Some of the more difficult PM topics, such as proper WBS, and time scheduling were introduced more in detail during the lectures, and consequently, the hours available for general system theory and QFD decreased. Some of the exercises were replaced by clearer ones, and the home assignment acceptance level was lowered to 70 % (21 out of 30). The ProDesim simulation game and the Caliber RM SW demonstration remained unchanged.

The biggest change in the new implementation was the extended duration of the course to an all-semester course (from 1 September to 10 December). This balanced the workload, since only one full day session was scheduled per week, and new PM and RM topics were introduced in a less overwhelming pace. Still, the weekly guided group work nurtured both sides, the PM and the SE & RM. This arrangement also left more time for the students to work on and prepare the required documents independently.

Another major reform was the introduction of an Excel based project workbook, which the author developed for group working. The workbook consisted of 12 project worksheets reflecting the major PM topics: Versions, Markets, Project scope, Stakeholders, Requirements, WBS, Communication, Organisation, Deliverables, Schedule, Budget, and Risks. Each worksheet included templates and instructions on how to use and fill out them, thereby facilitating and guiding the practical group work.

The course feedback was similar as in the 2010 implementation, but the general grade improved clearly (mean 4.4, variation 4-5, N=10). The students regarded that they had learned useful professional skills even better (mean 4.6, variation 4-5) than the group in 2010. The course, as a whole, also corresponded to their expectations (mean 4.2, variation 4-5). The free comments given in the feedback left no big requests for improvements: "I don't see any need to improve it", and "My best course in engineering".

As compared to the 2010 inquiry results, in 2011 the list of preferred learning methods was different. Apparently, the clear development in the PBL type teamwork with the new project workbook approach elevated the group work to be the most popular way of learning.

4 CONCLUSION

Generally, both the 2010 and 2011 implementations of the 6-credit course in Project Planning and Requirements Engineering can be regarded successful. For making the 'dull' topics more interesting and practical, a mix of suitable proven and new learning methods was tested, and the course implementation was adjusted on the basis of the feedback collected from the students. The results suggest that practical PBL type group working, when supported with more conventional methods, is highly suitable for learning the basic project planning and requirements capturing and analysis skills.

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92 A BRIDGE BETWEEN ENGINEERING AND LANGUAGE LEARNING: AUTOMATION AND GERMAN IN AN ONLINE COURSE

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ABSTRACT

Germany has one of the strongest economies in Europe and the world and is therefore very attractive as a trading partner for many European countries. Nevertheless, there is a lack of qualified engineers with international experience who have specific German language skills in certain fields such as the field of Automation Technology. Therefore, universities and companies from four different European Union countries (Tampere UAS, Reutlingen University, Tallinn UAS, VŠB TU Ostrava, T:mi Ulrike Eichstädt, HINTERWAELT Grafikdesign, InPunkto Softwareentwicklung) are working together to develop a curriculum and teaching material for an interdisciplinary online-course which combines the fields of Automation Technology and German as a foreign language. The course is named ADOK (Automatisierung und Deutsch im Online-Kurs/Automation Technology and German as an Online-Course) and will be available free of charge by the end of 2012 on the website www.adok.projekt.eu. In this course the German language is not functioning as a medium for learning another subject, but is rather a learning target of the same value as the PLC. The course is meant to train engineers in programming and German language skills. The course material produced is a combination of problem-based instruction in the field of Control Engineering and active learning of the German language. Situations from daily professional life are simulated and this will have a positive effect on the motivation of the students.

Computer modified, animated and interactive learning material for the combined teaching of Control Technology and German language will be produced on the basis of authentic texts and diagrams. These tasks will be embedded in Moodle, a widely-used online learning platform, so they can be used by the students to produce, for example, glossaries together. For language learning purposes, we will adapt an existing reading strategy which clarifies, for example, keywords. This reading strategy could be used for most European languages. In the spring of the year 2012 the course will be tested with students from the partner institutions. The outcome of the piloting will be presented at the conference in Turku.

Keywords: Interdisciplinary learning, Blended learning, Problem based learning, Language learning in action

1 INTRODUCTION

In this article you will find a description of a project called "ADOK: Deutsch und Automatisierung im Online-Kurs" (=Automation engineering and German in an online course). This project develops a curriculum and the online material for a course of the same name within the context of the LLP (Life Long Learning)-program of the European Union. In this inter-disciplinary course students acquire the basic principles to solve automation tasks, basic knowledge of German for the communication with customers and a reading strategy for the decoding of technical texts. The course simulates an international project from ordering to bringing into service a control system for traffic lights. This tri-annual project started on 1st October 2009. At this point of time the piloting phase is running and the work will be completed by the end of the year 2012.

2 HISTORY OF THE PROJECT

2.1 Starting point for the development of this course

Many publications emphasise the importance of language skills. In the article "Languages for Jobs" the writers assert that "the demand for foreign language competence and communication skills on the European job market is rising continually" [1]. The ELAN-report "Impact of lack of foreign language competence in business companies on the European economy" pointed out that a quarter of 2 000 small and medium-sized firms that were interviewed demand that their staff should have a better knowledge of English in the first place and the competence to speak German, French or Russian in all social and working environments in the second place [2].

Using the example of Finland we examined the actual situation. Finnish firms need personnel with a good knowledge of German because next to Sweden and Russia, Germany is the most important business partner. But are there enough engineers who can act properly in different working situations in German? The answer is: not anymore. Their language proficiency level is too low. Only a few engineers reach a proficient level in German: B1-B2 of the Common European Framework for Languages. There are different explanations for this. At Finnish schools a decreasingly number of pupils choose German as a first foreign language; the range of German courses is decreasing as well and is often reduced to beginner courses. The Tampere University of Applied Sciences for instance offers optional German courses for engineering students that lead from A0 to B1/B2. Whereas classes for beginners are often crowded more often there are not sufficient applicants for the courses leading to B1/B2-level and thus these courses may not be organised.

In order to upgrade the proficiency level of engineering students Professor Olavi Kopponen, lecturer of automation, and Ms Claudia Daems, teacher of German, developed the thought to impart engineering knowledge and language skills at the same time. In the field of automation Siemens is one of the market leaders. The laboratories at the universities use Siemens hard- and software and consequently authentic texts such as manuals with software descriptions and instructions that up to now were seldom used are now available for the students.

2.2 A thought turns into a project

It was clear from the start that the financial and personnel resources of TAMK would not last to develop a course on such a scale. The LLP-program of the EU offered the opportunity to create new curricula. Both lecturers looked for partners in three other European countries and together with them they wrote an application which was elected 2009 to be co-financed by the EU. The work started on 1st October 2009 and the project is expected to be finished by the end of 2012. The consortium comprises four universities and three firms: the Tampere University of Applied Sciences (TAMK), Finland (coordination, DaF=German as a foreign language, automation); Toiminimi Ulrike Eichstädt, Finland (DaF); the University of Reutlingen, Germany (DaF, automation); Hinterwaelt, Germany (graphic design); InPunkto Software, Germany (programming); the Technical University of Tallinn (TTK), Estonia (DaF, automation) and the Technical university of Ostrava (VŜB), Czech Republic (DaF).

FIGURE 1. *Project team.*

Together the partners develop a curriculum and material for an interdisciplinary online-course that combines automation, in practice programmable-logic control (PLC), and German as a foreign language. This online course has been developed for the Moodle platform and will afterwards be at everyone's disposal for free in the internet (www.adok-projekt.eu).

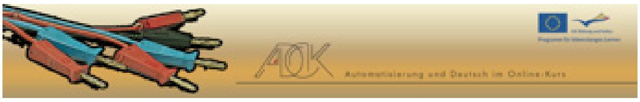

FIGURE 2. *Logo of the course.*

3 DESCRIPTION OF THE COURSE

3.1 The Linking of two Subjects

The connecting link between both subjects is to be found in their educational aims. In the subject automation as well as in the subject German the students are to obtain the ability to deal with tasks in automation projects in German and solve problems in an international environment. The detailed goals can be found under "Produkte" on the internet page www.adok-projekt.eu [3].

In practice the linking is realised through the simulation of a project handling. The students are grouped in international teams – in real teams or simulated ones depending on the situation at their college. Each team has to act both as orderer/buyer and supplier respectively. Each team of buyers has to order a set of traffic lights for a busy road. The nature of the task of which there are two versions, including the solution contains the description, a sketch and a list of functional conditions of the traffic lights.

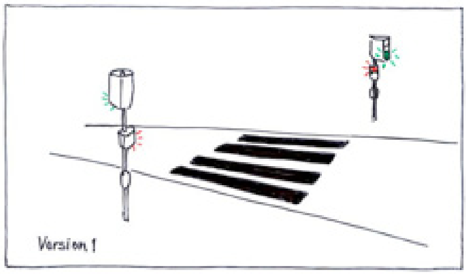

FIGURE 3. *Task for team 1.*

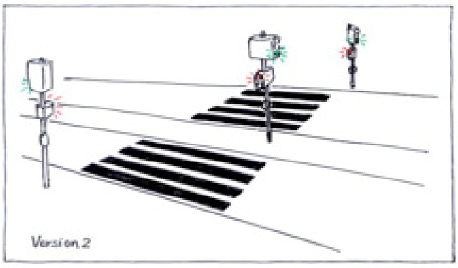

FIGURE 4. *Task for team 2.*

On the basis of this task each team writes a manual with the technical specifications and the order which is then sent to the partner team. This partner team (=the suppliers) uses the description for a graphical picture of the different phases of the traffic lights and writes a program for the steering of the lights with the help of the software program STEP7 for the programmable-logic control SIMATIC. During the project the teams communicate with each other for instance to arrange dates or solve technical problems. The course ends with the handing over of the project which includes a presentation of the pedestrian crossing. The students master the programming in their native language or in English but some of the authentic material is in German. Moreover in the laboratory the students can choose German for the software STEP7. In all cases the communication between the students is in German.

3.2 Length and content of the course

The course represents ten credits (= 250 hours of student's work):

Five credits are assigned to PLC, three credits go to German, one credit is assigned to company visits and one credit to intercultural activities. In the ideal case the course is spread over two terms. As needed or if the curriculum makes it possible the course can be used as an intensive course and be reduced in time to 15 weeks of about 16 hours of work per week.

In detail it looks like this:

For GFL (= German as a foreign language): 25 hours of classroom activities and online presence (German for project communication and STEP7-specialised texts), 50 hours for online work (Moodle: teamwork, documentation, communication between buyer and supplier), for intercultural activities: 25 hours (classroom presence and online presence), 25 hours for virtual and life factory tours.

For PLC: 25 hours for programming with STEP7, 50 hours online work (Moodle: teamwork, technical documentation, communication between buyer and supplier), 50 hours of work in the laboratory (programming on the computer with STEP7, testing of the program on the power and control unit, simulation of the light signalling system).

On the learner's platform Moodle you can find 10 modules:

Module 1: Meeting the team mates and getting acquainted with PLC.
Module 2: Introduction into PLC (hard- and software.
Module 3: Use of PLC (first examples of programming.
Module 4: Visualisation of hard- and software.
Module 5: Assignment of tasks.
Module 6: Communication between customers I
Module 7: Communication between customers II
Module 8: End f the project.
Module 9: Factory tours and intercultural activities.
Module 10: Reading strategies "Seven Steps to STEP7"

In parallel with modules 3 to 8 the students work on programming tasks in the laboratory. As regards the content of the online phases and presence phases they are made consistent which each other. The actual organisation of the lessons is left to the colleges. The basis for the work on and with the PLC is the SIMATIC-guide of Siemens with the example of traffic light pre-emption which was adapted for the classroom by the teachers of automation and further revised didactically by the teachers of German. At the end of each module the learning progress is tested. The project documents in German are evaluated as well. The failure-free functioning of the traffic light pre-emption is considered as the final test.

3.3 Key aspects of the German classes

The project communication includes introduction, small talk, product presentation, making appointments, business communication etc. The latter can be coped with the help of patterns that were created as Moodle test. There are written and oral exercises for communication.

For the simulated project "traffic lights" the students need a special technical vocabulary which they can acquire through several different exercises (such as flashcards, cloze texts, fill in matching words), tests and texts. The teachers of automation made a special vocabulary list in German, English, Estonian, Finnish and Czech.

Lest the students can work with authentic German texts the teachers of German developed a reading strategy "7 Steps to STEP7" which was based upon the method of seven sieves or filters of EuroCom [4]. With the aid of this strategy the students should be able to make a new text accessible step by step.

These are the seven steps:

1. First have a look at the pictures, drawings, numbers, names.
2. Identify the international words.
3. Use the special vocabulary lists for technical texts.
4. Mark the verb(s) in the sentences with across.
5. Some verbs consist of two parts. Find the components of these verbs.

6. Try to identify sentence structures that are typical for technical texts.
7. Look up the remaining unknown words in a dictionary.

For each of these steps the students are given examples and exercises. In every module the stress is put on a typical structure that is common for technical texts. The examples are followed by short exercises whereby the stress is on the identification and the use of that typical sentence pattern. The students are not as yet supposed to create new sentence structures of their own.

The following features are imparted:

passive voice sentences, nouns derived from verbs, verbs in connection with prepositions, passive voice with modal verbs, relative clauses, participles used as adjectives, to let + infinitive, to be + infinitive.

4 THE ACTUAL USE OF THE MATERIAL

4.1 Testing of the material

The material was tested several times already. In the autumn of 2010 the first two modules and the first two steps of the reading strategy were tested at the four participating universities. The evaluation by the students was positively encouraging. They found the material interesting and they were able to make the exercises even though some of the texts offered were a bit too difficult for them. They found the reading strategy helpful and had the feeling they could open up difficult specialised texts with the help of it. The exercises were level A2 and the instructions were clear enough [5].

Some selected exercises were tested with Belgian students of the KHK (Catholic University of Applied Sciences-Geel) in February 2011 and once more a year later.

In the context of an international week Professor Kopponen and Ms Daems conducted a workshop in which they showed that one can successfully combine the teaching of automation and German in classroom with foreign students. Also in the autumn of 2011 the FH Tampere organised a test flow with a somewhat shortened version of the course content (3 credits for PLC and 3 credits for German). Students without any knowledge of German were allowed to take part in this course but this proved to be problematic. The project process could be simulated but the learning progress was unsatisfactory.

4.2 Piloting

The pilot phase at TAMK and TTK started in January 2012 and two months later at the HS Reutlingen. TAMK and TTK offered the course as a bilateral specialised course. Two teams (one at each institution) kept in contact via Skype. At the beginning of March Professor Kopponen and the Finnish students went to Tallinn for four days and had lessons together with their colleagues. In April students from Estonia had the opportunity to come to Tampere for two weeks to work in the laboratory together with the Finnish students. They worked on the programming of the traffic lights and at the same time they had the possibility to learn German and PLC. During the second week of this intensive cooperation the project members organised a workshop. Teachers from the Czech Republic, Germany, Finland and Estonia lectured on intercultural subjects and discussed the themes with their students. The Finnish teachers and students also organised visits to factories.

FIGURE 5. *Prof. Kopponen teaching PLC.*

FIGURE 6. *Students solving a problem.*

At the Technical university of Ostrava the course is tested as a technical language course. The stress is put on vocabulary training, the study of typical sentence structures and the testing of the reading strategy.

In Reutlingen the piloting was done with exchange students from China, Brazil, Vietnam, Malaysia and Australia. This gave us the opportunity to find out to what extent the material is suitable for students who have to learn the German vocabulary via English. A peculiarity in this case was also the fact that the teacher of German was not involved in the project as a maker of the material. It led to the detection of difficulties when outsiders do the training.

5 CONCLUSION

Now that the project goes to an end time for reflection has come. Our first concern has always been the surplus value for the students. Thus we were anxious to hear what they thought of the lessons. In general their reactions proved to be very positive.

What the language learning concerned they had the feeling that they had made quick progress; often starting from only very little knowledge of German at the end of the course they found themselves able to exchange ideas and views with fellow students in the partner countries. They could open up new texts with the help of the reading strategy without being language experts. The reading strategy did not only help them to cope with German texts it also proved to be useful in opening texts in other languages as well.

The students were also very happy with the possibility they were offered to work together in an international environment. They found it an improvement in their professional and personal lives to experience how teachers and students work in other countries.

This is also the opinion of the teachers who worked together in this project for three years. They know that the course they developed is not perfect. Some exercises need rectification and adaptation but the overall feeling is one of satisfaction. The cooperation with so many colleagues from so different countries can never be without some controversy but at meetings everyone showed his goodwill to solve problems and especially the will to bring the project to a god end. They now hope that the course they developed will be used at many institutions and they are also motivated to improve it and at the same time they are collecting ideas to set up further projects in the future.

6 ACKNOWLEDGEMENTS

Thanks to the financial support of the EU within the framework of the Lifelong Learning Project (LLP), our international team is collaborating to produce contemporary teaching material.

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93 DESIGNING A GAME MODE FOR ONLINE LEARNING ENVIRONMENT

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ABSTRACT

There is an ever increasing buzz about using computer games in educational settings. However, there are barriers that we need to overcome to design and adapt games in order to use them in a productive way as a part of formal education. ViLLE is a learning environment which combines several exercise types with collaborative environment for teachers. The motivation to design a game mode into ViLLE was to increase students' engagement in doing the exercises. Our goal was to extend the existing system without compromising the learning effects that have been discovered earlier. The game mode was implemented so that the normal work flow of doing ViLLE-exercises is not disturbed. Instead of doing the exercise alone the students compete against other students. The students receive points similarly to normal mode, but in addition they can collect experience points, higher ranks and awards by succeeding in matches. The winner is based primarily on the score achieved, and only secondarily on the time used to emphasize the point of doing exercises properly.

Keywords: Programming education, learning environments, games based learning.

1 INTRODUCTION

Learning to program can be a frustrating task for novices. As stated in e.g. [1] and [2], students lack of motivation and the difficulty of the topics involved lead to high drop-out rates and poor learning results in the introductory programming courses. Hence, there are several new methods suggested to address these issues: Boyle [3] states that using new methods – and especially web-based environments – can lead to increased motivation and better learning results.

Online learning environments, especially when combined with automatic assessment and immediate feedback [4], can provide several potential benefits for both, students and teachers. The teacher can re-allocate teaching resources from exercise assessment to lecturing and personal guidance. The students can access the exercises from any location (and at any time), and usually re-take the exercises as many times as they want.

We have developed an online learning environment called ViLLE at the University of Turku. It contains several exercise types, all automatically assessed. The environment is used as an essential part of all of university's basic programming modules. However, it is likely, that the motivation to take the ViLLE exercises still remains external in many cases: the students complete the required amount of exercises, since completing those exercises is required to pass the course.

In this paper, we're presenting a game mode to increase students' motivation in using ViLLE. Instead of taking the exercises alone, the students can compete in any of the exercise types against other students. The emphasis still lies in learning: though the students competing are racing against time, the score obtained still primarily depends on the correctness of the answer.

The paper is structured as follows: first, related work, with focus on games and learning, is presented. Next, we introduce ViLLE and present previous studies of the system. In the following chapter, we discuss the motivation for developing a game mode, and introduce the game mode itself. Finally, conclusions and ideas for the future development are presented.

2 RELATED WORK

Susi et al. [5] state, that edutainment "refers to any kind of education that also entertains even though it is usually associated with video games with educational aims". Games based learning (GBL) [6] is a form of edutainment, where (computer) games are used to engage users to learn a new set of specific skills. Serious games refer to games that are used for "training, advertising, simulation, or education" [5]. Prensky [7] states that games are an excellent opportunity to engage students into real learning. Though the concept of using games in education is quite well accepted, there are little examples in using serious games to teach programming. Connolly et al. [8] present examples of using games to improve engineering education, and continue to introduce a game based on that literature. Rajaravivarma [9] presents a game-based approach for teaching introductory programming course; however, the focus is on word and number games instead of games designed especially for teaching programming concepts.

3 VILLE

ViLLE is a collaborative learning environment, developed at University of Turku. It contains several exercise types, all automatically assessed. Despite providing course and exercise views for students, ViLLE acts as a "Facebook for teachers", providing possibilities to browse, annotate, rate and utilize all public content created by other teachers. There are currently almost 5,000 students and more than 200 teachers registered into ViLLE. In this chapter, an overview of student and teacher views of ViLLE is described. Moreover, we present some earlier studies about the effectiveness of ViLLE. More information about ViLLE can be found at the tool website http://ville.cs.utu.fi.

3.1 Student view

There are several exercise types in ViLLE, including for example

- Visualization exercises: combine the graphical execution of the program code in selectable language with multiple choice and open questions. See Figure 1 for example.
- Code sorting exercises: an implementation of the Parsons puzzles [10], where the students need to sort the shuffled program code lines into correct order.
- Coding exercises: students need to write a program (or a part of it) to fulfill given requirements.
- Clouds & Boxes: turns the concept of visualization exercise upside-down: instead of

tracing the visualization, the students need to visualize given program code step by step.
- General exercise types: besides programming exercises, there are several exercise types (e.g. quizzes, surveys, puzzles etc.) that are utilized in all kind of courses.

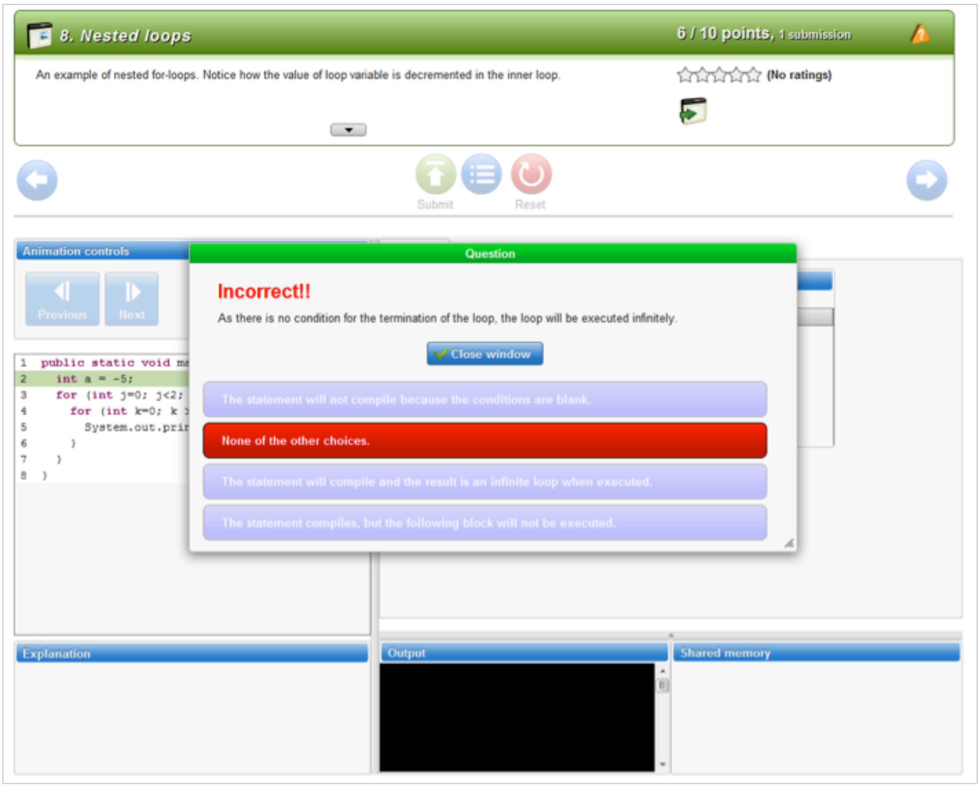

FIGURE 1. *The visualization view in ViLLE.*

ViLLE also supports a variety of programming languages, and provides an automatic translation between languages (though naturally only a selected subset of features is supported). ViLLE's math editor provides an easy way to write and display mathematics in web pages. Other important features include e.g. electronic exams, peer reviewed exercises and exercises constructed by students.

3.2 Teacher view

In teacher view, ViLLE provides versatile tools for handling courses, exercises and materials. Exercises can be created and edited using built-in editors (see Figure 2). Moreover, all content can be annotated, rated, commented and browsed based on any of these criteria. All public content can be immediately utilized in own teaching. Multifaceted statistics provide all essential information about students' actions in the course. Other important features include e.g. manually graded assignments with support for assigning them to assistant teachers, research project management and a one-click course copy feature.

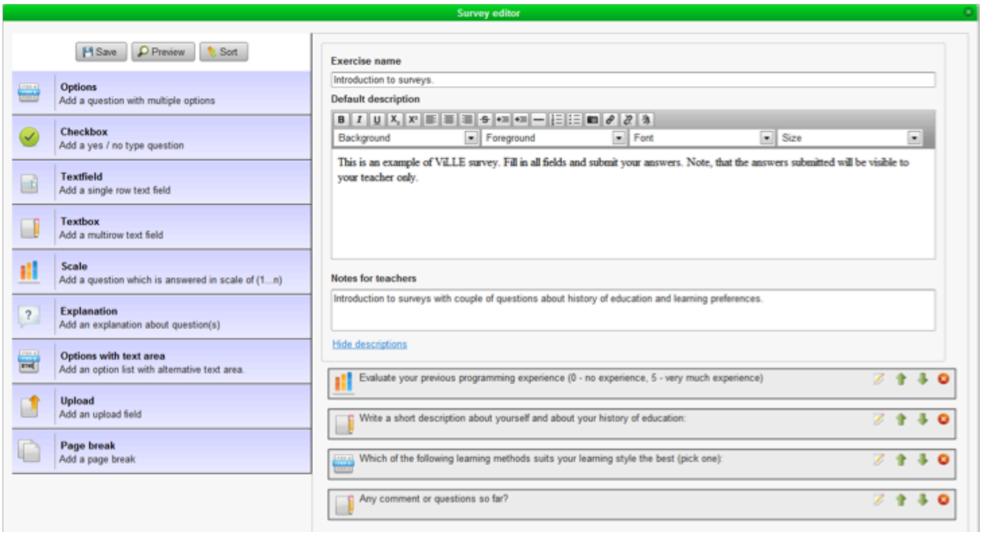

FIGURE 2. *The survey editor in ViLLE.*

3.3 Previous Studies

We have previously studied the effectiveness of ViLLE in various occasions: the effectiveness of ViLLE in learning results was studied in [11] and in [12]. We found out, that using the tool is highly beneficial for novice students, but only if used in higher levels of engagement. This supports the findings of Laakso [4]: automatic assessment and immediate feedback can be used to support the learning process substantially. We have also studied e.g. the collaborative use of the tool [13] and the effects on learning outcome when the tool is integrated into whole course [14]. More results can be found in [15]. The complete list of publications is available at ViLLE website at http://ville.cs.utu.fi.

4 GAME MODE

Students using ViLLE have found it both beneficial and motivating to use [15]. However, it is likely, that further increasing students' motivation would result into larger submission numbers, and hence better learning results. To accomplish this, we have designed and implemented a ViLLE Game mode, where the students can compete in course's exercises against other students.

4.1 Game mode in ViLLE

The basic approach in development was that the game mode should be integrated tightly into ViLLE's existing student view. Hence, instead of creating a whole new view, the existing view was extended to contain a possibility of doing the exercises in the game mode. Students can compete against other students in any of the exercise types (though currently some exercise type implementations for game mode are still incomplete). There are two factors considered when deciding the winner of the match: the first one, score obtained from the exercise, is the most influential. If the score is tied, the second factor, time used to complete the exercise, is used to decide the winner. The approach was chosen to encourage the students to still do the exercise as thoroughly as possible instead of rushing through to gain points.

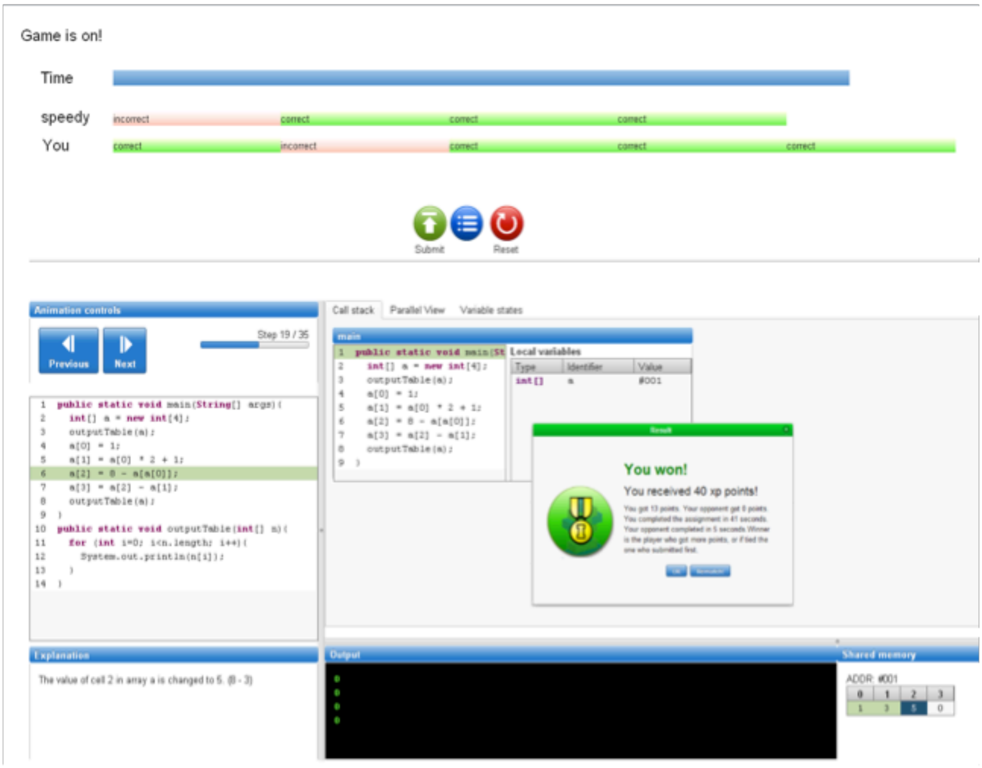

FIGURE 3. *The game mode in action. Current user has won the match.*

The other important factor we decided to include was the interactive view to the match: since the students are taking the exercise at the same time, other students' actions are displayed at the top of the exercise view in real time. This means, that for example in visualization view, the student can see other student's progress (including time consumed, correct and incorrect answers etc.) as she answers the same questions. Game mode also contains a chat function, which can be used to change messages with the opponent. The game mode view is displayed in Figure 3.

The reward system for playing was also considered. The students gain two type of points when taking matches: first, they get "normal" ViLLE points, just like when they are taking the exercises in normal mode. This means, that it's possible to complete the whole course's worth of exercises in game mode. Second, an independent experience point system was developed:

the students get experience points by winning the matches. The idea is later to create top lists for best players in the round, course and in the whole system. As stated in [16], the students are likely to complete more exercises and spend more time taking them, if a reward – even an insignificant one – is given and if the list of best players is visible to all users.

4.2 Online Mode

There are two modes for competing (though the mechanics are somewhat hidden from the students): in online mode a student competes against other students in real time. This means, that after logging into a course with game mode available, the student can challenge any of the other students currently online by picking up an opponent and an exercise. The online mode also features a chat, which can be used to message the opponent during the match. The online mode is not limited to the current course: the student is able to view a list of all students online attending any of the same courses.

4.3 Offline Mode

Since it's likely, that especially in the smaller courses (and in the odd hours) there are not players online all the time, we created an offline mode as well. In offline mode the player competes against other student's previously submitted answers at the real time. In student's point of view the match looks almost identical: the progress of the other player can be traced at real time similarly to online mode. The only feature missing is naturally the chat function. In offline mode the player can also select the difficulty level: in more difficult levels the system picks a better submission to compete against than in the easier levels.

5 FUTURE WORK

There are clearly some things we need to consider and implement in future to further improve the game mode functionality. First, there are still some exercise types that are not supported in the game mode. However, some types probably need to be left out: for example, it might be difficult to evaluate which student answered a course ending survey better. Moreover, the top list functionality is still not implemented thoroughly: in addition to course's top players we are planning to include more comprehensive lists, such as "best players in ViLLE", "best players using Java" etc. Also, we are planning to include ranking and award systems to further enhance motivation.

Another crucial issue is the throughout testing of the game mode. For now, the initial testing has been done in rather small programming course, with approximately 10 students. There are two directions we want to take the future testing towards: first, the game mode should be tested in larger (100 or more students) courses before releasing it to all students. Second, a study with controlled setup should be organized to find out if the mode can actually benefit students compared to ViLLE's normal mode.

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94 ELECTRONIC EXAMS WITH AUTOMATICALLY ASSESSED EXERCISES

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ABSTRACT

Electronic exam is a method of transferring an examination into online environment. The electronic form contains some substantial benefits compared to the traditional exams: scheduling is more flexible, as the students can take the exams when they want to, typing the answers via keyboard makes it easier to write and read the answers, and, presumably, electronic form makes it possible to include question types that are not possible with pen and paper.

ViLLE is an online learning environment featuring different kinds of exercises ranging from surveys to visualizations. All exercise types feature automatic assessment and immediate feedback to students. ViLLE automatically gathers data on students' actions in the courses; this data can be viewed by course's teacher at any time.

The electronic exams in ViLLE are designed to facilitate ViLLE's automatic assessment capabilities in their full form: any exercise type in ViLLE can be included in the electronic exam as well. This is a substantial improvement to traditional eExams: instead of answering multiple choice questions about programming, the students can (and need to) actually write and test the program code or simulate the execution. The eExams in ViLLE have been tested both in Finland and abroad with encouraging results.

Keywords: Electronic exam, CS education, Learning environment.

1 INTRODUCTION

To learn to program is a challenging task for many computer science students and the drop-out rates have been high in programming courses throughout the world. There are lots of research projects focusing on understanding the underlying issues of this phenomenon. One approach used involves utilizing visualizations as a learning aid. Especially, the use of visualizations accompanied with automated assessment and immediate feedback has been successful in tackling the learning problems in programming education [1].

We have developed a collaborative education platform called ViLLE [2][3] at University of Turku. The platform provides tools for creating various types of assignments and other types of resources which are by default shared with all the teachers registered to the platform. Students taking the assignments get immediate feedback generated by the platform as most of the assignment submissions are automatically assessed. The platform stores multifaceted data for each submission which enables teachers to closely follow the progress of their students.

While the automatically assessed content in ViLLE can be used as a measure of student success throughout a course, ViLLE also provides means for organizing electronic exams. Assignments can be collected into an exam round, where the teacher can change their characteristics in order to make them more suitable for exam use. For example, the immediate feedback should be in most cases restricted in exams. ViLLE also provides features preventing unwanted access to exams, including passwords for exam rounds and IP-filtering to allow access just from some selected computers. Exams can naturally include also assignments, which cannot be automatically assessed by ViLLE. A grading scheme can be assigned to such assignments, and the platform provides tools to automatically distribute student submissions to a group of reviewers.

The paper has the following structure. In the next section some studies related the paper's subjects are presented. The following section shortly describes the platform utilized in electronic exams and some previous studies on the effectiveness of various assignments in the platform. After that the process of organizing an electronic exam and the benefits of the platform in that process are discussed. Finally, in the last section we present some ideas for the future.

2 RELATED WORK

Electronic exams are rarely discussed in research literature. However, there are few papers that discuss the design of electronic exam setups as well as on how to assess student submissions automatically or semi-automatically.

TRAKLA [4] is an algorithm animation tool, which can be used to distribute students various types of DSA assignments. Students can resubmit their answers as many times as they want, and as the data sets for each assignment are generated randomly, students can't get good grades just by memorizing them.

Thomas [5] presents an automatic marking system and concludes that the correlation between the scores given by human and automatic markers was high. Thomas et al. [6] gathered feedback from students taking electronic exams at home. The feedback was mainly very positive but as the time limits were very rigorous, students were quite sensitive about any minor glitches (or anything that could result to some loss of time) in the system.

Castellà-Roca et al. [7] present a secure e-exam system and discuss the security concerns in electronic exams. They reviewed different exam stages and identified security properties the stages should satisfy. They note that much research is needed before students can be allowed to take electronic exams in a less restrictive environment.

Doukas and Andreatos [8] present a computer-aided assessment system used in providing tests to students. They discuss the differences between paper and electronic exams and state that majority of students thought that the electronic exams were equally difficult and more preferable than traditional tests, and that the automatically assigned scores better reflected their performance.

Rubyric [9] is an online assessment tool which can be used to give students personalized feedback. Rubyric allows teachers to create a scoring rubric, which includes assessment criteria and phrases that can be selected as a feedback for the students. According to a survey, the graders find the tool useful and recommend its use.

3 VILLE

ViLLE is an online learning platform developed at University of Turku. It supports creation and distribution of various types of exercises designed for teaching programming to novice students. While its main focus thus far has been on programming, some of its current exercises can be utilized in other subjects as well. For example, the platform has already been used in teaching math at high school level.

Most of the exercise types in ViLLE are automatically assessed. This has lots of benefits: Firstly, teachers can easily provide students with a large number of varied exercises, which the teachers don't have to evaluate by themselves. Secondly, students get immediate feedback while they are taking the exercises. In some cases the feedback might be just the score they got from their submission, in others much more detailed description designed to support their learning. Thirdly, the platform stores lots of data from the process of taking an exercise and provides various statistical tools and views for the teachers to study the progress of their students.

One of the main goals in designing the platform was to create a system that provides easy help for teachers in organizing and teaching their courses. All the content in ViLLE is by default shared with all the teachers registered to the platform. The content can be edited, commented and tagged by the teachers, and evaluated both by the teachers and students. This collaborative effort should in time generate top-of-the line content (courses, exercises, etc.) on the platform.

The effect of ViLLE exercises on learning has been studied in various ways. It has been found out the exercises can significantly improve learning of programming concepts, especially for novice students with little or no previous experience on programming. Another study shows that the learning results are better when the ViLLE exercises are used actively in higher levels of engagement. One significant finding is that students should be familiarized with such tools before studying their effectiveness in order to even out the cognitive load and to get more reliable results. Furthermore, the positive learning effect of ViLLE is enhanced if the tool is used collaboratively with another student [10]. [2]

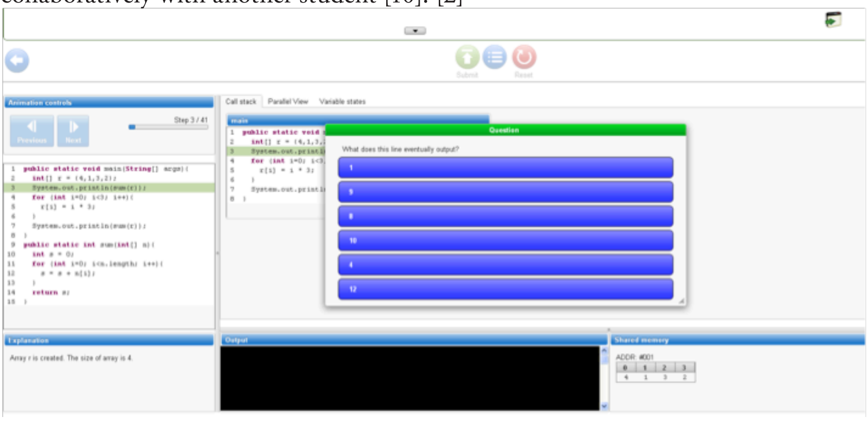

FIGURE 1. *Visualization assignment in ViLLE.*

4 ELECTRONIC EXAM

ViLLE platform has been piloted in electronic exams at university and high school level CS and math education. Students have used the platform in three distinctive ways: In medium size computer labs (20-30 computers), in a large lecture hall, and at home. In the lecture hall 92 students can connect their own computers to a network where we can restrict their access to the Internet. Usually students can only access the e-exam platform. We can assign ip-filters to exams so that the exams can only be accessed from selected ip-addresses (for example from the labs or the lecture hall). Additionally, exams can have a password, which can be given to students at the start of the exam, and which they are required to use in order to submit their answers. Naturally, if students take the electronic exam at home, the exams should be designed to allow students utilize any material available.

ViLLE platform includes tools for creating and distributing various types of automatically assessed assignments. Most of the assignments are best suited for CS studies, including program code writing, program visualization (reading and understanding programs), code line sorting (Parson's puzzles), and program simulation. Some general assignment types include sorting (sort text and images), multiple choice questions, short answer questions, and fill-in assignments (fill in the missing words).

Automatically assessed assignments are especially useful in large mass courses. There is no need to print out, hand out and collect papers and other materials. Additionally, all the submissions are equally assessed and the results of the exams can be shown to the students immediately after the exam.

We have collected feedback from students attending electronic exams. According to the surveys, student attitudes towards electronic exams are very positive. They had very little difficulties using the platform and would like to take exams electronically also in the future.

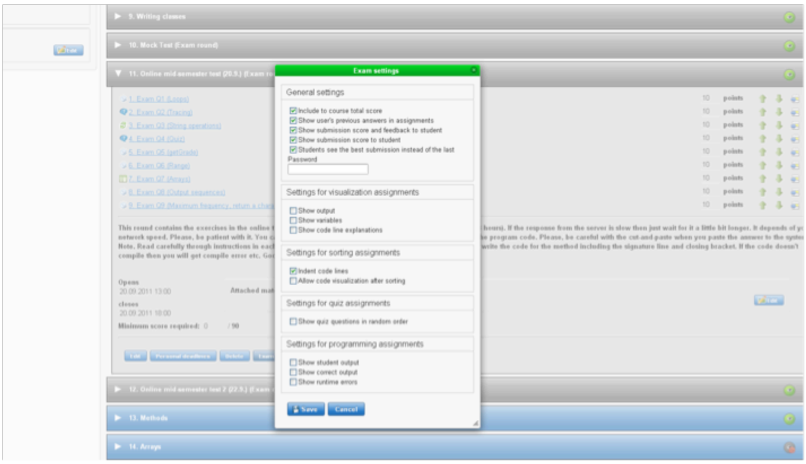

FIGURE 2. *Exam settings dialog.*

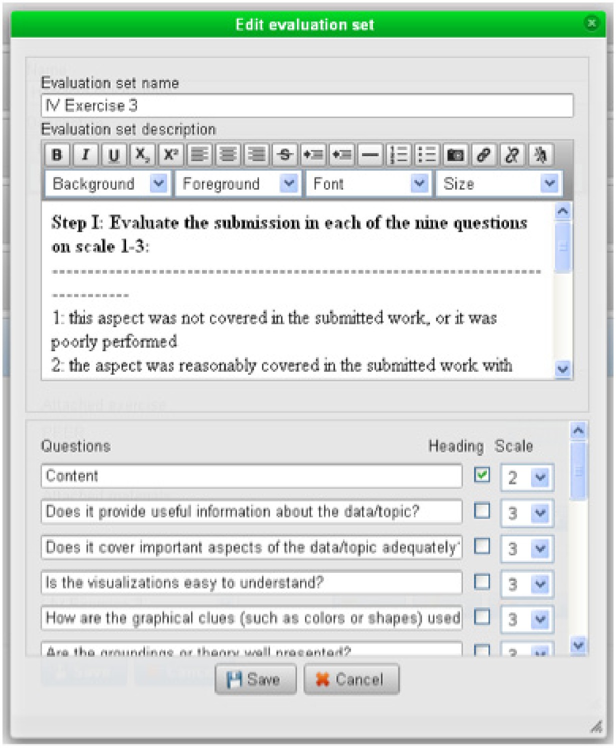

FIGURE 3. *Grading scheme editor.*

5 CONCLUSIONS AND FUTURE WORK

A collaborative online platform such as ViLLE provides a good basis for organizing electronic examinations. Exams can be easily constructed from the massive assignment collection created by the collaborative effort of all the teachers registered to the ViLLE platform. Additionally, all the teachers can utilize the created exams. If the whole exam consists of automatically assessed assignments, the results can be shown to students immediately after the exam.

In near future ViLLE will be used in organizing electronic examinations throughout the CS track in our institution. Based on the experiences we will refine the features of the tool as well as the actual process of organizing electronic exams.

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95 A ROBOT EXERCISE FOR LEARNING PROGRAMMING CONCEPTS

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ABSTRACT

Different methods of visualizing code execution and its relation to various state changes have been perceived useful in programming education. However, due to the nature of program visualizations, they are generally hard to successfully and efficiently integrate into different programming teaching curricula. ViLLE is an educational tool, capable of being used in teaching basic programming concepts via utilizing visualizations coupled with different forms of collaboration, immediate feedback and automatic assessment. Previous studies conducted with the tool have shown that it can be effectively and successfully used in its domain area. This article introduces a new exercise type as an extension to the ViLLE platform. Dubbed as the robot exercise, the main focus of the exercise is in providing visualizations for different types of repetitive tasks, commonly found throughout program implementations. Further, by providing the user with an easily comprehensible visual counterpart, the emphasis is in optimizing the crane or robot movement and visually demonstrating the outcome of possible programming hiccups as crane malfunctions.

Keywords: Program visualization, Repetition, Best-practices, Optimization,

1 INTRODUCTION

Visualizations promote programming learning. An exciting visual representation can help in motivating and engaging the students. Furthermore, the visualization can make the control flow of a program easier to follow. ViLLE is an online education platform featuring several different exercise types, some of which use visualization. However, the visualizations are currently limited to debugger-like information of the state in which the program is. While that information is vital for thorough understanding of how certain program works, it might be too verbose to optimally engage a novice programmer.

In this paper we present a new exercise type, in which the program code written by the students control a robot. The robot is animated and moves by the commands given in the student code. The students get immediate visual feedback of their code quality from the movements of the robot. As the animated robot is more visually thrilling than mere state representation of various variables affecting a program state, it is expected to be more approachable for a novice programmer. In the first version of the robot exercise, means to concretize repetition structures are provided. The main teaching goal is to help students to understand how different repetition structures work, and how their incorrect usage might lead to very long-running or non-terminating programs.

2 RELATED WORK

As stated in [1], automatic assessment, combined with immediate feedback, can substantially help students to understand the essential programming concepts. We are able to pursue this by following ViLLE format for exercise building and submission, discussed in greater detail in section 4.2. The importance of engaging the student while the program executes has been discussed in [2]. Achieving high student engagement is of top priority, and for that reason the student is given access to the execution flow controls. Access to multiple views during execution, code marking and dynamic rewriting are discussed in [3]. These features might be implemented in later versions, if studies conducted later with the current version encourage their integration. Further, [4] discusses how the execution controls must be comprehensive enough, and how the user interface must be clear and easily approachable [5] in order to avoid user frustration. Finally, the ability to provide language-independency is discussed in [6]. The program responsible for robot visualizations is capable of building animations based on strings representing command listings, and is therefore controllable by any language capable of producing them.

3 VILLE

ViLLE is a collaborative education platform, developed at the University of Turku. As mentioned previously, ViLLE is used as the implementation and distribution - as well as data gathering – tool in development of the robot exercise. The following shortly describes the most significant features of ViLLE in relation to the new exercise type:

Language-independency: the possibility to view exercises, as well as answer them in different programming languages, is an essential feature in ViLLE. Being able to switch effortlessly between different languages further enhances the learning experience and provides a clear linkage between commonalities of programming languages.

Flexible visualization controls: to further increase the learning process, the user may control the execution speed and direction of the visualizations in ViLLE. This feature was also adapted into the animation controls of the robot exercise.

Thin client distribution: ViLLE supports a method of building the exercise so that it can be distributed with minimal amount of prerequisites towards the user. The only requirement for using ViLLE is that the client has a JavaScript capable browser, which makes it easier to deploy ViLLE to new environments. Additionally, copies of the system can be run in local area networks – for example in exam situations where the access to internet needs to be restricted.

The student is presented with a clear user interface, providing instant access to all needed elements of the undergoing exercise. Questionnaires are simple and highlight the portion from which the question originates. After answering a question, the student receives immediate feedback (providing that the exercise creator has added feedback to the question). Further, upon completing an entire exercise the student gets to see a final draft of his or her performance before submitting.

The teacher side provides an easy-to-use editor for making the exercises. Teachers are also presented with tools to organize courses and rounds, and a comprehensive view with data gathered from a multitude of tracking points. The data gathered is available for review in both raw- and graph-forms. This is perceived especially useful in tracking the success of exercise presentation, as well as student performance and knowledge in different areas.

3.1 Previous studies

We have previously studied ViLLE in various occasions: the effectiveness of ViLLE was studied in [7] and in [8]. We found out, that ViLLE is especially useful for novice programmers, when the usage occurred in higher levels of engagement. This is supported by Laakso [1], who states, that automatic assessment and immediate feedback can substantially support the process of learning to program. We have also studied the collaborative use of ViLLE [9], and found out, that co-operation can be a beneficial form of learning when using program visualization tools. Further, the student opinions collected [10] support the results mentioned earlier: students seem to think that ViLLE is both effective and motivational tool to use. The complete list of publications can be found at ViLLE's web site at http://ville.cs.utu.fi.

4 THE ROBOT EXERCISE TYPE

With the new exercise type we wanted to provide students with a clear and inspiring visual presentation of repetition in programs. The most important learning goal of the exercise type is to understand the control flow and traversed value range in conditional repetition statements. To encourage an efficient use of source code space – and optimization in general – an optional penalty system was implemented: dynamic feedback can be provided based on the length of the program code and the cost of robot movement.

The idea of the exercise is to program a robot to move a number of indexed boxes from predefined starting locations into the required goal locations, while minimizing the number of steps needed. The robot itself starts from a predefined position and length. The three "arms" have different costs for their movement, relational to their position in the crane. A single command results in a single movement of an arm, which in its turn results in this cost being added to the total. The robot automatically skips commands that would make the crane hit edges of the area or other objects in the field.

4.1 Editor View

The editor is used for making new instances of the exercise. In the case of the robot exercise, this requires the creator to define the starting positions for the crane, as well as the start and goal positions for the boxes. Additional configurations include adjusting the number of boxes used, limiting the movement options for the crane, and tuning the aforementioned penalty system.

The basic editor view is represented in Figure 1: the three-part crane is on the left side of the screen, where two of the arms appear as orange honeycomb steel pylons and the last arm as a wire with a magnet attached to it. All of the arms have similar functionality: they may move up or down, or left or right in relation to their parent arm. Additionally, all arms may extend or withdraw. If an arm is a parent of another arm, a command issued to this arm may resolve into several arms moving at once, which again increases the cost of the step.

One of the most important things to notice when creating a new exercise is the initial positioning of the crane regards to the initial and goal position of the boxes. This part of the crane movement corresponds to the series of commands usually issued outside of any repetitive structures, and is only done once.

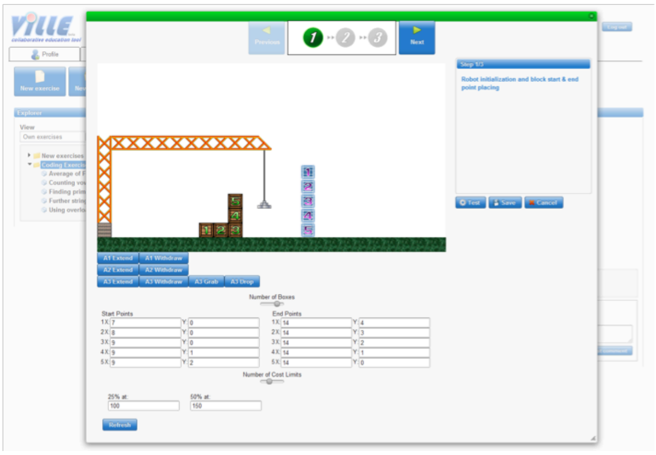

FIGURE 1. *The editor for a new robot exercise.*

The editor view also makes it possible to add cost limits. Exceeding these limits will reduce the student's score accordingly. These limits make it possible to reward control structures that do not take large amounts of space or require several costly commands to complete.

4.2. Student View

The student side of the robot exercise consists of two phases. The view in the first phase contains the crane in its starting position and the initial (brown) and final (blue) position of the boxes. To the right of this view is the programming area. Students use it to write a program that executes the required robot steps. Additional instructions are usually provided for the students, including the (possibly limited) set of commands usable for controlling the robot. The first phase view of the student side is presented in Figure 2.

When a student is finished writing the control code, the robot animation can be started by pressing the submit button. In phase two, a popup view opens, displaying the same initial state for the robot and the boxes. Instead of the coding area a set of execution flow controls is displayed. These may be used to control the speed and direction at the robot animation.

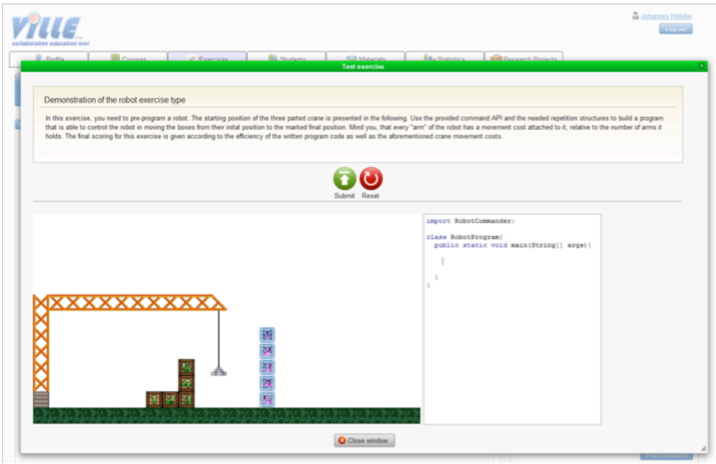

FIGURE 2. *the initial student view of the of the robot exercise.*

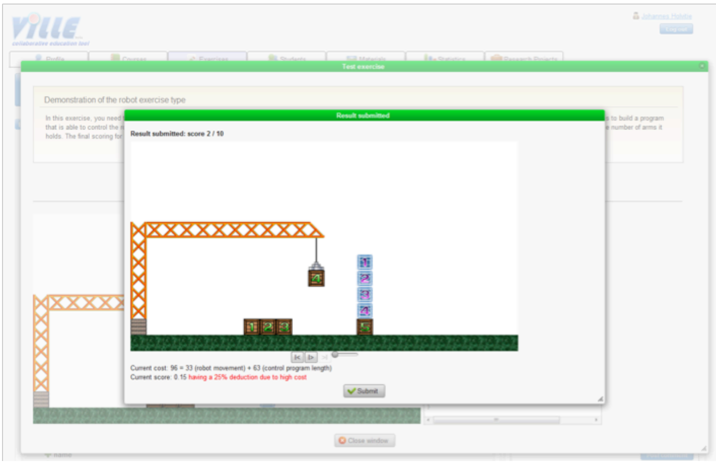

FIGURE 3. *the robot movement and exercise submission phase.*

Additionally, the final view shows the final score as well as keeps count of the live score relational to the robots movements so far. The point additions from placing boxes to correct goal positions and the possible penalties from exceeding cost limits are also displayed.

5 EXPECTED BENEFITS

By providing the students with an exciting representation of repetitive command execution in programs, we expect to promote the following learning goals:

1. Repetition control, especially value range definition and the consequences of unsuccessful definition.
2. Optimization, the importance of acknowledging command and algorithm costs as well as

cost multiplication due to repetition.
3. Importance of acknowledging a problem with a valid iterative and / or recursive solution, and the ability to implement it in a reasonable amount of time.
4. Efficient source code space usage and the ability to provide a solution that properly utilizes the expressiveness of the target programming language.
6. Conclusion

We have built a new exercise type for providing a clear and approachable method for understanding the basics of repetitive structures and command execution in programs. By integrating this newly built type into an already existing platform, we avoid the additional ground work, while bringing in several studied and tested features. We expect this new exercise type to provide the same level of ease of use and utilization as the other exercise types present in ViLLE do.

We acknowledge that to fully achieve the expected benefits discussed in section 5, a more evolved version of the new exercise type might be needed. The exercise will be studied and adjusted by the results of the studies. However, the exercise in its current state already contains the theoretically essential components for achieving the aforementioned expectations. As mentioned earlier, we are also planning on studying the robot exercise thoroughly. Later, required fine-tuning is to be made based on the results of the studies.

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96 MOLECULAR DIAGNOSTICS LABORATORY (MDL) – COLLABORATION BETWEEN STUDENTS AND SMES

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ABSTRACT

Molecular diagnostics laboratory (MDL) at the Turku University of Applied Sciences (TUAS) was established in 2009 to provide R&D services, education, and training in state-of-the-art molecular biological methods for students at different stages of their basic and advanced level studies. The idea is to bring students in close collaboration with their potential future employers in the SMEs and other work providers. MDL has provided further education in 'genome wide analysis' (30 ECTS) at the level of specialisation studies together with the University of Turku at Bachelor's/Master's level.

MDL is equipped with Roche LightCycler 480 II Real-time PCR, Roche 454-Genome Sequencer GS Junior (equipped with the Roche 454 Titanium chemistry), Agilent Bioanalyzer and Agilent Microarray Hybridization Oven. The performance of the laboratory equipment allows e.g. analysis of human whole genome DNA-microarrays (Agilent) for genotyping as well as the high-density DNA oligonucleotide (200K, Agilent) arrays for the transcriptomics analyses using either catalogue or custom-designed oligonucleotide arrays. GS Junior genome sequencer is able to produce ca. 65 Mb of sequenced bases per run with read lengths of approximately 500 bases in median (Phred score Q40) by using the Roche 454-Titanium chemistry. The sequencing plate can occupy flexible amounts of samples through bar-coding procedure of the samples. The laboratory is dedicated for testing, validation, and development of custom-tailored molecular diagnostic methods and services for biodiversity analysis of environmental samples, microbial detection of food and food production industry, fermenting industry, and analysis of animal/human microbiota for various scientific and clinical diagnostics purposes and to the future needs of personalized medicine.

The laboratory performs also bioinformatic mining of high-throughput data from Agilent/ Illumina microarray analysis and Illumina-/Roche 454-sequence data. MDL will be providing training for 20-30 students/student assistants annually serving both national and international study programmes such as 'internship' training for European students. In addition, the laboratory organizes training for student groups in quality control and quality management.

MDL aims to implement ISO 17025 standard for certification and accreditation of the services provided by the laboratory.

Keywords: Genome Sequencing, Roche GS junior, molecular diagnostics

1 INTRODUCTION

"Next Generation Sequencing" or NGS has revolutionized molecular research profoundly during the past 10 years being the most significant technological advancement in the biological sciences in the history. The NGS technologies evolved along with the first effort to sequence the entire human genome. The effort was capitalized by the successful assembly of the first draft of the human genome 2001 (or the first assemblies during 2001-2003). These first assemblies of the human genome consisted of several individuals' DNA pooled as one, respectively. The first draft of the human genome was revealed, nevertheless, for the first time to mankind. This was without doubt a milestone and a starting point for the "genome era" for real. The cost of the very first draft was incredible 1 Billion dollars. Due to the high costs the achievement started immediately a competition between the technology providers to produce a system that could sequence the human genome on thousand dollars, a price that everybody could afford! The race was started 2001 and it is still going on 2012. It is not only question of the plain costs of sequencing but also the quality of the sequence that plays an ever growing role now and will continue to do so in the future.

MDL develops methods to study genetic sequence-based variation at the molecular level in all its' meanings. The aim of the laboratory is to function as a training laboratory for engineering students at the different stages of their studies. The gene tests that are developed in the laboratory are aimed for the use of health care professionals and hospital laboratories. The gene tests we perform in the lab are therefore not aimed directly to the person tested without consulting by the aid of a physician. The reason is simple, we do mere technical method development in a teaching environment and we will therefore not participate in any interpretation of the results other than sequence similarity/variance to the defined reference sequence. Our mission in MDL is to give training to engineering students using up-front technology platforms such as NGS in a laboratory environment providing services on genetic testing related technologies. MDL applies and develops NGS based gene tests instead of Sanger sequencing to reveal the complete coverage of the DNA-sequences present in the region of interest (i.e. that contain a suspected site for a pathological mutation) in the sample.

Essentially, the benefit with the NGS methods is that the laborious cloning step of the DNA to be sequenced is no longer necessary and more samples can be processed in parallel. The pico titer plate (PTP, Roche) that we employ in GS Junior genome sequencer has 380 000 wells instead of 96 as in the regular "micro well plate". This means a 4000x difference in throughput! In the NGS the cloning step is totally omitted and replaced by PCR in the "massively parallel amplification" fashion, which procedure is partially responsible for the depth of the sequenced DNA-fragments. The amplification step in the NGS methods is either miniaturized into Pico liter reaction wells (Roche 454 GS, Ion Torrent) or will occur on the surface of the reaction chamber as a "cluster" (Illumina). Sequencing that is subsequently performed is achieved by "sequencing-by-synthesis" type of sequencing reactions (as in the Sanger's method) are currently employed e.g. in the NGS systems of Roche 454 GS, Ion Torrent PGM and Illumina to name some. The SOLiD system (ABI). on the contrary relies on a ligation based method. However, common to all NGS methods or the so called "2nd generation sequencing methods" is the use of polymerase-chain-reaction (PCR) to amplify the target DNA. The advantage of the "clonal amplification" by the NGS methods is one can reveal the complete (or at best, the near complete) diversity (or the depth) of the different sequences present in the sample. In the human body we seldom have a situation, where we would have a single clonal cohort of RNA-transcripts per gene expressed by the cell. Usually distinct sub-populations or at least the normal transcript variants (e.g. through differential splicing) co-exist in otherwise a perfectly healthy cell. The powerful NGS methods will start to reveal the secrets of the nature deeper than ever before.

1.1 Development of gene testing for medical diagnostics

MDL has a focus on diagnostic genetic testing. The background of the current staff ranges from running of a hospital/university core facility in Finland and abroad using diverse state-of-the-art high-throughput scientific equipment (microarrays, LC-MSMS, sequencing etc.). The second very important aspect in our effort in developing novel gene tests is the fact that Turku is the national center for drug development and diagnostic industry. Third, at TUAS our laboratory is able to apply quality education provided by TUAS into the quality management issues of the laboratory. Both teachers and students are involved in various study projects around the quality issues. Through collaborative efforts we are able to build the quality system that is necessary for our laboratory as we aim to produce diagnostic services in the future. We work in close collaboration with the university hospitals and industry, which have their respective demands for the quality system. It is therefore of outmost importance that we are able to exploit student labor, which is properly educated into the management of the quality according to the respective collaborators quality demands. We hope that our contribution will lead to numerous commercial applications that facilitate personal medicine to be applied in diagnostics, preventive medicine and pharmacogenomics purposes.

2 RESULTS

MDL staff has participated in a large European FP6 research consortium 2006-2009 involving eight European Universities by contributing with a work package developing a microarray platform for the study of the industrially important and potentially harmful human pathogen Aspergillus terreus (Raina et al., 2012). [1,2] The work is still in progress in part, and one of the staff members (MSc Elina Palonen) is working on her PhD thesis based on the results of this research collaboration. We have also applied microarrays in a study using single brain cells isolated by micro-dissection (Laurén et al., 2010).[2] Another large study, where the staff members of MDL have been involved was a national microarray study to screen biomarkers in ovarian cancer (Huvila et al., 2009). [3]

Only a couple of years later The Cancer Genome Atlas Research network published comprehensive results of the mRNA expression, microRNA, promoter methylation and DNA copy numbers in 489 high-grade serous ovarian cancers. In addition, TCGA had performed massive parallel sequencing coupled with hybrid affinity capture that provided whole-exome

DNA sequence information for 316 of these ovarian cancer samples (The Cancer Genome Atlas research Network, 2012). They reported in this study low prevalence but statistically recurrent somatic mutations in nine genes including NF1, BRCA1, and BRCA2.

Incidentally, MDL has recently contributed in research collaboration towards development a genetic test for the mutation analysis of the NF1 gene. Our work appears to have significance in the cancer field as well, since NF1 belongs to the class of tumor suppressors. NF1 gene is functional during development and mutations in this large structural gene containing 60 exons can cause either inherited (in case the mutation occurs in a germline cell) or sporadic (if the mutation is somatic) causing a disease called neurofibromatosis affecting children in their early childhood. The mutation can be a single point mutation at the nucleotide level that lead to an amino-acid change at the protein level. Pathological mutations are of type missense or non-sense mutations that typically lead to the premature abruption of the NF1 protein with the common pathological consequences. These include versatile symptoms that range between apparently harmless café-au-lait spots or freckling of the skin to severe cognitive disability and in the worst scenario may contribute to a large tumor burden. The occurrence of neurofibromatosis is approximately 1:3500 births worldwide. From clinical point of view, the disease causing mutation in the NF1 gene is amongst the most difficult to diagnose due to its' large size. The currently available diagnostic test is performed abroad by Sanger sequencing (University of Alabama in Birmingham, AL, USA) and costs 1300 € per test. The mutation analysis in this case is performed by sequencing the cDNA extracted from cultivated tumor Schwann cells from the fibromas of the patient. Our laboratory has co-worked with the current attempt to build a NGS based method and using a non-invasive sampling technique since the affected are commonly of at their early childhood. We have therefore sampled genomic DNA from the saliva. The test has recently being piloted for the neurofibromatosis clinic in Turku (Turku University Central Hospital) with the test being performed in our laboratory. The current test employs the Roche GS Junior sequencer that we have in the laboratory. The speed of the test and the costs per test has been reduced concomitantly.

MDL function is to serve both as an R&D laboratory providing services in targeted genome sequencing issues towards the industry as well as to function as a training laboratory for the engineering students at TUAS. We are currently integrating students both from TUAS as well as international trainees from European Universities through the Erasmus program into common training projects in our laboratory. We have been training at least 20 students annually of which one third are international students performing 'internship' on Erasmus funding. All students receiving training in our laboratory will be engaged with our currently on-going R&D projects. We have partners both from the academia and in the industry. We have also interdisciplinary projects within the study programs at TUAS. We integrate students with different backgrounds and study programs to work on joint themes such as the topic of our current work package in the Agricola project: "Non-invasive sampling methods in the promotion of health". Our laboratory functions thus as a bridge between the university and industry providing education and practical training that is partially financed by the industry. The other part of the costs will be covered by competition for external funding from different sources, both nationally and from EU. SMEs will be attracted for collaboration by providing R&D services that they need. As an example can be mentioned various method validation studies performed by our students that SMEs can further exploit in the marketing of their products.

3 DISCUSSION

MDL was originally established at TUAS for the demand of the NGS technology needed for scientific research collaboration within an EU FP6 project. We realized that we had rapidly become dependent of much higher throughput methodology than what was actually available or could be considered useful for a 3-year EU project. As the economy guides us to miniaturizing the experimental reaction systems, we inevitably face the fact that with the ever decreasing reaction volumes we are in the absolutely need of a proper quality system in the laboratory. Good quality system will reward the laboratory with an increased quality and validity of the results in the end. This is agreed by everybody and when the scientific results should be commercialized the demands are even higher or even more obvious. The problem is in general how to improve quality with the decreasing resources. Maybe the answer is that we simply have to do so in the current situation.

MDL would like to benchmark the laboratory as a genome sequencing laboratory providing services on targeted genome re-sequencing with Roche 454-NGS platform. NGS in genetic testing has been reported to supersede the sensitivity of Sanger sequencing and pyrosequencing. Yet at the moment, other methods than NGS based gene test dominate in the diagnostic cancer testing. Standard Sanger sequencing is not detecting mutations if present in less than 10%. Specific allelic discrimination assays have an average mutation detection sensitivities approaching 90% but the sensitivity drops sharply when analyzing formalin fixed sample material. On the contrary, the NGS methods have been reported to detect 100% of the patients with the target responsive allele. The major technical challenge with the NGS based methods will still be the heterogeneity of the tumor material due to the degradation caused by the fixative to the DNA-sample. The newest incomer to the NGS field, Ion Torrent by Life Sciences, has rapidly gained popularity among researchers. Interest has especially been focused on the comprehensive cancer panel –product that is based on amplicon sequencing. The platform has the same developer as Roche 454 (Jonathan Rothberg), taking all the advantages of the 454-technology but built on a semiconductor base, which brings scalability and cost-efficiency to the testing. Recently Ion Torrent launched a web page based primer design service to make the use of the Ion Torrent system even easier.

We have chosen the Roche 454-platform to our laboratory for quality reasons: Roche 454-technology can produce the longest sequence reads with the highest quality. Quality is valued in our laboratory and means usually profound understanding what is being done and documenting of the work accordingly. Our function at TUAS is currently to plan how the quality issues could best be taken into the study programs in the engineering studies integrated with the practical training in the sequencing laboratory. The aim of MDL is to transfer our experiences and knowledge to the next generations of future employees/employers. We have thus been functioning as a test site for the “innovation pedagogy”, and our laboratory seems to be ideally fitted within these ideas at TUAS.

4 CONCLUSIONS

The experiences of MDL as a training laboratory at TUAS are encouraging. The integration of education for the engineering students within the frame of an R&D laboratory appears to be manageable. Our experiences support the aims of TUAS to start giving education in quality management to the engineering students. The initial quality projects that we have recently started in our laboratory have increased the quality of the entire laboratory and improved our performance in NGS methods. The implementation of a quality system in the laboratory processes in general is expected to constantly improve the over-all quality of laboratory functions and the services provided by the laboratory. The most important of all, the laboratory quality system should ensure the quality of the results. The quality system is also valuable for us in the development of novel gene tests for ultimately diagnostics purposes and towards commercialization. Educating students in collaboration with SMEs facilitates technology transfer in both directions so that quality managing skills by our students could be expected to give us an instant feedback from the industry. Collaborative efforts between SMEs and the university are also expected to pave our way towards novel innovations and business opportunities. The keys for the success in the future engineering education could therefore include focusing into the quality management education as well as to the "innovation pedagogy".

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97 ACTIVE LEARNING THROUGH VIDEO LECTURES

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ABSTRACT

Active learning, which refers to the engagement of the student(s) through activities in the classroom/other places, is widely recognized as being superior to passive learning that occurs when the students merely listen to lectures. On the other hand, multiple modes of information delivery, such as video lectures, web-courses, etc., on-line, are now commonplace in many parts of the world. One of the challenges of the on-line modes of delivery is that the innovations developed to improve learning in a classroom setting, such as active learning, possibly cannot be effectively invoked. This paper demonstrates the possibility of effectively invoking active learning in a video lecture format, to either a single learner or a group of learners, at the other end. The possibility of invoking active learning calls for a different strategy to structure the video lectures. Such a novel strategy has been employed in developing a course on Thermodynamics (Classical) for Biological Systems and was given for the National Program for Technology Enhanced Learning (NPTEL). This paper presents the relevant strategies, and discusses the details.

Keywords: Active learning, Video lectures, Distance education, On-line learning, Strategies of better learning, Animation of mathematical equations

1 INTRODUCTION

Active learning [1]-[3] refers to the style of pedagogy in which the students are actively involved in the process of their learning. Active learning is usually contrasted with passive learning, which typically occurs in a standard lecture mode of information delivery, i.e., the lecturer talks and the students listen. Although the arguments of the initial detractors to active learning included the possibility that all learning is inherently active, and consequently, students are actively involved during the traditional lectures in a classroom [3], it was later accepted that the term, active learning, involves strategies that make students do relevant things, and think about what they do [3]. It is well argued in the literature [1] [2] [4] that the active learning strategy produces better learning in the students.

In the current times of significant virtual connectivity, and consequent specialized possibilities in education through on-line and distance modes, video lectures have become common-place for information delivery to registered students as well as to any interested learner. The learners could be comparatively homogenous if the video lectures are meant as a substitute for a particular lecture(r) to registered students, or they could have highly diverse backgrounds, abilities, and nationalities, if the intent is to provide material to anyone in the world who may be interested.

The video mode of lecture delivery to registered students in a University has been available from the 1950s onwards (e.g. from a Table in [5]). These were available mainly for the registered students to make up for lost classes, or to improve their understanding [5], or for the part-time students from the industry to obviate their need to be physically present at the University to attend the lectures [6]. The possibility of distance education for anybody who may be interested became popular with the open course ware (OCW) initiative of the Massachusetts Institute of Technology (MIT) after it was officially launched in 2003, in which videos of some of their lectures were made open to all across the world. Such initiatives are highly relevant to India, where there is acute shortage of good teachers in many Universities, especially in the North Eastern Regions of India, which are slowly coming into the mainstream.

More importantly, the number of students graduating with a PhD/Masters degree in the Engineering disciplines in India is currently much smaller than the required number of people in the teaching profession in the Engineering disciplines – an estimated 80,000 per year x 4 years of a UG program, for a student:teacher ratio of 10:1. In addition, only a fraction of the doctoral or masters graduates would opt for an academic career. Until the initiatives to increase the number of people in academia in the Engineering disciplines bear fruit, to bridge the gap between the demand and supply for good teachers, video lectures of complete courses are being generated, and made available to all across India (and the world). The National Program on Technology Enhanced Learning (NPTEL) in India is the most important initiative in that direction with 1100+ full courses in various branches of Engineering to be made available at the end of the second stage, probably by the end of 2012. About 300+ courses are already available. The NPTEL lectures are toward complete courses, which are designed to a generic University syllabus, that is typically different, in the details, from the syllabi for MIT courses; further, they are designed to help the students understand the material as well as to pass their University exams. The video lectures are made available free through the dedicated website (www.nptel.iitm.ac.in) as well as through social media such as YouTube, for popular access. For those who so prefer, a DVD of the lectures for each course is also available.

The advantages and disadvantages of the video lecture format have been widely discussed [7] [5] [6] and Bennett and Maniar, 2007 (accessed from http://www.e-learningcentre.co.uk/eclipse/Resources/academic.htm on 20th April 2012). One of the common disadvantages that still exists, is that the methods to improve learning that are available for face-to-face use in a class-room have not been successfully translated to the courses in the video format. This paper discusses the novel aspect of incorporating active learning strategies into video lectures to improve the learning of viewer-students, for the course on `Thermodynamics (Classical) for Biological Systems', which was created for the NPTEL.

2 THE NATURE OF THE CHALLENGE

Many techniques, which have the support of extensive research, are available in the literature [9] to improve the student learning in a classroom setting. Active learning is one such technique where the lecture is interspersed with relevant activities done by the students toward their improved learning, either individually or as a group. If the activities are done as a group, the term used to describe it is active-cooperative learning.

At the first consideration, the scope for application of some such techniques in a video lecture to improve the learning of viewer-students in a distance mode seems to be limited. The important aspect of directing such activities, which were developed for real time use in a classroom, seems to be challenged by the distance and the virtual time/asynchronous aspects inherent in a video lecture format. Nevertheless, as shown in this paper, it is possible to suitably incorporate active learning techniques in video lectures.

3 STRATEGIES FOR ACTIVE LEARNING THROUGH VIDEO LECTURES

In the video course, Thermodynamics (Classical) for Biological Systems, active learning was incorporated through a few strategies. The most obvious one was through the need for the viewer-students to solve problems, in a directed fashion, immediately following the presentation of a concept or a set of related concepts – the video time was set aside exclusively for that purpose. In other words, the video lecture pauses for the needed time, say anywhere between 2 and 20 minutes, during the 50 min video lecture to give the average viewer-student enough time to work out the problem, with a set of instructions, and hints. A running clock on the video along with some appropriate background music provide the break from monotony, and set the environment for the viewer-student to work out the needed aspect, as a part of the lecture itself. Moreover, the hints could be appropriately placed, say after a certain amount of time, which is usually sufficient for the average viewer-student to think about the approach, or to do some initial calculations, has elapsed.

Another situation in which active learning could be beneficial is when the viewer-students are given time to understand the lay-out of the data in a Table or Figure, say for example, the steam tables. For example, when the use of steam tables was introduced as a need to solve a problem, about five minutes were given for the viewer-students to familiarize themselves with the layout of the data in the steam tables, and the fact that different tables need to be used depending on the condition of the steam – say, saturated, or superheated. Some initial pointers were given regarding the layout of the thermodynamic properties of steam in the steam tables, and then the viewer-students spent time, during the lecture time, to become familiar with the steam tables. Some questions about the specific thermodynamic values at some specified conditions can also be included to improve the understanding of the data layout. It can be appreciated that the learning that occurs when the viewer-students themselves find out the use of steam tables to get the needed data, is far superior to the learning that occurs when the instructor merely describes the table in a video lecture.

A further situation in which active learning could be invoked is when viewer-students are needed to work out a part of a bigger mathematical derivation, with suitable directions, and are given the time during the lecture itself to do it. For example, in this particular course, let us say that we are in the process of getting an expression to evaluate the residual enthalpy in terms of the more easily measureable properties such as compressibility factor, pressure, and temperature. Let us say that we are at the stage given by the first equation below.

$$\left[\frac{\partial\left(\frac{G^R}{RT}\right)}{\partial T}\right]_P = \left[\frac{\partial\left\{\int_{P_{ref}}^{P_2}(Z-1)\frac{dP}{P}\right\}}{\partial T}\right]_P$$

This involves partial differentiation of an integral, which can be done by the generalized Leibniz rule. The viewer-students can be given time during the lecture to do the mathematics of the Leibniz rule application. For example, the following steps can be worked out by the students with appropriate directions – maybe the generalized Leibniz rule (the first equation below) needs to be explicitly given first before the viewer-students work out the individual terms through differentiation and integration steps, as given below.

$$\left[\frac{\partial\left\{\int_{P_{ref}}^{P_2}(Z-1)\frac{dP}{P}\right\}}{\partial T}\right]_P = \int_{P_{ref}}^{P_2}\left[\frac{\partial}{\partial T}\frac{(Z-1)}{P}\right]_P dP + \left[\frac{(Z-1)}{P}\right]_{P_2}\frac{dP_2}{dT} - \left[\frac{(Z-1)}{P}\right]_{P_{ref}}\frac{dP_{ref}}{dT}$$

Since the II and III terms on the RHS involve derivatives of particular values (limits of integration, which are constants for a given case), they are each zero. Thus,

$$\left[\frac{\partial\left\{\int_{P_{ref}}^{P_2}(Z-1)\frac{dP}{P}\right\}}{\partial T}\right]_P = \int_{P_{ref}}^{P_2}\frac{1}{P}\left[\frac{\partial Z}{\partial T}\right]_P dP$$

Therefore, $\frac{H^R}{RT} = -T\left[\frac{\partial\left(\frac{G^R}{RT}\right)}{\partial T}\right]_P = -T\left[\int_{P_{ref}}^{P_2}\frac{1}{P}\left[\frac{\partial Z}{\partial T}\right]_P dP\right]$

So, $\left(\frac{H^R}{RT}\right) = -T\int_{P_{ref}}^{P_2}\left(\frac{\partial Z}{\partial T}\right)_P\frac{dP}{P}$

The requirement that the viewer-students need to work out the detailed mathematical steps serves multiple purposes. In this author's experience, about 80% of the students in a typical undergraduate class in Biotechnology are not naturally talented in Mathematics (e.g. cannot foresee the results of multiple sequential steps), and spend a lot of time trying to understand how the various mathematical steps in a typical textbook are arrived at; the typical textbook usually does not elaborate the intervening steps in a derivation. For example, a typical approach in a textbook for the above mathematical steps would be to say that `by application of the generalized Leibniz rule, one can arrive at the final expression'. A significant percentage of interested students in a typical class get frustrated when they are unable to work out the mathematics. Thus, if the steps are required as an active exercise, the appreciation for the rigour in the subject becomes better to an average student. Of course, it may be boring to a viewer-student who is naturally talented in Mathematics (less than 20% in a typical engineering undergraduate class), and such people can move to a further position in (fast forward) the video earlier than the others.

4 PRESENTATION OF MATHEMATICAL EQUATIONS

A related novelty that was introduced is the method of equation presentation in the lectures. It is common knowledge that student appreciation of the equations is far less when presented using presentation software, such as Microsoft PowerPoint®, compared to a presentation using say, the chalk board. Deeper thought led the author to realize that the chalk board presentation of equations is more effective because of the inherent time involved in writing the equations. Students process the various terms as they are being written, and that processing leads to a better understanding and appreciation of the equations, compared to what is possible in a normal slide presentation through presentation software, where the equation is usually presented as one piece. Nevertheless, the clarity in the writing of the terms on the board could depend on the instructor, whereas it is standard and acceptable in presentation software. These thoughts led to the development of a different presentation strategy for equations when presentation software are used, i.e. animation of individual terms, or small groups of terms in an equation, so that they appear sequentially at subsequent mouse-clicks. Such a presentation provides the learner student with the time for better processing. It also renders itself naturally, to a better explanation of the terms involved by the instructor.

5 AN IMPORTANT CONCERN

One of the important concerns that the author had to deal with, especially from the content administrators, is on the significance of the need to provide pre-determined pauses in the lecture, and thus take away the video time, when the viewer-students can pause the video themselves for whatever time they need. To understand the need for pre-determined pauses, one can consider the recent emphasis by Ragan [9] for on-line courses: the role of the instructor in on-line courses is actually more important than has been previously considered; the earlier consideration was erroneous, because of the impression that the on-line courses were supposed to be designed as self-instructed modules. To quote, `the students are looking to the instructor to serve as the guide, facilitator and "teacher" and the need for them to do so is pronounced because of the lack of face-to-face interactions' [9]. More importantly, the viewer-student needs to understand the time needed for an average viewer-student, to decide how to pace his/her own learning, and these pre-determined times give reference points to the viewer-student for self-evaluation. If the viewer-student realizes that (s)he needs more time, then the video can be paused for a longer time than allotted; if less time is needed, then the viewer-student is better than the average, and (s)he can move to the end of the allotted time on the streaming video as soon as (s)he finishes the task.

6 FEEDBACK

At the time of this writing, the video lectures for the NPTEL course on Thermodynamics (Classical) for Biological Systems, had been available on the web for about 6 days. The lectures have been reasonably popular going by 1500+ views for a single lecture on Open Systems (lecture no. 9), and the other available lectures getting views of a few hundreds. The user comments thus far have been positive – in fact, no negative comment has been recorded, thus far. One perceptive viewer-student appreciated the time given during the lectures for working out the problems, with the solutions being presented at the end of that time. The comments from viewers who were not engineers that they were able to easily follow the lectures, was indeed heartening.

Since this is a video course that is available to unregistered users, especially through social media, it becomes difficult to know whom to send the feedback questionnaire. Thus, requests for feedback were made in the relevant view-pages, and the available feedback is presented.

7 CONCLUSIONS

Active learning techniques were incorporated into video lectures, for use in distance learning.

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104 A NOVEL APPROACH TO INTRODUCE RESEARCH IN UNDERGRADUATE ENGINEERING CURRICULUM

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ABSTRACT

The Department of Electrical and Computer Engineering undergraduate curriculum has design components that involve minimal research. Our approach here is to introduce research to suture graduate students in engineering. The faculty selects students based on their academic capabilities and interest in graduate studies to do research. The department is a member of the Engineering Research Center group based in Reseller Polytechnic Institute in Troy, New York. We present here the smart lighting acoustic characterization of power emitting diodes (LEDs) as a case study for the students.

Light emitting diodes (LEDs) are increasingly replacing fluorescent and incandescent lamps (electrically inefficient devices) as ordinary light sources. They already appear in several applications such as automobile illumination. They are more efficient than fluorescent and incandescent lamps. LEDs operate at low dc voltages and take less current (about 20 volts dc and 1.5 Amps compared with conventional light sources that operate at 110 volts, 60 hertz ac, ac and around one (1) amp or more). They are becoming very important in daily use especially at this time of the word's dwindling energy sources. Their luminance depends on high frequency rectangular pulses that can be associated with temperature rise and noise that need to be minimized. This is a case study performed by research undergraduate engineering students' trainees in preparation for graduate studies.

Keywords: undergraduate, research, smart, lighting, acoustic, diodes, thermal

1 INTRODUCTION

The progress or success of any nation depends on continuous research. For many decades the US has continued to enjoy the global leadership role in developing and implementing cutting edge research [1] in universities and other agencies. However, there are few underrepresented groups researchers. A diverse population of scientist and engineers is necessary to meet the world's competitive environment in technology and research. Presently, very low percentage of underrepresented groups participate in research. According to the US census bureau underrepresented groups will make about 48% of the workface by the year 2050 as opposed to 26% in 1995. There is always need more for science, technology, engineering and technology (STEM) workforce. At the moment STEM labor force are mostly white. However, there is a talented underrepresented group that needs to be tapped and trained for research. Advanced research provides significant innovative approach and overall impact to the progress of a nation.

The main funding sources for research include the National Science Foundation (NSF) and other federal government agencies such as Department of Defense (DOE).

This paper discusses how undergraduate students are introduced to how to research in an innovative way under the guidance of the engineering faculty especially during the summer months of May through August. They learn about the overall impact of research to society, significance and research methods. They are introduced to mathematical formulations, algorithms, simulation, the level of details needed for the research, clarity, and hands on approach. They are introduced to such diverse areas in research including communications such as proposal writing, report writing, teamwork, oral presentations (power point preparations, posters preparations and the importance of showing a reader interpretation of data. They also learn about the specific aims of a research topic and the significance of the research approach.

2 UNDERGRADUATE RESEARCH ENGINEER RATIONAL

The engineering community in the US is trying several approaches of introducing undergraduate students to cutting edge research and also to motivate them become future researchers and educators. [2]. Howard University, located in the nation's capital, Washington DC, is one of the Historically Black Universities and Colleges (HBCUS) that offer advanced degrees including doctoral (PhDs) in electrical and computer engineering. Howard has a leadership role in the US and to the global community. There are several advanced research centers on campus including an energy based and material science research centers with concentrations of research presently in electric power smart grid and nanotechnology. The mission of Howard University includes reassert and teaching contribution the global community. Even though, the department of Electrical and Computer Engineering recruits graduate students every year, the intake is not enough to fill graduate studies positions. Our aim is to introduce undergraduate students to reassert techniques and also to motivate them to pursue graduate studies up to the doctoral levels. We recruit a handful of the top students for summer research under the leadership of the faculty and work alongside with graduate students. They go through lecture, seminars, reassert methodologies, communications and technical writing and how to write technical papers for scientific journal.

Ability for undergraduate engineering students to perform research will also improve their employability skills in industry. According to [6] employability of a graduate is includes communication skills, ability to function in a team, integrity, and intellectual ability. The graduates must be able to apply theory to real problems posed by industry customers. They must have understanding of theory, be creative and innovative. They must have ability to perform experiment and interpret data according to Accreditation Board for Engineering and Technology (ABET) assessment of courses requirements. They must possess life-long learning including technical breath. Business skills will be helpful. Our students are required to take a course in economics. It is important that our trained engineering graduates with research skills will be competitive and meet industry and academia research needs. Further more they will advance to graduate studies up to the PhD level. Besides, design requirements in our curriculum, we introduce research in the curriculum. And of course, a researcher must have computational and experimental skills for verification of theory and hardware.

A research in Light Emitting Diodes (LEDs) is presented as a case study of research done by selected undergraduate trainee students at Howard University last summer.

3 CASE STUDY: LIGHT EMITTING DIODES

We present here as a case study of research done recently by the selected students last year summer. The results show preliminary studies of the LEDs.

3.1 Abstract

Light emitting diodes (LEDs) are quickly replacing fluorescent and incandescent lamps that are electrically inefficient devices as ordinary light sources. LEDs appear in several applications such as automobile illumination. They are more efficient than fluorescent and incandescent lamps. LEDs operate at low dc voltages and take less current (about 20 volts dc and 1.5 Amps compared with conventional light sources that operate at 110 volts, 60 hertz ac, ac and around one amp or more. They are becoming very important in daily use (to save electric energy consumption) especially at this time of the word's dwindling energy sources. Their luminance depends on application high frequency rectangular pulses that can be associated with temperature rise and noise that need to be minimized.

3.2 Introduction LEDs Characterization

Power light emitting diodes (LEDs) packages are very important solid state lighting. It is well known that LEDs can get very hot during operation, so thermal management of the LED systems are important part of reliability of LED smart lighting system design. A critical thermal bottleneck in an LED package is the connection between thermal pad and the LED chip, where thermal interface material is typically filled with epoxy or gold eutectic solder. When an LED is operated in rectangular pulsed mode, the junction of the LED chip can reach thermal equilibrium very quickly, and if the pulse is fast enough, thermal expansion of the LED chip can be detected acoustically. We propose the acoustic signal (measured outside of the LED package) can contain important information regarding its thermal performance and the quality of the package manufacturing process using a simple testing acoustic process including rise and all times of the pulses. We use NMOS as a switch [3, 4]

3.3 LEDs Characterization Preliminary Studies

The objectives of these prelim studies of pulsed LEDs are to determine the characteristics of various electronic LEDs under pulsed conditions using variable pursuits. WE obtain the rise and fall times of the pulses. NMOS transistor is used as the switching device.

The actual testing will consist of puke generator in amps range, power MOSFETs and power LEDs of various types (in the amperage range). We will obtain the acoustic signatures and temperature distribution of each LED under various pulse-widths with rise and fall times.

This research is a component of ongoing research at Rensselaer Polytechnic Institute (RPI) where Howard University is component of the outreach schools of the Smart Lighting (Engineering Research Center) program.

3.4 Experiment

The experiment set up is shown in Figure 1. An NMOs transistor is used as an electronic switch to generate rectangular pulses to control the operation of the LED..

The test circuit was set up as shown in Figure 1. A digital oscilloscope was used to observe the voltage across the LED (VDS).

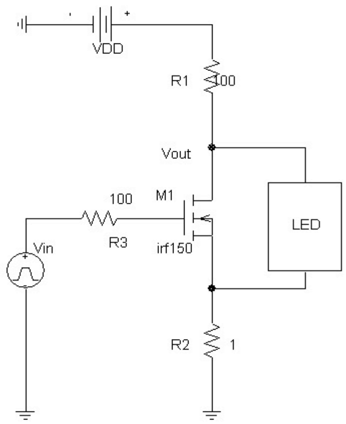

FIGURE 1. *Pulsed LED test circuit diagram.*

The MOFET dc voltage supply V_{DD} is set to 6.0 Vp. And the gate drive pulse voltage V_{IN} is set to 2.5 Vpp at 1 kHz. Figure 2 displays the resulting voltage waveform of the LED.

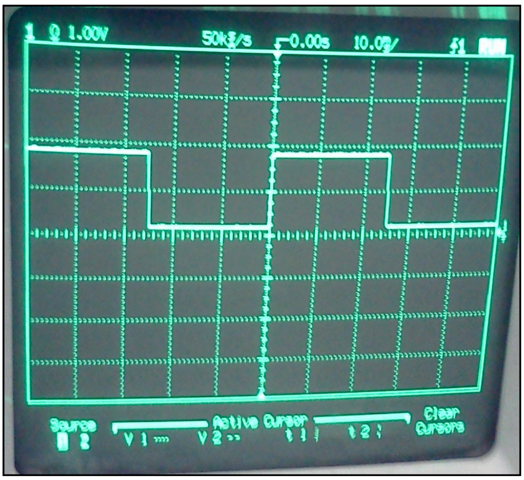

FIGURE 2. *LED Voltage Waveform.*

The frequency of V_{IN} is then varied and the following results are obtained as shown in Table 1.

TABLE 1.3 *Effect of Input Frequency on Output Voltage.*

f_{IN} (Hz)	V_{OUT} (volts)	
	Vpp	Vrms
10	0.6875	1.531
50	0.6875	1.532
1000	0.6875	1.532
5000	0.6406	1.532

As can be seen, the output voltage does not change much despite the change in frequency. Next, V_{IN} is set to 10 kHz and its amplitude is varied to see the effect on V_{OUT}. The following table displays the results. A graph of these measurements is shown in Figure 3.

TABLE 2. *Effect of Input Amplitude on Output Voltage.*

Vin	Vpp	Vrms
5.0	1.7660	1.285
4.0	1.7030	1.282
3.0	1.6250	1.290
2.9	1.5940	1.285
2.8	1.5310	1.285
2.7	1.4370	1.285
2.6	1.2500	1.285
2.5	0.8750	1.285
2.4	0.3125	1.285
2.3	0.1406	1.285

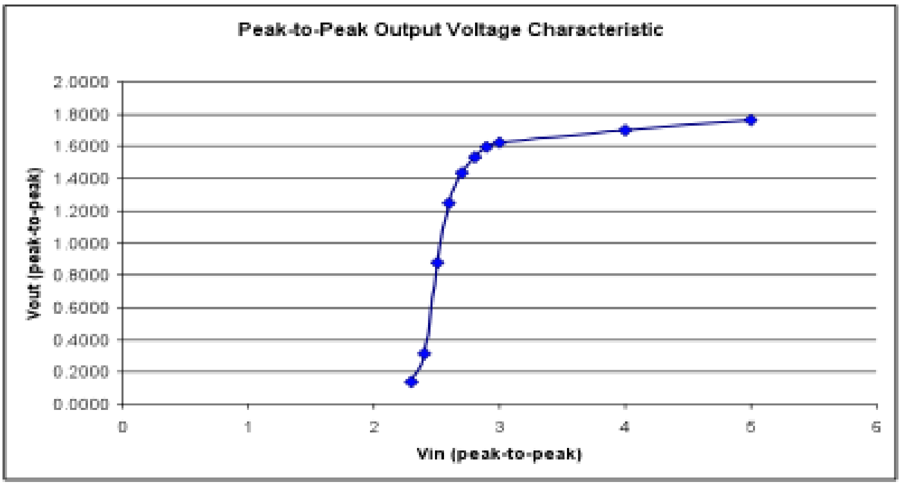

FIGURE 3. *Graph of Output Voltage as Input Amplitude is Changed.*

The LED peak-to-peak voltage changes very rapidly as the input voltage amplitude varies between 2.0 and 3.0 V. The DC component of the waveform remained unchanged, however. At 1.9 V, the LED switching characteristic was virtually non-existent.

Finally the rise time of the waveform was measured. Figure 4 displays the oscilloscope measurements. The rise time measured is 22.00 ns.

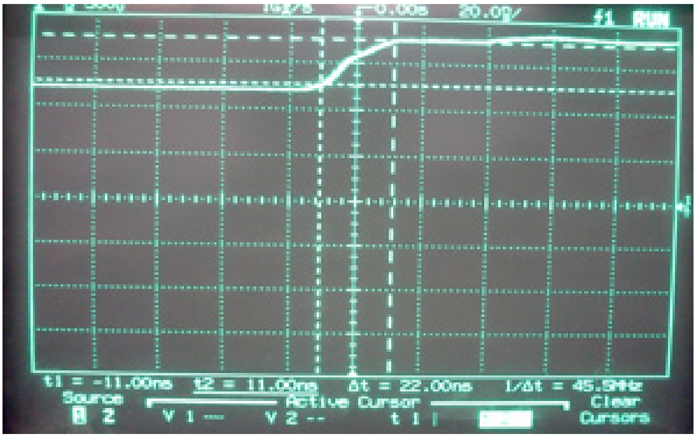

FIGURE 4. *Measurement of Rise Time.*

3.5 Conclusion and Future work

As can be seen from the above studies, we obtain good results for operating the MOFET at several frequencies to optimize illumination while minimizing losses.

Actual tests will involve high current pulse generator, power MOSFETs, various power LEDs to observe acoustic signatures characteristics and temperature distributions

FIGURE 5. *Nanotechnology Center, Undergraduate research trainees briefing by a professor.*

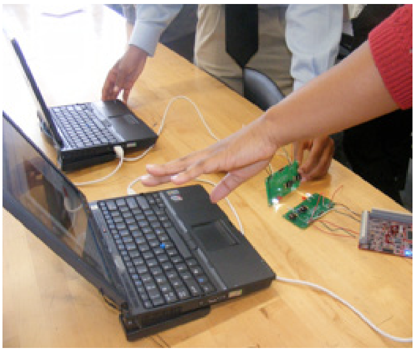

FIGURE 6. *Smart Lighting Research, Undergraduate trainees research demonstration.*

Figures 5 and 5 show research facilities and activities in the Department of Electrical and Computer Engineering that involve undergraduate reaserch engineers trainees.

4 CONCLUSION

Our approach is to introduce undergraduate students to research in the curriculum during summer and research trainees. The students are motivated to work under the supervision of the faculty and being able to brainstorm with graduate students. We are very positive this research approach will attract these young minds to pursue graduate studies and make a contribution to engineering research and cutting edge technology and education profession and sustain the environment.

5 ACKNOWLEDGEMENTS

We thank students and staff for their contribution in the LEDs preliminary research. We also like to thank the Smart Lighting research group of Rensaler Polytechnic Institute (RPI) for their support of the research.

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106 DESIGN OF A PICAVET SYSTEM THAT SUPPORTS A REMOTELY CONTROLLED PAN AND TILT DIGITAL CAMERA EQUIPMENT

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ABSTRACT

This paper introduces the reader to a freshman engineering design project where students were required to design a picavet system that supports a remotely controlled pan and tilt digital camera equipment that can be used for aerial imaging projects. Students utilized planning and teamwork concepts to complete the client's project with fixed time and budget constraints. This project provides a meaningful medium to educate freshman engineering students on both concept and teamwork principles. The unique nature of the assignment lies in the need for the concept to be low cost and practical. Team leadership styles were evaluated and compared against design outcomes. This paper examines both the engineering aspect of the students' learning as well as their leadership growth and interaction between group members as well as the interaction with the client. With students from various engineering backgrounds involved in the course, this paper also provides the audience the ability to examine the applicability of this approach to other subject areas.

Keywords: Freshman Engineering Design, remote sensing, Multi-disciplinary teams.

1 INTRODUCTION

One of the issues confronting learning environments is the ability to integrate diversity of approach both in teaching and learning modalities. With the freshman engineering course we have attempted to use the diverse faculty in the department which has both engineering and aviation sciences programs to structure projects related in some ways to both programs. This is done to advance engineering principles as well as proof of concept, as the case may be in its application to the aviation program.

The benefit for students is that they are able to engage the faculty both as clients and instructors that result in a variety of learning modes. For this project, the class was kept as a whole with one defined project leader who oversaw several project teams. Engineering design concepts with emphasis on various aspects of planning, developing and product design via hands-on approach was the key to this course experience. It also enhanced the students' communication skills and teamwork. Product visualization utilizing computer software such as word processing, power point, and spread sheet enhanced the students' ability to collaborate in defining, developing, and designing a working prototype. Students learned the components of product development such as brainstorming, time allocation, project management, alternative designs, and cost constraints.

Students engaged in team work in a multidisciplinary team environment such that the reality of cooperation in a global economy became a lesson realized early in their freshman engineering year in college. With a dynamic market place, graduates need to be able to interact effectively in diverse fields. One important goal of multidisciplinary design is to identify the many solutions needed to solve a single problem while keeping in mind the many differing objectives of the overall project. A multidisciplinary approach to engineering design is valuable in that it asks that students make certain that they receive experience in solving problems with diverse technologies1. Students partaking in the engineering exercise are forced to confront concepts outside of their normal field of expertise in the short span of a semester and make decisions on a cost and design schedule.

ENGE 150 is a freshman engineering design course that is a core course requirement for all students enrolled in the Engineering program at UMES. Students in the Spring 2011 Engineering Design course were given a written design problem statement and presentations by two of the Aviation Sciences faculty in their Department. Students were asked to design and build a deployable parachute system for a model aircraft. The initial meeting included a question and answer period where student could ask key design questions to the faculty members playing the customer role. This session is initiated only when the class has fully researched the project by reviewing previous work done in the subject area. It is intended to provide students with a knowledge-base from which an intelligent discussion about the project can begin. Their interaction with the client at this stage is also viewed as a process of fine tuning their communication skills. Throughout the course, students studied the design process which included key concepts such as team design, understanding the client's needs; functions and design specifications; generating design ideas; connecting design concepts to engineering objectives; outcome reporting; oral presentation skills and final report elements.

The freshman engineering design student body met regularly with aviation faculty to clarify outcome criterion and design direction. The course instructor finds that this type of bidirectional communication provides the clients the opportunity to gain an enhanced perspective which further aides them at the end of the semester during the project evaluation stage. Students routinely adjusted timelines and reported to the faculty and clients any unforeseen difficulties. Formal reports were logged and submitted to the instructor to be later summarized in a final report and presentation for the client.

In addition to the final written report, students are assessed for their ability to complete the following outcomes: 1) applying knowledge of math, science and engineering; 2) design, construct experiments and, study and interpret data; 3) design a system that meets the client's needs; 4) identify, formulate and solve engineering problems; 5) communicate effectively within the group and to the client; 6) utilize knowledge of contemporary issues; and 7) utilize techniques, skills and modern engineering practices. The class project was evaluated by the instructor with input from the faculty clients utilizing assessment of weekly reports, final project product, project report and group presentation including a question and answer session.

Students were asked to design a picavet system that supports the client's new pan and tilt digital camera equipment. System must be able to be lifted by client provided kite system (figure 1). Previously designed system (figure 2) cannot house the new system due to size and freedom of movement issues.

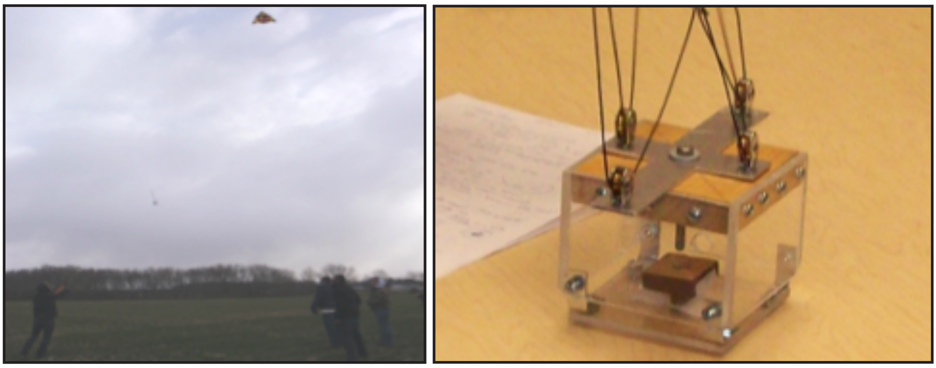

FIGURE 1. *Kite-based aerial imaging system with picavet design.*

Additionally, current system has a tendency to hang up the strings at the attachment points (pulleys) causing jerky movements that affect the camera's ability to take a clear image.

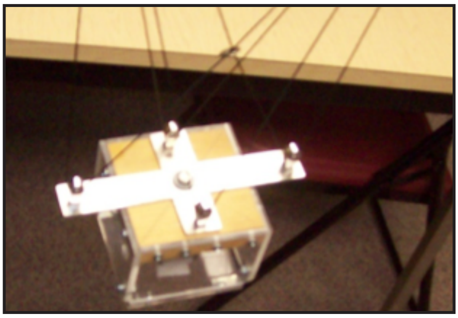

FIGURE 2. *Suspended picavet.*

2 PROJECT DETAILS

Students were comprised of freshman engineering majors in the Department of Engineering and Aviation Sciences from the University of Maryland Eastern Shore (UMES). UMES is a historically black university (HBCU) providing a rich and diverse project team. One team was comprised of the whole class due to the limiting size of participants. The sub-groups were self-selected by team members at the onset of the project.

Students felt comfortable with how well they managed their project. The group selected a leader from among the class who reportedly engaged everyone in the project through email, text messages, and scheduled meetings. All members reported being heavily involved in class discussions.

2.1 Cost Analysis & Materials

Students were able to purchase all materials for less than a total of twenty dollars ($20). Students purchased all their own supplies.

Students submitted the following material inventory to the client:

8 Crown bolts (hook screw); hook diameter 1 inch, length, 2 inches.
6 foot long string/line vinyl coating thicker then kite string.
1 Packet automotive grease.
4 Washers flat steel; inside diameter 1/2 inches; outside diameter 1 - 1/16 inches
4 Washers flat steel; inside diameter 1/4; outside diameter 5/8 inches
1 Small tube of gorilla glue
3 6x6x1 plywood

2.2 Time Utilization

Students reported spending most of their time in the planning/research phase and securing supplies for the final design build. Approximately a third of the time was spent in final construction and preparing for the final report.

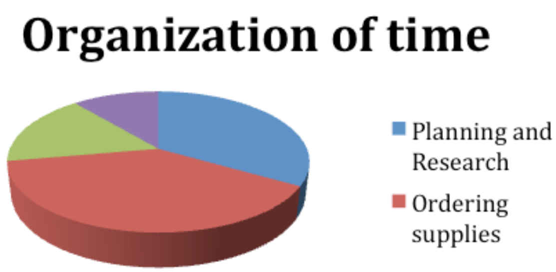

FIGURE 3. *Student time utilization.*

2.3 Picavet Design- Concept

The design team investigated different picavet systems other than the system developed by the previous freshman engineering design course. Knowing stability would be an issue for the camera system, they began by researching design concepts that incorporated a pendulum.

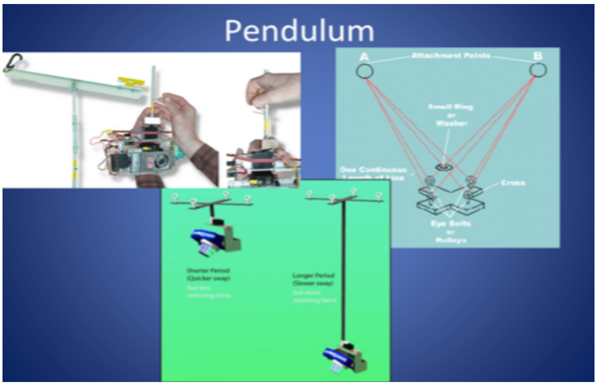

FIGURE 4. *Student presentation slide on pendulum picavet systems.*

Students reported to the client how they decided on their design…

> *On March first, we analyzed the different possible forms of the picavet I brought in. After analyzing the cross model, the X model, the T model, and the H model, we narrowed it down to the H model and the cross models because of their wide area of support of the base. But after [student] pointed out that the H model would be really uneven due to its form we decided to use the cross model. I then made a list of the items we would need and drew the design of what they would look like. [student] then proposed a method of combining the pendulum method with the picavet but the concept was brought down by [students] saying that it is complicated and would add more work for no reason. Also, that it would not change the fact that it would impair the balance of the camera. I then looked at [students] picavet and decided which qualities we should adopt for our own picavet, so together [students], and I decided on making a double sided picavet. March 3rd, 2011 I demonstrated to the rest of the group the uses of the double sided picavet and its concept on how it will filter out unwanted movement of the camera more efficiently.*

Students are assessed via weekly progress reports, a mid-term examination which measures team cohesiveness, two oral presentations; one following the mid-term exam and one at the end of the semester. Additionally, the client evaluates the students presentations and consults with the course instructor regarding the extent to which the expected objectives have been achieved.

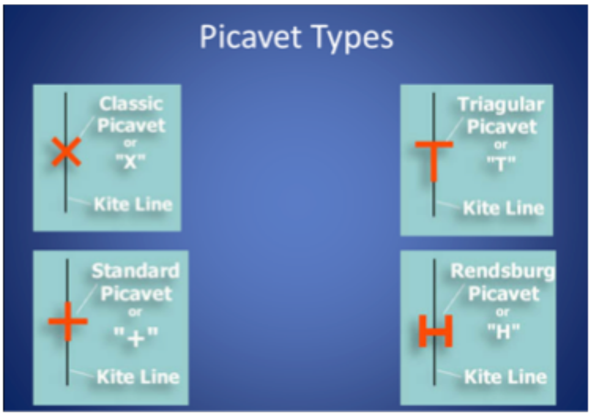

FIGURE 5. *Picavet types.*

2.4 Camera and Picavet integration

The device underwent many design changes including several preliminary test picavet designs created by individuals or spontaneously generated teams. These initial designs were refined, debated, tested and recreated many times before a final design was agreed upon. The inherent simplicity of the picavet lent itself to this process. This process allowed the students to become intimately familiar with the principles of picavet design. This further allowed the group responsible for designing the picavet to deliver a product within the short timeline that met the client's original design specifications.

FIGURE 7. *Final design demonstration.*

3 CONCLUSION

Students encountered some issues with group leadership early in the design phase. The student report indicates…

"[Team lead] suggested that we make a model of what we were trying to do, but the group declined and said that we should start building the final product and make changes as needed. I then instructed that we make a list of materials we will need in order to request them. [Team lead] and I also decided to try 3 different picavets, because due to our researched we found out that wide picavets work more efficiently than normal picavets. We wanted to use this idea but were not sure how it would work on our double picavet. We concluded that we do not have enough time before the break to do much work so building will be after spring break but [other student participant] requested that the crosses be made out of wood."

Additionally, some students, specifically those on the team assigned to create the camera platform, complained that the picavet design team had the "easy job". This dissention within the group as a whole led to some divisions within the group. These divisions hampered the communication and cooperation that was to be essential to seamless integration of the two designs. As a result, the integration of the picavet with the camera platform was somewhat of an afterthought. Although the students met the client's design specifications for the project, the overall performance would have been enhanced by appointing a leader to handle the integration and effect communications between the teams.

A common difficulty students face in the design process is identifying materials needed and receiving them on time before the semester ends. After receiving all parts and materials, students reporting difficulty harnessing the double picavet together with the string they had ordered.

Another common difficulty for students presents itself during the build phase of the project when specialized skills with tools and fabrication may be required. Often, the student members of the teams do not possess these skills and rely on the client for advice and assistance with fabrication. During this project, however, several students possessed the woodworking skills necessary to fabricate the picavet and camera platform. This, too, was an advantage of a relatively simple design project.

This forms the building blocks for design courses such as the senior capstone design course. The lessons learned are transferrable as the students are prepared in the art of communication and project management.

4 ACKNOWLEDGEMENTS

We would like to than NASA for its support of the Chesapeake Information Based Aeronautics consortium (CIBAC) and for the assistance of Geoff Bland and Ted Miles from their NASA Wallop's Island, VA site.

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108 INTEGRATING HUMAN FACTORS RESEARCH INTO UNDERGRADUATE COURSEWORK IN AEROSPACE/AVIATION: A CASE STUDY IN PILOT COCKPIT DISTRACTION BY A PORTABLE ELECTRONIC DEVICE (PED)

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ABSTRACT

This paper introduces the reader to an upper level aviation psychology course design project in human factors in aviation psychology. Students were required to design a methodology to measure the effects of cockpit distractions on pilot performance. Student's utilized eye (gaze) tracking hardware and software to begin to study the general aviation pilot distraction phenomena introduced by emerging hand held devices known in the aviation industry as Portable Electronic Devices (PED). The aim of this study is was to introduce students to basic research methods and how to begin to ask questions about distraction in a novel setting. Initial findings on pilot distraction as well as the processes encountered by students in setting up the experiment will be discussed.

Keywords: Human Factors, undergraduate research, learning outcome measurement.

1 INTRODUCTION

One of the issues confronting learning environments is the ability to integrate diversity of approach both in teaching and learning modalities. The aviation program at the University of Maryland Eastern Shore has been routinely collaborating with the engineering program within the same department on freshman engineering design projects, serving as the aerospace client and evaluating project objectives. Following that same model, aviation faculty introduced a similar hands-on research design component into its two human factors courses (Human Factors & Aviation Psychology). This paper addresses the progress made by the Aviation Psychology students during the fall semester. In collaboration with the freshman engineering courses, we have attempted to use the diverse faculty in the department which has both engineering and aviation sciences programs to structure projects related in some ways to both programs. This is done to advance engineering principles common with aviation learning outcomes. Additionally, it has served in identifying students that are academically equipped to participate in faculty led research outside of the classroom. Aviation faculty have been able to utilize engineering design concepts in the classroom with emphasis on various aspects of planning, developing and product design via a hands-on approach. Similarly, student research projects accomplished throughout the academic semester affords the opportunity to practice and refine communication and teamwork skills. Students learned the components of concept development such as brainstorming, time allocation, project management, alternative designs, and cost constraints.

1.1 Collaboration across disciplines

The Aviation Science program within the Department of Engineering & Aviation Sciences at the University of Maryland Eastern Shore is comprised on four concentrations: Aviation Management, Computer Science, Electronics and Professional Pilots. In the Aviation Psychology course, students engaged in team work in a multidisciplinary (diverse academic concentration) team environment promoting scientific inquiry into areas of the aviation/aerospace system which they interact. The National Airspace System (NAS) in the United States is a diverse field requiring critical thinking skills and the ability to solve complex problems with complex and diverse solutions. This course exercise provided the framework for students to begin the initial steps of problem solving in a group setting.

1.2 Applied science to aviation/aerospace

Aviation Accreditation Board International (AABI) is the accrediting agency for aviation/aerospace degree granting institutions. AABI outcomes share similar educational outcome measures with the Accreditation Board for Engineering & Technology (ABET). AABI outcome measure (a) requires students demonstrate their ability to apply science to aviation related disciplines and (g) asses contemporary issues. Additionally, students should be assessed for their ability to utilize modern technology (outcome h) and apply that knowledge to identifying and solving problems (outcome j).

An objective of the in class exercise was to apply concepts learned in the curriculum to a real world contemporary problem and outline how to solve the problem.

1.3 Course Design and student motivation

Aviation Psychology is an integrative field within human factors studies in the aerospace industry involving knowledge of just about all areas in psychology, including perception and attention, cognition, physiological, experimental, organizational, clinical, and educational settings. As a course requirement (design project comprised of a third of their overall grade), students were required to select a problem in the industry and:

- Determine the latest research on human performance problems and opportunities within aviation systems.
- Envision design solutions that best utilize human capabilities for creating safe and efficient aviation systems.

1.4 Initial Design Requirements

Students were asked to identify a novel problem in general aviation relevant to the field of aviation psychology. Aviation psychologist focus on cognitive behaviours of users in complex systems that interact with the NAS. Workload management and mitigation strategies are key. Students were to design the initial study and pilot the system internally before submitting approval for a full-scale study to take place in the future. Faculty embraced the free exploratory discovery strategy utilized by instructional designers [1] where broad goals are established and the learners are free to determine what method they will select to achieve the desired learning outcomes.

2 ENHANCING SCIENTIFIC INQUIRY

Students were comprised of eight (8) upperclassman aviation/aerospace majors in the Department of Engineering and Aviation Sciences from the University of Maryland Eastern Shore (UMES). UMES is a historically black college/university (HBCU) providing a rich and diverse project team.

Since the class size was small and manageable, the students worked as one team. Leadership was shared with all students taking on the leadership role as necessary and in a specific area of interest. Students utilized consultation with the Aviation and Engineering faculty primarily in the equipment operation and data collection stages.

Within the classroom setting, students utilized the existing Precision Flight Control Advanced Aircraft Training Device (AATD or Simulator) as the environment and measured student gaze and object interest area with an Applied Science Laboratories (ASL) Mobile Eye Tracker. The initial metrics presented were produced by the tracking device's internal data analysis software.

Students spent the first half of the semester identifying the problem of distracted flying, defining what distracted flying is in the context of general aviation, constructing the problem statement and conducting a literature review on the topic. Based on the class findings, the students prepared the next steps for building a future experiment for the next semester.

3 STUDENT LITERATURE REVIEW

Today, drivers are faced with many in-vehicle activities that are potentially distracting. Data on police-reported crashes in the United States suggest that driver distraction and inattention is a factor in upwards of 55% traffic crashes [2]. Recent studies have indicated that drivers have slowed responses to sudden external events and frequently miss important traffic elements [3]. Moreover, there is growing evidence that operators may not be fully aware of distracting effects of in-vehicle tasks on their own performance. Operators engaged in a secondary tasks, may employ adaptive behaviour in the navigation task to compensate for the additional demand on mental resources. That is, they will try to increase their safety margin. Adaptive behaviours may also be evidenced by strategic decisions to postpone or delay certain operator tasks within a given trip, based on the knowledge of the route as well as expected challenges and difficulties they normally face [4].

Vehicle operators are not passive recipients of these tasks; rather they decide whether or not (or how) to perform them. A study of drivers [2] determined that, given knowledge of the upcoming road demands, people will strategically delay performing certain activities until demands were reduced. Twenty drivers drove an instrumented van around a closed track that was divided into sections of varying demands and difficulty. Drivers were asked to perform one of four in-vehicle tasks (phone conversation, read a text message, find an address, or pick up an object off the floor); however, they were free to choose when to initiate these tasks, provided they finish them before a given deadline. Although drivers were fully aware of the relative demands of the road, they did not tend to strategically postpone tasks. Rather, drivers tended to initiate tasks regardless of the current driving conditions. This strategy led to many driving errors. On average, drivers made one error every five times they performed a task, indicating that secondary task performance negatively impacted driving performance.

The limitation with this study was that it was conducted on a closed track environment that is unlikely to result in crashes, injuries, or fatalities. Drivers may have been less fearful of the negative consequences of performance failures or driving errors. As such, they may be willing to take on greater perceived risk than they would in the real world.

Concerns over driver distractions are growing, as more and more technologies are embedded into automobiles or brought in as portable devices. New technology, and the distractions they pose, is affecting all forms of transportation. Many states across the United States have followed the Guidance of the US Department of Transportation Secretary, Ray LaHood, and imposed laws against the operation of PEDs while operating vehicles on the highway. This phenomenon is not limited to the road. Distractions in the cockpit among general, corporate and commercial aviation operators are an ever-growing concern in the aviation industry as more and more technology is being implemented and used by pilots.

In April, 2010 the Federal Aviation Administration (FAA), under the United States Department of Transportation (DOT), issued an Information for Operators (InFO) covering the subject of cockpit distractions. The purpose of the InFO was to better understand the safety risks associated with the use of PEDs during flight operations [5].

Despite lawmakers and federal regulators calling for a ban on laptops and certain other PEDs in airline cockpits just two years ago, the FAA has recently approved a charter company called Executive Jet Management to use Apple iPads © as a replacement for paper charts [6]. The iPad © can achieve this status thanks to a new map application (app) developed by aviation chart-maker Jeppesen. While airlines and pilots are rejoicing about the iPad's © potential, NASA aviation researcher [7] stated that continued use of automation in aircraft increases the likelihood of distraction. The iPads © will certainly save weight but the question still remains as to whether its other features, such as internet capabilities, will cause distractions in the cockpit as in the 2009 case of Northwest Airlines Flight 188, an A320 enroute to Minneapolis-St Paul International/Wold-Chamberlain Airport. According to an FAA InFO [5] bulletin, the two pilots were distracted by their laptops.

Aeronautical Decision Making (ADM) is defined by the FAA as a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances [8].

Between 1970 and 1974, Jensen and Benel [9] reported that 51.6% of fatal general aviation accidents were associated with decisional errors. The FAA tried to address these early findings by introducing training directed at improving the decision making of various pilot groups. While FAA regulations do require decision making to be taught during pilot training, there is little guidance as to how this could be accomplished and there is no suggestion of how decision making could be measured except for that of actually observing a pilot while in flight [8].

In 1987, six manuals were published by the FAA concerning the decision making needs of variously rated pilots. Six independent studies were done to test the validity of the implementation of these materials into pilot training and the results were significant. It was found that pilots who received ADM training made 10-50% fewer in-flight errors than those who did not receive the training [10].

With so much more at stake in ADM compared to conventional decision making, a key portion of ADM must always be an awareness of the importance of attitudes in the decision making, a learned ability to search for and establish the relevance of all information, and the motivation to choose and execute the actions which assure safety in a timeframe permitted by the situation [10].

We often time assume that increased automated resources should contribute positively to the ADM process. We need to carefully weigh the impact automation has in the critical decisions we make in the cockpit. New technology that is deemed by pilots as providing increased levels of safety often affect their decision making and influence their level of vigilance. This concept is commonly referred to as risk compensation [11].

With computer automated systems increasingly being utilized in aircraft cockpits a major concern must be whether or not these systems are a benefit to pilots and flight crews or if they are a distraction. While accident records show that more advanced aircraft generally have lower accident rates than their less automated counterparts, pilots do tend to make more errors of omission and commission more frequently in aircraft equipped with more automation [12].

Since citizens are prone to obeying authoritarian figures, it has been hypothesized that pilots and flight crew automatically react to computer automated systems (that are designed to prevent human errors) as smarter than and more authoritative than their users [4].

Along this same line, research has identified that people are less productive when working collectively with partners [4]. Since computers share task responsibilities with pilots, the computer can be mistaken for a team-member and the pilot thus expends less cognitive effort.

A study was conducted [4] where researchers reviewed 960 source documents ranging from papers to incident reports and even their own documentations. After reviewing the documents they found several commonalities among flight deck automation concerns and two particularly noteworthy ones were that (1) pilots may not understand the structure and function of automation or the interaction of automation devices well enough to safely perform their duties, and (2) the attention demands of pilot-automation interaction may significantly interfere with performance of safety-critical tasks.

After further consideration of the results, the researchers [4] determined that, "there is strong evidence and agreement that automation can and often does draw pilot attention away from safety-critical flight control tasks" (Pg. 3). However, they did not find a strong link between automation strongly increasing workload. Subsequently, the same researchers conducted another study of 420 Aviation Safety Reporting System (ASRS) incident reports (210 reports filed by pilots flying advanced technology aircraft and 210 reports filed by pilots in traditional technology aircraft). They concluded that the statistical difference in the types of reports filed was significant enough to suggest that task management may be more difficult in advanced technology aircraft [7].

4 STUDENT PROPOSED DESIGN

The students proposed using the ASL Mobile Eye Mapper in the flight simulator to measure the amount of gaze distraction on a pilot due to interruption by a PED while performing a normal operation on an airport such as taxiing to the active runway and returning to the starting point.

The students will measure the percentage of in and out of cockpit time for the exercise without distractions (control group). The experimental group will be instructed to respond to a text message request during the exercise.

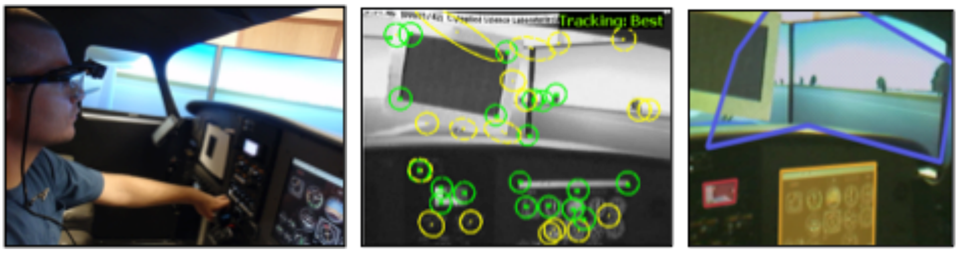

FIGURE 1. *Experimental set-up with cockpit mapping.*

Inside cockpit and outside cockpit measurements will be recorded by student's defining the areas of interest and mapping the cockpit interior.

5 CONCLUSION: KNOWLEDGE GAINED, CHALLENGES AND NEXT STEPS

Students were able to apply concepts as primary/secondary task measurements, mental workload and situational awareness concepts found in the text readings [13]. Students preferred the hands on application to traditional readings.

A common difficulty students faced was in the calibration of the ASL mapping. High contrast is needed to properly define the areas of interest. Students will be adding a drape to cover the top of the monitors and aircraft cockpit. Additionally, screen display settings were modified.

The students will have the opportunity to compile the necessary paperwork to request the campus Institutional Review Board (IRB) to review their design, consent form, and training on the protection of human subjects. With approval, the students will begin a small pilot study utilizing students in the professional pilot program.

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110 METACOGNITIVE KNOWING AND SOLVING PROBLEM: CASE STUDY ON SOLVING-PROBLEM IN ENGINEERING THERMODYNAMICS

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ABSTRACT

The learning in a structured educational setting may be thought of as a two-step process involving the reception and the processing of information. An objective of engineering education should be to help students build their skills in both their preferred and less preferred modes of learning. Metacognition allows the student to be aware of what, why and how to know. This paper presents a case study of structuring and solving an Engineering Thermodynamics problem in the second year of an Electronic Engineering graduate program at the University of Burgos during 2011/12. An energy analysis of a coupled steam turbine-air compressor problem is posed to students at the beginning of the module. Small groups of students work on a cooperative learning project for fourteen weeks, while the teacher act as the coach and the facilitator of knowledge acquisition. A metacognitive, problem-solving approach has been developed to help the teacher and the students to face up the learning of thermodynamic principles and fluid behaviour. Results could be helpful for interested readers in any other engineering topic.

Keywords: Metacognition, thermodynamics learning, problem-solving in engineering.

1 INTRODUCTION

Metacognition is one key of successful learning. Learning in a structured educational setting may be thought of as a two-step process involving the reception and the processing of information. An objective of engineering education should be to help students build their skills in both their preferred and less preferred modes of learning. Metacognition activity allows the student to be aware of what, why and how to know [2]. Along this process we can differentiate two aspects. First, the self-knowing of the process itself [1]. Second, the capacity to self-regulate the process [3]. Nowadays these processes are especially relevant in Higher Education, as well as the relation between the competences of Know-What (declarative knowledge) and Know-How (procedural knowledge), respectively. The recent metacognitive research points out that some students can be aware of their metacognitive skills but they do not know to use them in the learning context [4]. From this point of view the learning is a dynamic process and it involves the planning and assessment of the performances (Self-regulation) [5]. Therefore, the design of the teacher in the presentation of the student-solving tasks is essential to obtain good results by the students.

Many of the last research on learning in engineering curricula are centred on laboratory work or on the problem solving processes. To get the success with the students, it is very important that the teacher should be enough trained on problem-solving processes, which means a study of the most effective problem-solving methodologies in typical engineering problems. This approach has shown to be most effective when working in small groups of students [6-8].

This paper presents a case study of structuring and solving an Engineering Thermodynamics problem in the second year of an Electronic Engineering graduate program at the University of Burgos during 2011/12. An energy analysis of a coupled steam turbine-air compressor problem is posed to students at the beginning of the module. Small groups of students work on a cooperative learning project for fourteen weeks, while the teacher act as the coach and the facilitator of knowledge acquisition. A metacognitive, problem-solving approach has been developed to help the teacher and the students to face up the learning of thermodynamic principles and fluid behaviour.

2 PROBLEM-SOLVING APPROACH IN ENGINEERING EDUCATION

Some of the mistakes done by engineering students during the problem-solving process can be first related with the lack of previous knowledge needed to solve this kind of problems [8]. Secondly, they can be also due to the lack of operative knowledge (problem analysis, planning, etc.) [9-11]. Thus, it should be relevant that the teacher should be aware of the previous knowledge of his students and should work on the acquisition of problem-solving skills [12]:

a) To study the problem to solve (To read and analyze).
b) To be aware of the relation between the problem and the previous knowledge needed to solve it in a successful way (To explore).
c) To prepare the plan (To plan).
d) To carry out the plan (To develop).
e) To check the answers (To verify the plan).
f) To assess the results of the solving-problem process (To assess both the results and the process itself).

One of the methodologies pointed out as very effective to develop this approach to learning consists in the use of self-questions that lead to the construction of learning. In this environment, the teacher should present tasks that allow the students several solution options. Moreover, the teacher should give the students appropriate help and feedback about the tasks [13]. It seems to be that students that work in this way use less try & error approach, less time to solve the problem and develop a higher degree of learning mechanisms [12]. Then, the teacher that works with small groups at seminars or laboratory, before presenting the problem to students, should think over the following aspects:

1. The way to present the elements of the problem.
2. The definition of the aims of the problem.
3. How to allow that the problem could be solved in more than one way.
4. How to guide the students to get right solutions when the students produce errors. (Error analysis).

5. How to promote the students to propose their own judgments over the problem, and to defend their understanding.

In addition, to help the students in improving the problem-solving skill, the teacher should use presentations with some clear steps:

1. Ability to differentiate between observation and explanation.
2. Ability to differentiate between explanation and prediction.
3. Ability to differentiate between observation and experimental tasks.
4. Ability to differentiate between experimental tasks and prediction.
5. Ability to develop hypotheses and deductive thinking.

In order to assess these abilities, the protocols of Think-aloud and metacognitive questions can be used [14-15]. These protocols will allow the teacher:

a) To analyze some aspects of knowledge learning: tasks partition, learning strategies.
b) To compare the quality of the alternative solutions.
c) To assess the evolution of the processes.

In summary, the analysis of the problem-solving processes requires not only that the students acquire the needed conceptual learning referred to the particular problem, but also the relevant procedural abilities (planning and evaluation). It should be considered that the way the teacher presents the problem is a key factor for the successful learning. Besides, the students should check the solution and the alternative options, and argue their election, identifying the concepts not understood.

3 CASE STUDY ON ENGINEERING THERMODYNAMICS

A structured problem based learning strategy was used in the study module 'Engineering Thermodynamics' during the 2011/2012 academic year. The subject is part of the third semester year of an eight-semester undergraduate program leading to a degree in Electronics and Control Engineering at the Higher Polytechnic School of the University of Burgos (Spain), as shown in Table 1. The set of first to fourth semesters are devoted to basic engineering sciences, and they are the same in any of the engineering degrees related to industry concerns (mechanics, electronics, control, industrial management, etc.) at the University of Burgos. The aim is to give deep foundations in basic engineering sciences to allow the engineer to adapt to changing roles along his working life.

TABLE 1. *Electronics and Control Engineering Degree at the University of Burgos.*

First Year			
1st semester	**ECTS credits**	**2nd semester**	**ECTS credits**
Physics I	6	Physics II	6
Mathematics I	6	Mathematics III	6
Mathematics II	6	Chemistry	6
Technical Drawing	6	Materials Science	6
Computers I	6	Economics	6
Second Year			
3rd semester	**ECTS credits**	**4th semester**	**ECTS credits**
Engineering Thermodynamics	6	Fluid Mechanics Engineering	6
Statistics	6	Electronics Fundamentals	6
Electrical Engineering Fundamentals	6	Mechanic	6
Production Management	6	Electrical Circuit Theory	6
Elasticity and Strength of Materials	6	Automation & Industrial Control	6
Third Year			
5th semester	**ECTS credits**	**6th semester**	**ECTS credits**
Electrical Machines	6	Power Electronics	6
Regulation & Control	6	Microprocessor Systems	6
Digital Electronics	6	Electronics Instrumentation	6
Analogical Electronics	6	Industrial Automation	6
Electronics Technology	6	Production and Manufacturing Systems	6
Fourth Year			
7th semester	**ECTS credits**	**8th semester**	**ECTS credits**
Computers II	6	Industrial Automation	6
Technical Projects	6	Industrial Robotics	6
Optional Module I	6	Final Project	18
Optional Module II	6		
Optional Module III	6		

The 'Engineering Thermodynamics' module was taught over a period of 14 weeks and involved four hours of timetable contact per week (2 classroom/theory hours, 2 seminar/laboratory hours), for a total workload of 6 ECTS credits. This compulsory module aims to impart a fundamental knowledge on Thermodynamics and Heat Transfer, with a special focus on energy analysis of basic heat and work fluid processes. Within the context of the undergraduate program, the subject is mainly related to (i) energy conversion devices (e.g., turbines, compressors, pumps, steam generators), and (ii) heat transfer issues (e.g., heat exchangers).

The problem proposed consists in the energy analysis of a coupled steam turbine-air compressor, following the scheme shown in Figure 1. The students were asked to carry out a parametric energy analysis of the installation in terms of fuel consumption, energy production and CO2 emissions, depending on certain range of pressure and temperature of fluids and on the isentropic efficiency of turbine and compressors. During the academic year 2011/2012, the study module is being taught using a structured problem based learning approach. A total of 48 students participate distributed in teams of four people. The students started working with very simple, clearly defined problems and gradually moved on to more complex ones. The early problems, here called tasks, were aimed at enabling students to gain some basic knowledge of the thermodynamics and heat transfer fundamentals as well as to give them some time to get to know each other in their teams. The students therefore attended the formal lectures as a single group and worked in teams during the seminar hours.

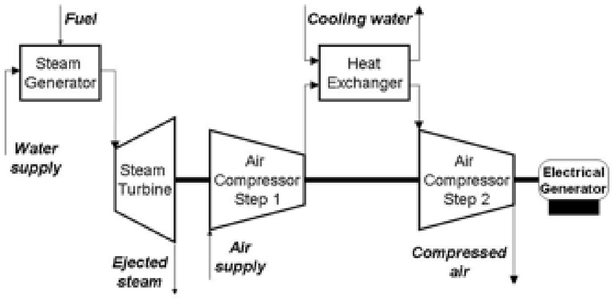

FIGURE 1. *Coupled steam turbine – air compressor.*

To help the teachers with the development and implementation of problem-solving skills amongst students, a metacognitive check list has been developed by the engineering teachers with the collaboration of staff from the Department of Educational Sciences. Table 2 presents the corresponding items. The table has been used by the teachers when planning the learning tasks of the students, in order to focus on metacognitive skills.

TABLE 2. *Teacher's check list of metacognitive items to promote problem-solving skill.*

Problem-solving skills in Engineering Thermodynamics	
A.- What is the aim of the problem?	1.- Which topic does the problem deal with? 2.- What previous knowledge have I on the topic? 3.- What additional knowledge do I need? 4.- Do I have any experience to solve this kind of problems?
B.- How can I solve it, which strategies should I use to initiate its solution?	1.- *Strategies of self-knowledge.* 2.- *Strategies of self-reflection.* 3.- *Strategies for planning.* 4.- *Methodology of resolution in Thermodynamics*: - To define the system (closed or open systems). - To define the limits of the system (walls). - Mass conservation Law. - First Law of Thermodynamics (energy) - Second Law of Thermodynamics (entropy). - To differentiate between transient and stationary systems. - To be aware of SI units. - To use the concepts of Work and Heat as energy transfers. - To be aware of the ideal gas equation of state. - To be aware of other equations of state, as well as databases to estimate thermodynamic properties of fluids. - Heat Transfer mechanisms (conduction, convection, radiation) - Energy analysis of combustion processes - CO_2 to energy conversion factors
C.- Resolution process.	*Analysis of the text* 1.- Is the system an open or closed system? 2.- Should I consider the transient or stationary state? 3.- Which types of energy are relevant in each device 4.- Which equations of state or databases should I use to estimate fluid properties?

4 RESULTS AND DISCUSSION

Student attitudes and perceptions to this learning approach were surveyed through an anonymous questionnaire of 5 items, shown in Table 3. Information was gathered by the presentation of statements to which students were invited to respond on five-point scale ranging from 'strongly agree' (5) to 'strongly disagree' (1). Although forty-eight students were involved in the subject, only thirty students completed the questionnaire.

TABLE 3. *Questionnaire relating to the student's attitude towards the problem-solving skills.*

Question No.	Statement	Average
Q1	I look for new information to solve the energy problems by myself	4.1
Q2	I look for new ways to solve the problems when I don't find the right solution at first	4.2
Q3	To solve a problem helps me to face up new challenges	4.4
Q4	I use planning strategies to solve the problem	3.7
Q5	I give myself instructions when I am trying to solve the problem	3.8

In relation with the results shown in Table 3, we can appreciate that students generally felt that the learning experience was relevant. Solving a problem as a way to solve new problems is recognised as the most valuable characteristic of the approach (Q3). The search for new information (Q1) and the exploration of new methods (Q2) are also very well valuated by the students. By contrast, the use of planning strategies (Q4) receives a valuation slightly over the scale average. The same occurs with the self-empowerment ability (Q5). The last two results mean that these skills have not been improved as much as the first set of Q1, Q2 and Q3. We consider that the acquisition of planning strategies and the self-empowerment ability probably require specific training, that can't be achieved by means of the common activities of a 6 ECTS subject.

Besides, from teacher's experience, another question that arises is that, for example, many students from electronics engineering see mechanical subjects (thermodynamics, fluid mechanics, strength of materials, etc.) as hard topics to study, because they feel them as topics far from the specific profile on electronics. And the opposite can be said of students from mechanical engineering with respect to electronic topics. This fact constitutes an additional barrier to effective learning. To overcome this lack of interest in non-electronic topics, to increase the emphasis on the industrial context of the problem is suggested. The students should be placed as if they were just graduated engineers recently employed by an industrial company where energy consumption is a critical cost factor; and the teacher should play the role of the senior engineer of the company.

5 CONCLUSION

A structured problem based learning approach in an Engineering Thermodynamics course has been presented. The experience gained from this course revealed that several issues are important for effectiveness problem-solving skills.

Some concern over problem based learning is that second-year students may not have the skills to tackle engineering problem solving and that some of them may they lack the maturity to cope with open-ended situations. This work has shown that both of these can be addressed by providing intensive tutor support and guiding frameworks in the student's early encounters with the thermal and mechanical aspects of electronics engineering activities. However, some mid-term and long-term abilities, like planning strategies, should require specific training seminars taught out of the regular schedule of the engineering degree.

The case presented demonstrates that problem based learning can be employed effectively in teaching non-electronic engineering sciences related to the electrical and electronics engineering curriculum.

6 ACKNOWLEDGEMENTS

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III ANALYZES OF COMPETENCE BASED APPROACH TO LEARNING

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ABSTRACT

Since 2010, when the competence based approach was introduced in ISC e-learning environment in Tallinn University of Technology in Department of Computer Control, a lot of information about the students' behaviours is being collected and can be analysed to restructure the learning process to fit with the rapidly changing learner.

In the last two years almost 300 different competences have been identified which can be individually marked. Also, algorithms used to evaluate student answers were analysed to see if there is any connection between the structure of the algorithm and the students' result. Also, changes in student results, learning behaviour and the pattern of using different kinds of help-materials were analysed, and some surprising results were found.

Keywords: competence learning, automatic evaluation, answer evaluation, student behavior.

1 INTRODUCTION

Improving the quality of learning can only be based on improving all components in a closed-loop feedback system, particularly improving the system of measuring a student's abilities and behavioural characteristics. Classical "topic-based" learning is insufficient in obtaining details of a student's knowledge. A novel "competence-based" approach was offered by which the studying outcomes can be measured as skills are processed separately to give a much clearer picture. After almost two years of using that novel approach to learning, its impact and the way it changed student learning behaviours is analysed.

2 BACKGROUND:

2.1 Learning Environment ISC

ISC is an e-learning environment used in Department of Computer Control, Tallinn University of Technology (TUT) from the end of 1990s [1].

The system is used in the teaching of many different courses in computer science field, not only in TUT, with some courses having overlapping material. The system started with the classical "topic-based" approach, where the set of tasks were divided into discrete topics [2]. For every topic in a course, student's state of knowledge and level of efficiency was measured. The system is fully web-based, giving students the ability to solve tasks when and where they wish, by not being bound to campus. Also, the system supports HomeLabKits – portable lab equipment that gives students the possibility to complete the entire course via the Internet in the time and place of their own choosing [3] [4]. ISC takes the "authentic" student input. It uses automatic evaluation for the tasks and lab exercises; therefore, no teacher interference is needed to solve exercises. Students get instant responses thanks to algorithms used to process answers. These algorithms give comments and calculate results.

In the 2010 fall semester, competence based learning was introduced into the ISC system. Classical topic-based learning was replaced by skill-based competence learning to achieve a clearer and more detailed view of student abilities [2]. Since that time a lot of information has been gathered and conclusions can now be drawn.

2.2 Competence-Based Learning

Competence-based learning is a knowledge based methodology which concentrates on/ measures what a person can actually do as a result of learning [6]. The main issue with measuring knowledge is that when using only one grade to represent the knowledge of some wider topic, it does not measure elementary skill or competence but instead the summation of different elementary competences (i.e. summative grading). For example, if grading the mathematical equation x=(2*5+4)/2 in the classical "topic-based" approach, we check if 'x' is correct and discard the intermediate states/skills as opposed to analysing student ability to add, multiply and divide in competence based approach. Instead of evaluating the one result for each task ('x'), every exercise is analysed to extract smaller parts of skills (e.g. multiplication, adding) that the task uses, checks or requires [9].

Therefore, if we wish to give a proper representation of students' abilities, instead of summating or averaging the grading of skill levels, we should look into each and every competence presented in a task and process them separately.

3 ANALYSIS

3.1 Use of competences

As of April 2012, there are almost 28,000 tasks with almost 300 competences connected to them in ISC system. On average, every competence has 94 tasks in its pool where the task will be chosen when that competence is requested to be activated in an exercise. On average every task has 2.5 input competences connected to it, meaning those competences can trigger a student to get that exercise. In reality, tasks have more competences they can affect – they are called non-input competences meaning that they do not trigger that exercise to be solved but they may be affected under certain circumstances. The number of competences related to a task varies from 1 to 12. There are almost one third of tasks representing only one competence. This shows that merely processing the answers alone is not enough: all tasks may have different reasons for getting an incorrect result and further development based on analysis of the results obtained can improve processing and increase the number of competences.

On average, student has been graded in 73.8 competences. In 70% of competences, the students' averages were above 77, which is considered the borderline of having acquired competence. Also, all the students' average results for all the competences are 82 which is close to expected -3dB level 90.

3.2 Results

The positive effect of competence based learning is that the student results improved remarkably with repetition. The margin between totally wrong and correct over all competences in the system fell from 17.69% to 8.34%. Wrong answers also fell from 29.15% to 23.74%, meaning that totally correct answers rose significantly from 53.16% to 67.93%. Also, when looking at competences and the students first five attempts together, the average result was 0.52. Their last five attempts with the competence gave an average result of 0.66.

One of the goals with competence based learning was to make students repeat the same competence over and over again, to be sure the skill was stored in their long term memory. Figure 1 shows clearly that this goal was achieved. Students tend to spend on average 83 seconds on each exercise (almost a minute and half). In 66% of cases, they spent less than minute, in 46% less than 30 seconds, and in 18% they only had the task opened for 10 seconds before they hit the submit button.

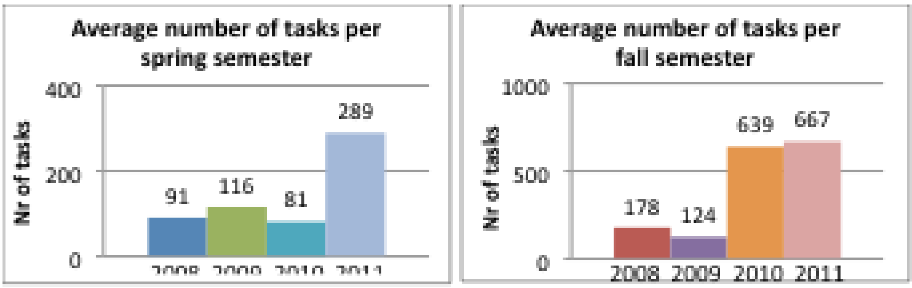

FIGURE 1. *Average number of tasks per semester.*

3.3 Algorithms

Automatic evaluation is used to check student results. There are more than 1100 algorithms used in the competence based approach. When reducing algorithms into simple programming language elements (if statement, while loop, statement sequence etc.) without semantics (ignoring variable names etc.), it comes out that there are actually, in form, only 155 distinct structural types.

There were 82 simplified forms that were used by only one group of exercises. That leaves the other 73 structures (which is less than half of all identified structures) to be used in 93% of cases. Leaving out the structures used only once, on average the structure was used in 14 classes.

When comparing the structure and the student results, it is clearly visible that the more complex and specific algorithms correlate with a higher average result for the class they associate with. When looking at the top 10 algorithm structures with highest average mark, all of them, except one, associate with only 1 or 2 groups of exercises.

3.4 Use of help materials

TABLE 1. *Use of help materials (%) by type and semester.*

	2008S	2008F	2009S	2009F	2010S	2010F	2011S	2011F
kup	4	10	13	12	10	19	16	22
pdf	41	30	27	41	44	36	22	37
pps	11	11	10	7	8	7	4	7
interactive slides	29	36	32	27	29	26	43	12
video	2	8	13	9	4	7	2	3
wikipedia	13	5	5	5	4	4	12	19

In the ISC system, a student has the ability to access a variety of help materials. Throughout the years, some changes in the students' behaviour in using the material are noticeable. Students tend to use less and less of the recorded lectures, even though there were no formal lectures held. This shows that students don't find lectures the best form of obtaining information. They tend to prefer getting all the required information in a small concentrated portion, and that explains why Wikipedia links are becoming more popular (table 1).

TABLE 2. *Student results with and without hint.*

Hint nr	Before competence approach		After competence base approach without hint		Competence based approach with hints	
	Normalized avg results	% of correctly answers	Normalized avg result	% of correctly answers	Normalized avg results	% of correct answers
1	0,085	0,45	0,592	25,43	0,784	76,37
2	0,071	1,04	0,577	31,05	0,631	58,47
3	0,149	5,82	0,623	39,05	0,739	73,87
4	0,093	2,87	0,585	35,47	0,672	64,64
5	0,018	0,70	0,530	41,88	0,587	57,43
6	0,156	6,76	0,624	30,11	0,846	81,30
7	0,057	0,47	0,570	32,43	0,689	68,89
8	0,052	0,26	0,569	32,31	0,651	65,03
9	0,038	0,35	0,553	32,60	0,610	60,97
10	0,156	7,45	0,604	18,91	0,732	72,80

For years there has been growing drop in the average number of materials accessed. As it became clear that students don't really go and look up materials until they are in serious trouble, hints were introduced to the system. They usually contain basic information that forms a foundation for solving the task. They were only shown until the student achieved what is considered a borderline knowledge. As an experiment, 14 different hints were introduced, and the students' performance with the tasks before the competence based approach, and after the competence based with and without hints, was analysed.

It was thought that adding hints would improve the results but it was never expected that the improvement is so great (table 2). This indicates to us, that if the students have the materials they will use them, but that they are too lazy to go and look for them themselves. When they are offered, students make good use of them.

3.5 Students' study behaviour

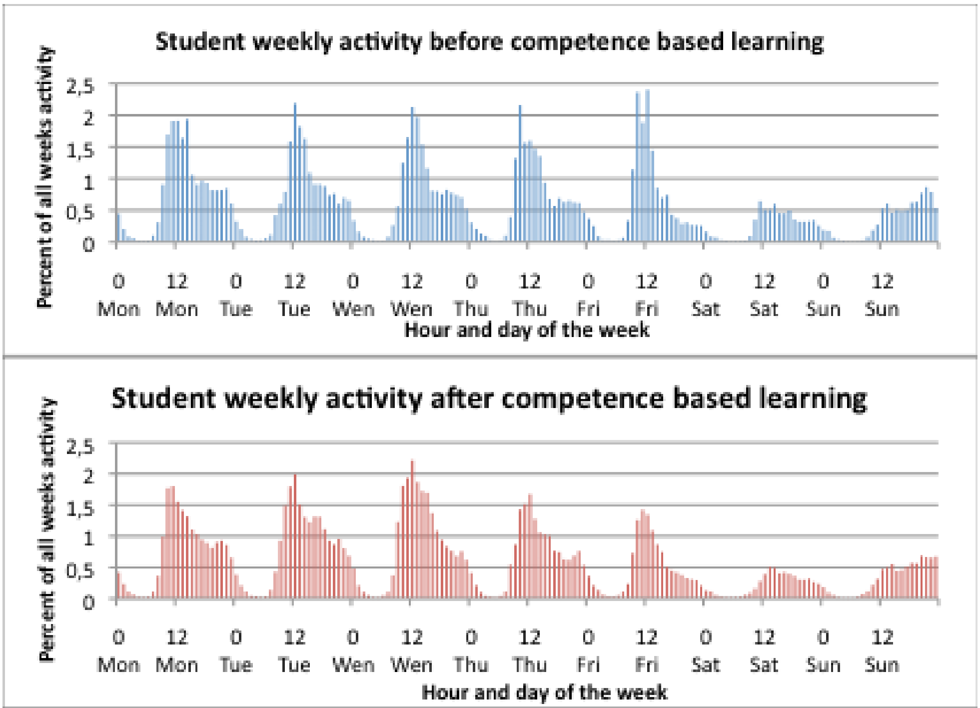

FIGURE 2. *Student weekly activity.*

With competence based learning, the student's daily activities remained the same. When comparing the students' weekly activity (figure 2), there are more visible changes. Before competence based learning, all the work days seemed to have the same kind of activity. After changes, the start of the week seems to be busier than Thursday and Friday. Friday in particular showed major changes. Also, before competence based learning there seemed to be more peak times correlating with the offered lab timeslot, while. After the daily activity seems to be more divided, and the drop of activity after usual lab hours is more gradual. It can also be seen that student activities usually go on until 4 am, with the exception of Friday and Saturday. Sunday seems to have lost little of its popularity, but is still remarkable.

When comparing the average results students achieved during certain times of the day (figure 3), it is clear that with competence based learning, the average results rose. The average results seem to be steadier than before, and during lab hours the results look to be slightly better which contradicts the drop in the previous case. Therefore, it is probable that changes in lab supervision and help are the cause of the difference.

It was expected that the results during the night would not have been as good as those during the day, as the students would have been tired, and probably in a hurry when doing exercises in the middle of the night. However, the results show no clear signs of this. The results around midnight are actually better than those during the lab hours and earlier in the evening, reaching the highest peak of the day at 2 am. After this time the results reflect more of what would have been expected, as there is drop in the average results.

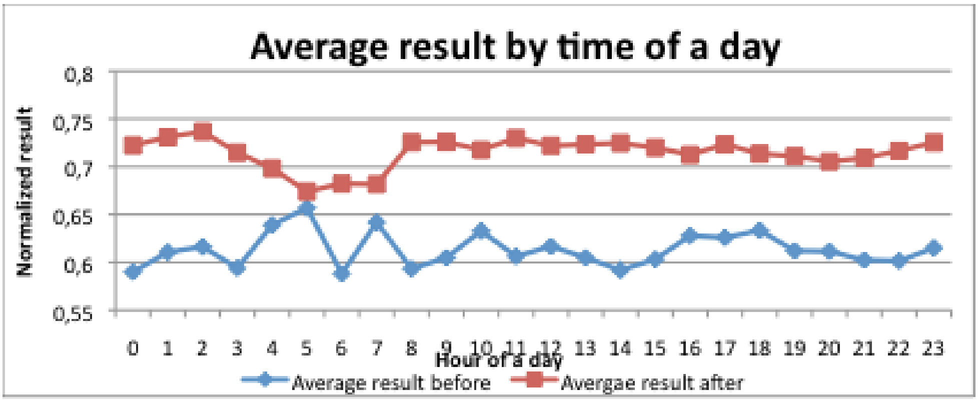

FIGURE 3. *Average result by time of a day.*

Different patterns can be seen when comparing the students' behaviour and the preferences of working either in lab or on their own outside university (figure 4). More and more students tend to work outside university and complete all or the majority of the course work outside the lab and without supervised help. This shows that we have managed to give students enough ways to get help: having materials and tips next to exercises, providing options to send questions to the teacher after the result is shown, or by mail inside the system.

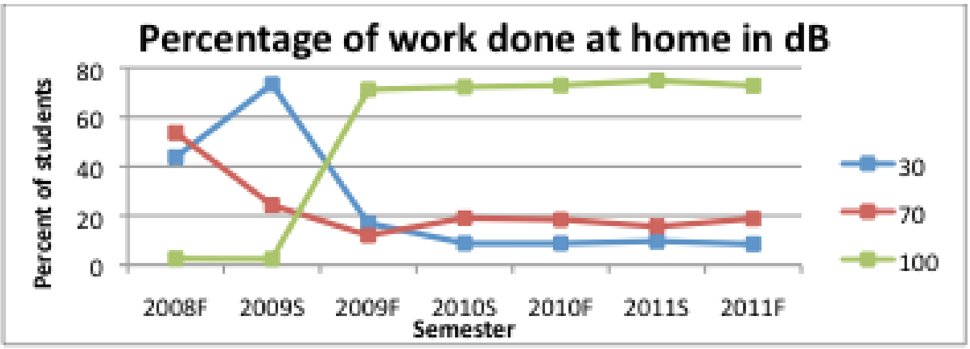

FIGURE 4. *Student working behaviours.*

3.6 Coverage

Converting old tasks into a form suitable for competence analysis exhibited several problems. First, it appeared that some competences are covered very unevenly. There are several important items of knowledge that are not represented at all and many are underrepresented, i.e. there too few tasks related to them. Numerically, distribution of the number of tasks vs. the number of competences is exponential. One third of competences are represented by 8 or less tasks, and half of the competences are represented by up to 30 tasks. These are very low numbers and leads to repetition of tasks, which not only causes protests from students, but also lowers the quality of the control.

Another conclusion is the following. Students are frequently directed to very simple tasks that are connected to simple but basic concepts, and it appears that a student cannot solve these problems. This may happen later when student has worked on many complex tasks, because the system is able to detect weak points in student's abilities. This reflects the well-known fact that simple and basic concepts can be difficult even if a student can solve (somehow) more complicated tasks. This was evident from the beginning of the competence-based process. The conclusion is that many simple tasks related to basic concepts should be created, inserted, and given somehow a higher priority.

4 CONCLUSIONS

1. The competence-based learning environment allows and demands much more detailed consideration of the knowledge and skills that a student can obtain. Introduction of this approach has shown very quickly that there are two weaknesses in the traditional problem sets:
   a. Competences are very poorly covered (few tasks for many competences).
   b. There is a lack of low level tasks that would help to teach the basics of a field, and in fact, testing with complex and complicated tasks masks poor understanding of fundamentals.
2. It appeared that it is possible to extract a lot of information even from very simple tasks, which can be used for a better control of the learning process. However, for this improvement a lot of practical experience (log files) is needed to discover a learner's way of thinking
3. Competence based control produces much higher results partly because of connections between competences through tasks, and partly because a student can never decide not to touch a competence again.
4. Students' workload becomes more even both over the day and over the semester.
5. Using hints in the form of small bunches of supporting information together with problems (i.e. on the same page) helps the student more than links to material consisting of several pages.
6. Competence-based control enables much better formation of control signals (i.e. task selection) because of a more precise adaptation to the student's abilities.

Finally: transferring to competence-based models and control has benefits; however, it has also shown how much work is needed to get the most from this approach.

5 ACKNOWLEDGMENT

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113 MATHEMATICAL MODELING AND ENGINEERING MAJORS

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ABSTRACT

Mathematical modeling is becoming a popular approach for mathematics instruction from primary to post-secondary education, especially for those students entering the sciences or engineering. Yet, we know little about how individuals draw on their mathematical and real-life experiences to view problems. The purpose of this study was to examine factors that may affect engineering students' transitions between the real world and the mathematical world when approaching mathematical modeling tasks.

Keywords: Mathematical Modeling, Design Research, Mathematics

1 MATHEMATICAL MODELING

The purpose of this study was to examine factors that may affect engineering students' transitions between the real world and the mathematical world when approaching mathematical tasks. A model is a simplified representation of some system. It does not take into account all of the information or elements in the system; it accounts only for those assumed to be essential to the system. Mathematical modeling is a process marked by a variety of activities that collectively relate the mathematical world to the real world. A mathematical model is the triple (S, M, R), where R is a relation that maps the objects and relationships of a real problem situation S onto the objects and relationships of mathematical entities M [1].

Mathematical modeling is a cyclical process that searches for a mathematical problem equivalent to a real world problem [2]. The idea is that knowing a mathematical solution to the equivalent problem can help in solving the real world problem. The process begins with a situation or problem in the real world that is represented and then solved mathematically before a solution is reinterpreted in terms of the real-world conditions. A schematic of the process is given in Figure 1.

The real situation or problem occurs in the real world [stage a]. Working to understand [activity 1] the problem produces a situation model [stage b] in the mind of the modeler. The situation model [stage b] is based on the individual's formulation of the problem. Simplifying/structuring [activity 2] refers to identifying, introducing, and specifying variables and conditions. This creates a real model [stage c] which is an idealization of the system being modeled. Through mathematizing [activity 3], the modeler represents the real model [stage c] mathematically which creates a mathematical model [stage d]. The mathematical model [stage d] is itself a relationship among key variables that is expressed mathematically (e.g., algebraically, graphically). Working mathematically [activity 4], or performing analysis, produces the mathematical results [stage e], a solution to the mathematical equivalent to the real-world problem. The mathematical results [stage e] are then interpreted [activity 5] in terms of the real problem situation in order to get real results [stage f]. These real results are then checked against the situation model using methods of validation [activity 6] (e.g., through direct observation) which may vary from problem to problem. Lastly the individual exposes [not pictured] or shares his model with others. In other theoretical models of the modeling cycle, this is known as communicating.

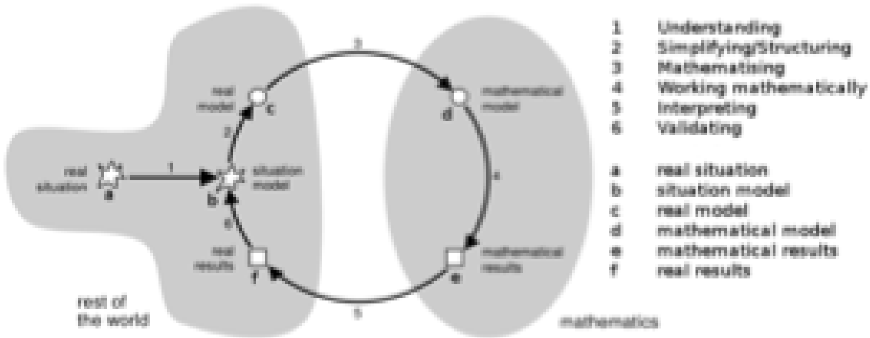

FIGURE 1. *Six stage modeling cycle [2].*

The theoretical model in Figure 1 is both cyclical and nonlinear. That is, the goals identified and work done in any stage is, in part, a product of those which came before. Within the mathematical modeling cycle, research has indicated that students struggle particularly in transitioning between the real world and the mathematical world, which is sometimes attributed to difficulty in understanding [activity 1] or framing the problem [3] or to identifying and articulating assumptions [4]. A student's prior mathematical and non-mathematical experiences impact both of these activities. Thus, a critical part of mathematical modeling is formulating a conceptual representation of the problem and clarifying which factors may play a role in developing the model. This research was guided by the question: What features of a mathematical modeling problem situation are students attending to as they solve it? This paper reports on preliminary results of a study of engineering students' identification and justification of these problem features.

2 METHODOLOGY

This report is part of a larger design research project to study how engineering students engage in mathematical thinking. In this paper, I present two mini descriptive case studies drawn from a series of intensive and in-depth clinical interviews that focus on the students' thinking during transition from a problem situation to a real model.

Students were first- and second-year engineering majors enrolled in a course on differential equations. Fifteen of eighty invited students completed a calculus pretest. Of those, a sampling strategy was developed based on the students' scores on a calculus pretest. Four students scoring above 60% on the procedural portion of the prestest were selected so as to maximize variety in the sample: high/low score on coneptual problems and high/low score on a mathematical modeling word problem. Conceptual items were graded correct/incorrect and the modeling problem was graded for accuracy in each of the mathematical modeling cycle stages. I selected two students for detailed study in this paper because they allow me to investigate what features of a problem the students considered.

The interview questions were adapted from the work of Chris Haines, Rosalind Crouch, and John Davis [4, 5] (Form A) by replacing British English terms with American English terms and asking the student to elaborate on his reasoning for choosing his answer to each multiple choice question (MCQ). Each of the eight MCQ's was targeted at one stage of the modeling cycle. The format allowed assessment of students' skills within a limited time frame and for exposure to a variety of contexts so as to avoid bias by relying on only one real world setting. The MCQ's underwent Rasch analysis, which demonstrated reliability and robustness of the scales [4]. The researchers offered a rubric for qualitatively [5, see Table 1] and quantitatively [4] assessing performance on each item.

TABLE 1. *Classification of processes used in solving MCQs [5].*

Level	Descriptors of processes used
A	Evidence of accounting for relationship between mathematical world and real world input to model
	Some limited evidence of above, such as
B	(i) mentions having thought about the model, but little evidence this has been done
	(ii) has obviously thought about the model, but lacks knowledge of the real world and/or mathematics to solve the problem effectively
C	(i) No evidence that the relationship between the mathematical world and the real world input to the model has been considered nor that a modeling perspective has been adopted
	(ii) the problem was looked at simply in real world terms, or entirely in terms of mathematics without reference to the needs of the model nor to the interface between the mathematics and the real world

The MCQ's are given in two stages (see Table 2). A real world situation is presented, then a question targeting one stage of model construction is posed. The task then gives five choices of statements (or questions) that address the targeting question. In the Bus Problem, each of the choices (a), (b), and (c) are necessary for formulating a mathematical model. The preferred option is (c) [2 points] since assumptions about weather cannot be immediately incorporated into the model. Choice (b) [1 point] may or may not be included in the model. In the Bike Problem, none of the options (a), (b), or (c) address smoothness and option (e) [1 point] is more general than option (d) [2 points] which is directly mathematizable.

I used the MCQ's differently than intended. Whereas the authors developed the items as a quick assessment of student's mathematical modeling skills relative to a theoretical modeling cycle, I used the items to open discussions that originated within particular stages of the mathematical modeling cycle in order to get a more detailed understanding of how the students identified factors, assumptions, and criteria critical to mathematical model development. Students were asked to think aloud as they reasoned about the problems and told that I would ask them for clarification or for explanations about how they made decisions.

The interviews were audio and video recorded, with the camera focused on the students' writings. Immediately after each interview, I expanded my field notes and reviewed the videos for use in qualitative data analysis software. I then indexed the content of the videos, flagging notable occurrences or shifts in the students' thought while documenting the features and factors that students considered relevant to addressing the problem. For each student in each problem, I assigned a score and a process level.

Each 1-2 hour interview opened with a series of questions about the students' educational background and modeling experiences. Students were then presented the eight MCQ's, one question per page. The discussion in this paper is limited to Questions 1 and 2 (see Table 2), the Bus Problem and the Bike Problem, since they address understanding [activity 1] and simplifying/structuring [activity 2]. The Bus Problem asks students to consider the placement of a new stop that will be built with a covered shelter and targets the specification of simplifying assumptions [activity 2]. The Bike Problem targets the students' understanding of the problem [activity 1], given smoothness as one way to operationalize best size for bicycle wheels.

TABLE 2. *Multiple choice questions.*

COTA Problem: *A bus shelter has to be placed along a road on a new COTA route. A covered shelter will be provided. Where should the stop be placed so that the greatest number of people will be encouraged to use the new bus line? COTA wants people to use the service, but cannot send buses on demand.*	Bike Problem: *What is the best size for bicycle wheels?*
Which **one** of the following assumptions do you consider the **least** important in formulating a simple mathematical model?	Which **one** of the following clarifying questions most addresses the smoothness of the ride?
(a) Assume that just one bus shelter will be erected.	(a) Are the wheels connected to the pedals by a chain?
(b) Assume that the road is straight.	(b) How tall is the rider?
(c) Assume that the weather is twice as likely to be dry as it is to be wet.	(c) Does the bicycle have gears?
(d) Assume that the bus runs on a half-hourly timetable	(d) How high is the highest curb that can be ridden over?
(e) Assume that customers will not walk great distances to catch a bus.	(e) Does the terrain matter?

3 CASE PRESENTATIONS

In this section, I present a brief descriptive profile of each student before summarizing their performances on the two MCQ's. Names are pseudonyms. Mance and Torrhen were selected for this presentation because: (i) they used the same differential equations curriculum, (ii) Mance performed well on the pretest modeling task and poorly on the conceptual items, which is opposite to Torrhen's performance, (iii) they exhibited similar behaviors and preferences when identifying key factors in modeling tasks, (iv) they had differing views of the nature of mathematical modeling.

3.1 Mance

Mance was a second-year environmental engineering student who has held no internships. He preferred practical problems to theoretical ones, specifically mentioning that the utility of Taylor series was limited to understanding how calculators evaluate special functions. He stated that the nature of mathematical modeling depends on the field, but is typically using equations to accurately depict series of events, noting that including more variables makes the model more complicated. He performed well on the modeling word problem (correct model, incorrect analysis) on the prestest, although he scored low on the conceptual problems, missing questions about the existence of a limit, interpreting the sign of a derivative, relating rates of change, and function notation. Mance's hobbies included mountain biking.

Mance chose (c) as his answer to the Bus Problem. He began the Bus Problem by reading through the problem statement, the question, and the five response choices. Sinc ethe question was posed as an MCQ, he adopted an elimination strategy for answering it. He ruled out (a) since the problem statement made that assumption explicit. He indicated that (b) was important because the shape of the road affects the spacing of the stops. Mance initially ruled out (c) because "not many people are necessarily going to care whether or not there's a shelter at the stop" when there is a greater probability of dry weather than wet weather. When considering (d), he stated that the bus usually runs every half hour or less, but that people's willingness to wait depends on how far they are trying to go. He indicated that (e) was important because it implied need for more stops on the line. He eventually selected (c) because the weather does not encourage people to use the bus line. Mance first reasoned from the perspective of the end-user and the end-user's preferences before considering the choices against information given in the problem and mathematizable factors. Mance received process level B for this problem since he discussed dependencies of some quantities on others: "the time table and the distance are going to be important based on how many people you can get to use the bus line" and that the straightness of the road determined the total number of stops that would be needed.

Mance chose (e) as his answer to the Bike Problem. He determined that (a) and (c) did not matter since most bikes have chains and gears. Although "how tall the rider is is going to determine the bicycle wheels size," it would not affect smoothness, therefore ruling out (b). He then stated that the height of the curb is relevant but does not directly correlate with the smoothness of the ride. He chose instead option (e) since the type of terrain determined whether one would want a mountain bike or a road bike. Mance reasoned both from the end-user's perspective and from the perspective of ensuring smoothness of the ride, but ultimately made a decision based on his personal experiences with mountain biking. He received a process level C since he considered the problem only in real world terms without relating it to mathematical terms. When asked to consider what other factors might affect the best size for bicycle wheels, Mance responded with factors that indicated he was considering the purpose of the boke, the comfort of the rider, and aesthetics.

3.2 Torrhen

Torrhen was a first year honors student in computer science engineering. He held an internship at the National Aeronautics and Space Administration (NASA). He defined mathematical modeling as "describing real world things in terms of equations," and stated that physics is involved in interpreting and setting up the problem, but the rest is all mathematics. He scored well on the conceptual questions of the calculus pretest, missing only one but his performance on the modeling word problem was low, with an accuracy rating of zero. Torrhen also rode his bike as a hobby.

Torrhen gave (b) as his answer to the Bus Problem since he "personally wouldn't care" when using a bus stop whether the road was straight. He also stated that the weather would not affect where the transit authority installed the bus stop as long as only a small local area was considered.

He further claimed that what truly mattered was the population density near the bus stop, but then stated that “it kinda seems like opinion.” He implied that since the problem was “all words too, not numbers” and that he was “just used to numerical answers” that mathematics did not play a role in selecting an answer. Therefore, he was given a process level C.

Like Mance, Torrhen answered (e) on the Bike Problem, but for the following reasons: most bicycles have gears (c) and pedals connected by a chain (a), most people don’t ride over curbs (d), and since he was tall he knew that the height of the rider would not have an effect on smoothness (b). He then justified his choice (e) by noting that the greatest deviation from smoothness is achieved by greatly varying terrain. Torrhen was assigned process level C on the Bike Problem since he did not consider the clarifications mathematically. When asked what other factors might affect best size, Torrhen responded with factors that indicated he would be most concerned with the rider’s comfort, but would also consider the rider’s purpose in purchasing the bike.

4 DISCUSSION

The Bus Problem asks the student to advise the transit authority based on a situation that is best for the end-user. In the Bus Problem, the students were able to reason from experience to a correct answer. In contrast, the Bike Problem asks the student to consider one criterion that could be used to assess best size for a bicycle wheel, instead of considering the bicycle rider.

Despite both students mentioning that mathematical modeling requires descriptions of phenomena in mathematical forms, like equations, neither selected assumptions in anticipation of introducing mathematical formalism. Indeed, in the Bike Problem, both students chose the “more general” answer over the directly mathematizable one. In both problems, the students relied on “common sense” and consumer-driven criteria to make modeling decisions over considering which assumptions were mathematizable. While this may indicate that the students are trying to build robustness into the model or consider the practicality of design choices, it demonstrates underappreciation of the need to operationalize conditions and criteria for analysis. Such a tendency might indicate that the student are not seeing mathematics as a tool to systematically and rigorously address life-like problems.

Both students were capable of producing lists of factors that addressed criteria other than smoothness suggesting that these students recognize that there are a variety of ways to operationalize a condition like best. Both struggled to serpate the primary factor affecting the consumer (his height) from the selected criteria. The most direct evidence for this claim is when Torrhen stated “I felt like the terrain would affect the smoothness the most, but for the size of the bicycle wheels, I definitely feel like it’s the height of the rider.” This statement further suggests a disconnect between understanding [activity 1] and simplifying/structuring [activity 2].

5 CONCLUSION AND RECOMMENDATIONS

These preliminary results reveal some of the complexity in the students' thinking. They brought personal experiences as consumers to bear on the construction of explicit assumpts as well as introducing implicit ones, a finding that supports existing research [e.g., 3]. The findings also shed some light on the sources of students' difficulties in appropriately understanding [activity 1] a modeling problem and points to the students' personal experiences as sources for (sometimes inappropriate) warrants in simplifying and structuring [activity 2] the problem statement.

By using the MCQ's as discussion questions, the students demonstrated an ability to change perspective when necessary, but also some confusion in understanding how operationalizing important elements in a problem statement either foregrounds or backgrounds factors that relate to the problem. Specifically, in the Bike Problem both students exhibited difficulty in ignoring the height of the rider – a factor that does influence the preferred size of bicycle wheels – to consider optimizing wheel sized based on different criteria. Students' attempts at decontextualizing through distances their perspectives from the problem situation seem to result in adopting a consumer's or end-user's perspective, a beneficial skill they are likely learning in their engineering courses, but that does not automatically lead to selection of appropriate simplifying assumptions in mathematical modeling.

The MCQ's were developed to assess students' skills relative to the theoretical modeling cycle, but neither of the students were inclined to work toward mathematizing the problems, as evidenced by the lower process level ratings. The students' reasoning was far more complex, which simultaneously supports the idea that certain modes of thinking are not limited to particular portions of the modeling cycle [6] and calls into question our ability to rank students' engagement in modeling with the process levels.

The students spoke candidly on the relationship between modeling and equations though they did not view the MCQ's as modeling problems. This may be due to the tasks being more vague or unstructured than students are accustomed to, a discomfort which may be further complicated by the fact that the MCQ's were encountered in a non-classroom setting. This reveals a serious weakness in our approaches to teaching engineering students. Ideally they would see such situations as sites for modeling. The question for future research becomes: What may need to be added to a problem statemet for a student to see it as a mathematical problem instead of (or as well as) a life-experience problem?

Components of mathematical modeling skills may be overlooked by engineering professors due to a view that mathematical thinking is separate from real world, or even engineering thinking [7]. These same components are likely overlooked by mathematics professors. Lack of coherence and coordination between the two departments' pedagogical strategies might explain why the students in this study do not attempt mathematization of the two life-like MCQ's. Since engineers are expected to solve similarly unstructured problems in their careers, it is imperative that educators work to highlight the links between the two modes of thinking.

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115 ECOLOGICAL ASPECTS OF RUSSIAN AGRICULTURAL ENGINEERING EDUCATION

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ABSTRACT

In this article are considered the issues of environmental pollution like waste management issues and the current state of waste oil and lubricant recycling. It is offered to solve these problems by advanced training of specialists in SPbSAU.

Keywords: waste oils, environmental security, post-graduate education of engineers

1 INTRODUCTION

The past period of restructuring of the economic system in Russia was characterised not only by the economic reform, but also by redistribution of spheres of influence, forms of ownership, etc. A number of industrial objects were lost in connection with the bankruptcy of public sector enterprises. The abandoned objects were often pillaged, littered, turned into dumps of waste with different degree of toxicity. The abandoned objects of that kind located on the banks of rivers, lakes, reservoirs and on the shore of the Gulf of Finland of the Baltic Sea represented a particularly serious environmental hazard [1].

2 METHODOLOGY AND RESULTS

The Department of “Automobiles and tractors” of St. Petersburg State Agrarian University, as part of the educational process and moral education of the future engineering staff in the sphere of agricultural production, carried out a local monitoring of the coastal zone surface of the Gulf of Finland being a part of the Baltic Sea, to determine the environmentally hazardous objects, from the position of technical ecology. It showed that in the abandoned sites, in close proximity to the shore, unauthorised dumps and discharge of used motor oil are organised so far.

In particular, the monitoring of the coastal zone of the Gulf of Finland at the Baltic Sea in the area of St. Petersburg revealed the following environmental violations and hazardous objects (see the figure).

FIGURE 1. *Segment of environmental monitoring of the coastal zone of the Gulf of Finland at the Baltic Sea and revealed "hot spots"*

1 - a basement of a ruined house flooded with used oil on the shore of the Gulf of Finland;
2 – used oil products flowing out to a stream from a completely filled barrel;
3 – a dump and discharge of oil products in the abandoned structure;
4 - barrels with used oil on the territory of motor transport enterprise, stored in immediate proximity to the river;
5 – drainage of electrolyte to the sewerage;
6 - drainage of spilled gasoline in the storm sewerage;
7 - draining of used oil organised behind the territory of automobile garages;
8 - abandoned sewerage wells, completely filled with oily waste, in the way of the circular highway under construction;
9 - used oil puddles on railway tracks;
10 - oil lenses formed as a result of durable discharge of used oil into soil;
11 – a barge all filled with used oil, located on the guarded water area of a military unit.

In connection with the foregoing, it is expedient to make advanced technical monitoring of the coastal zone of the Gulf of Finland of the Baltic Sea, adoption of relevant jural decisions and measures, active and effective use of these actions in the educational process with the purpose of environmental education of agroengineers and formation of their civilian position in the sphere of environmental safety of agricultural production, protection and preservation of the natural environment, supporting and securing health of rural residents.

This is especially important in connection with significant intensification of the Russian agriculture, its technical and technological resource. Agricultural enterprises use modern technologies, buy new agricultural machinery, including imported and high-power equipment. The use of agricultural machinery requires competent use of operating materials, including fuel and lubricating materials. The most environmentally hazardous, with regard to agriculture, are lubricants, especially used lubricating oil.

At the time of planned agricultural management, the matters of selection, rational and efficient use of fuel and lubricating materials were handled by the engineer specialising in such materials; the higher educational agricultural establishments trained specialists of this profile.

Today the Russian educational standard 110300 "Agroengineering" has a specialisation 110308 "Fuel supply complexes and oil storages", which envisages training of engineers operating oil-storage and fuelling equipment for agricultural production, engineers on application of fuel and lubricants in operation of agricultural machinery, engineers for management of fuelling complexes. However, higher educational institutions do not in fact provide for training in this specialisation, motivating this gap by absence of demand. This results in lack of specialised knowledge of specialists of the engineering service in the field of fuel and lubricating materials.

It should be noted that at present the oil market of Russia presents a great number of fuels, lubricating oils, plastic lubricants and technical fluids, varying in quality and range. Numerous firms offer their own fuel and lubricating materials, significantly differing in price and quality, for the same type of equipment. The presence of fake oil products in this uncontrolled market leads to breakdown of expensive equipment and even greater costs. The engineering services specialists' lack of specialised knowledge in the field of fuel and lubricating materials and the shortage of specialised periodical literature on that subject forces the managers to take technical decisions on their own responsibility.

In Russian higher educational establishments of agricultural profile the third year students study the discipline "Fuel and lubricants". And, according to the latest requirements of the educational standard, the number of laboratory and lecture hours in this discipline has been reduced by 50%; thus, out of 60 hours meant for study of the discipline, the students must study the material independently within 30 hours. However, our students traditionally are not ready for this.

Due to the fact that the oil market develops very dynamically, it faces the appearance of new types of fuel and lubricating materials; the standards change, new kinds of imported lubricating materials appear, special environmental requirements are put forward not only to fuel and lubricating materials, but also to automotive equipment – therefore the students' knowledge, by completion of studies, is significantly behind the practical reality at the market of fuel and lubricating materials.

The imported automotive and agricultural equipment procured by agricultural enterprises is often not only difficult in design and construction, but in some cases has not been studied at educational establishments at all. The fundamentally new types of engines (from hybrid and hydrogen engines to external combustion engines), different fuel feed systems (from direct injection of gasoline to accumulator system of fuel injection), the lubrication systems under pressure, electronic engine control - a present-time engineer must be able to handle all this variety of technical systems. And not always can he apply to a dealer, as recommended by the manual for operation of certain equipment, as he is in a quite remote area, and the customer service is not developed sufficiently so far.

However, many of the above-mentioned problems may be eliminated by organisation of supplementary (postgraduate) training of agroengineers in these specific areas [2].

The need for such advanced training is emphasised by the fact that the technical ecology, environmental protection bodies and ecological services tighten the control over industrial waste disposal. This includes used lubricating oils, greases, technical liquids, rubber, used air and oil filters, etc. In particular, in connection with liquidation of Russia of the centralised system of collection and recycling of used lubricating oils, small and medium consumers, including agricultural producers, have to solve the problem of disposal of used lubricating oil independently.

Since there are no nationwide - and therefore regional - laws on waste reclamation and no corresponding regulations at the level of provinces or cities - therefore the consumers, in violation of environmental regulations, tend to discharge the used lubricating oil to dumps, sewerage networks, or drain it in secluded places. The used lubricating oils are burned or drained to the ground, which is a sustainable source of contamination of soil, water basins and the atmosphere.

Mainly, pollution of biosphere WO come by seepage into the ground and contact with the surface and ground waters in the passages and leaks. In case of ingestion of used oils in soil formed the so-called oil lenses. The nature of the components of the spread of WO of these lenses is determined by the structure of the soil, the presence of groundwater. In the soil of the oil penetrate under the action of gravity and surface-active phenomena. The spread of WO in the soil depends on the nature of under-soil layer, hydrological conditions, composition, density, viscosity, wetting ability of WO, content and type of additives in them. In the process of penetration of liquid hydrocarbons in soil process occurs of sorption on the walls of the pores. The ability to sorption depends on the capillary forces of surface layers. The most active sorption there is a cultivated agricultural lands (arable land, stubble, steam). The quantity of sorbed substance is determined by the structure and composition of the soil, humidity (tabl. 1).

TABLE 1. *The ability of various soils to sorption of hydrocarbons.*

The type of the ground	Permeability, мкм ^{2}	The quantity of sorbed product, l/м ^{3}
Coarse gravel, detritus	115	-
Gravel, coarse sand	11,5-115	8
The sand of large, the sand of medium	1,15-11,5	15
The sand of medium, the sand of small	0,115-1,15	25
Clay sand, clay	$1,15*10^{-3} – 1,15*10^{-1}$	40
Loamy soil	$1,15*10^{-3} – 1,15*10^{-5}$	60

With the growth of water-saturation of the soil decreases their ability to absorb petroleum hydrocarbons. Adsorbed substances, in turn, are subject to the desorption of water. The described processes are gradually lead to a decrease in biological productivity, soil degradation, degradation of vegetation, reduction of fertility.

The pollution of ground water is one of major sources of pollution of soil water. About 85% of the total pollution are "chronic" minor leaks and spills, and only about 15% - major disasters. The ecologists have found that the used lubricating oils make for at least 50% of the total oil pollution. The hydrocarbons within the used lubricating oil, having a low degree of biodegradability (10-30%), getting accumulated in the environment, shift the ecological balance [3]. The toxic components of used lubricating oil get into man's digestive system through food, are deposited in adipose tissues, causing cancer and disorders of the immune system.

However, the used lubricants represent primary energy materials, the reuse of which, after appropriate treatment, will prolong their life cycle. Relevant small-size, movable, mobile plants for purification or regeneration of used lubricating oil have been developed, including at the Department "Automobiles and tractors" at St. Petersburg State Agrarian University. The regeneration of lubricating oils made with regard for environmental requirements, becomes by right one of the best ways of their utilisation. Securing the increase in local oil production resources, it protects the environment from pollution.

3 CONCLUSION AND DISCUSSION

The ways of solution of these environmental problems by specialists of engineering services may be identified in the course of periodic post-graduate training or retraining in the relevant areas, on the basis of higher educational institutions engaged in retraining and professional improvement of managers and specialists of the agro-industrial complex and specialised enterprises. Moreover, a number of such programmes may be granted by the department "Automobiles and tractors" of St. Petersburg State Agrarian University to organisations interested in this.

In accordance with the present situation in Russia specialists do the refresher course on the basis of higher educational institutions of not less than 1 time in 5 years. During this time can be produced significant changes in the technical regulatory documents and markings of fuels, oils, process liquids. In addition, in the framework of the offered at the Department «Cars and tractors» Saint-Petersburg State Agrarian University programs of improvement of qualification of specialists get new knowledge - the information, which was not in the curriculum during their studies in institutions of higher education. All of the above is the two basic components, which ensure the effectiveness of the training. If necessary, course of post-graduate training may be amended and supplemented for subsequent implementation jointly with Russian and foreign partners.

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116 SEAGEP SCIENCE AND ENGINEERING IN THE GLOBAL CONTEXT PROJECT AND ASSESSMENT OF ITS EFFECTS

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ABSTRACT

Study abroad experiences for students in the sciences and engineering are potentially an important tool in the internationalization of these disciplines and the development of globally aware citizens. However, given the demographics of the typical study abroad student, programs to diversify the study abroad population are needed to ensure that tomorrow's scientists and engineers have the global perspective that is considered of paramount importance. In recognition of the need for global experience as well as the limitations of current programs, the University of Florida South East Alliance for Graduate Education and the Professoriate developed an international program entitled Science and Engineering in the Global Context that involved short-duration trips for underrepresented doctoral students. In parallel, a research project was conducted to determine if such short-term trips can provide students with the desired global awareness. A research-based evaluation tool for science, technology, engineering, and mathematics international programs was developed to assess the level of attainment of the desired academic and personal learning outcomes. We believe that this knowledge will facilitate the development of much-needed new and improved study abroad opportunities for students in the sciences and engineering.

Keywords: STEM, Global awareness, Minority PhD students.

1 INTRODUCTION

Study abroad experiences for students in the sciences and engineering are potentially an important tool in the internationalization of these disciplines and the development of globally aware citizens. However, as is evident from the published statistics and the conclusions of the Commission on the Abraham Lincoln Study Abroad Fellowship Program report [1], students majoring in the sciences and engineering are among the most underrepresented groups in study abroad programs. These findings are further supported by national statistics from the Institute of International Education Open Doors 2009 Report on International Educational Exchange [2]. This report compiled data from over 900 U.S. institutions of higher education and determined that, of all the students who studied abroad in the 2007–2008 academic year, only 7.2% were physical or life science majors, and 3.1% were from engineering. In fact, studies have shown that study abroad in the United States has primarily been an activity for white, female undergraduates majoring in the social sciences, business and management, and humanities at smaller institutions; furthermore, most U.S. study abroad students go to European countries [2, 3, 4].

Students in science, technology, engineering, and mathematics (STEM) disciplines who want to pursue an international experience face access issues related to the time commitment typically required for participation in such programs, as the curricula of STEM disciplines are generally crowded. Graduate students in STEM fields who want to gain international experience have additional obstacles, such as mentors reluctant to allow them to leave the lab for extended periods and the lack of funding for such experiences. Hence, it is not surprising that only 0.3% of the study abroad students in 2007–2008 were PhD students [2].

Given the demographics of the typical study abroad student, programs to diversify the study abroad population (across student level, race, ethnicity, country visited, and discipline) and that address issues of access are needed to ensure that tomorrow's scientists and engineers have the global perspective that is considered of paramount importance.

2 SCIENCE AND ENGINEERING IN THE GLOBAL CONTEXT

In recognition of the need for global experience as well as the limitations of current programs, the University of Florida (UF) South East Alliance for Graduate Education and the Professoriate (SEAGEP) developed an international program entitled Science and Engineering in the Global Context. The program provided a three-credit-hour course that involved four short-duration trips to less developed countries for a multidisciplinary group of underrepresented STEM PhD students. The ultimate goal of the program was to enable the students to develop the global competencies deemed necessary for all students: the ability to understand local economies and cultures, knowledge of commercial and technical developments, and awareness of technical skills in different cultures [2]. It has been assumed that the development of such competencies is directly proportional to the length of a student's international experience, which presents an obstacle to STEM graduate students. However, a recent study conducted by researchers at the University of Minnesota-Twin Cities concluded that the length of time in a study abroad program does not impact the level of global engagement in later life. The group looked at 6,400 students from 22 colleges that had studied abroad in the past 50 years. Students who went abroad for four weeks or less were as likely as those who spent months or a year abroad to be globally engaged [5]. Therefore it can be concluded that a shorter duration trip could be equally effective. This could make international experience more accessible for graduate students for both academic and financial reasons.

Four destinations were selected where UF, the lead alliance institution, had liaisons and established partnerships to help facilitate the international experience. These included Chile, China, South Africa, and Brazil. Each trip included visits to local industries, lectures from local researchers, visits to local academic institutions, meetings with local research funding agencies, and a cultural experience. In some cases, SEAGEP scholars made research presentations at local universities. The team of scholars in each country was divided into groups that were assigned to one of four research topics (science and technology, science communications, technology transfer, education) to investigate during the trip. Upon return to the United States, each country's team was responsible for writing a report. The culmination of the project was a presentation by each country team at the SEAGEP Annual Meeting that was held at the University of Florida in September 2011.

3 PROJECT ASSESSMENT

A research study designed as part of the SEAGEP course specifically addressed the learning outcomes for students in science and engineering who participated in the program. The purposes of this study were: (1) to examine self-reported academic, personal, and intercultural outcomes for current SEAGEP graduate students who participate in STEM-related international programs; (2) to examine how perceived learning outcomes differ for life and physical science students compared to engineering students; (3) to examine how learning outcomes for the SEAGEP study abroad students differ from those of under-represented, graduate STEM students who did not participate in the international program; and (4) to examine the extent of alignment between the student learning outcomes and the objectives of the program, as outlined in the syllabus.

It was also anticipated that the development of a research-based evaluation tool for STEM international programs would be of broad applicability for universities and colleges as they attempt to assess the level of attainment of desired academic and personal learning outcomes for science- and engineering-related study abroad programs. The evaluation tool would also provide feedback to faculty about the effectiveness of study abroad programs in the sciences and engineering, thereby ensuring more effective implementation of well-designed programs. It is our belief that this knowledge will facilitate the development of much-needed new and improved study abroad opportunities for students in the sciences and engineering.

3.1 Methodology

This study used a mixed-methods approach, with a combination of surveys and observations, to ensure a comprehensive assessment of the impact and outcomes associated with the SEAGEP international program for underrepresented graduate students. Quantitative survey tools were used to describe overall characteristics and plot changes over time, while the qualitative observations were used to provide supporting evidence about the process of this change. As such, these tools were used to assess students' academic learning, personal growth, and intercultural development as a result of the international experience. A pre- and post-test design, with a comparison group of non-study-abroad participants, was implemented.

Study abroad participants from the trips to China (May 2011, enrollment = 15), South Africa (June 2011, enrollment = 10), and Brazil (July 2011, enrollment = 10) comprised the sample population. In addition, 32 STEM graduate students who did not participate in these study abroad programs were recruited to provide a comparison group for the study. Demographics of the group are listed in Table 1.

TABLE 1. *Demographics of student participants of the SEAGEP international program and a comparison group of under-represented STEM graduate students.*

Participants	Discipline	Ethnicity	Sex
International Program	18 Engineering 17 Life & Physical Science	17 Black/African/African American 14 Hispanic/Latino/Spanish 2 American Indian or Alaskan Native 2 Other	18 Male 17 Female
Comparison Group	11 Engineering 21 Life & Physical Science	15 Hispanic/Latino/Spanish 17 Black/African/African American	14 Male 18 Female

The lack of a pre-existing, validated survey instrument for assessing perceived student academic learning and personal growth outcomes resulting from participation in STEM study abroad programs necessitated the development of a new tool for use in this study. The study therefore developed the STEM Outcomes Survey to assess students' self-reported outcomes related to the SEAGEP international programs in China, South Africa, and Brazil. The STEM Outcomes Survey consisted of three sections, the first assessing academic outcomes, the second assessing personal outcomes, and the third eliciting demographic information. Within the academic and personal outcome sections, there were several sub-scales. Questions were randomly ordered in the survey tool to avoid response bias. Additionally, internal validity for the academic and personal outcome scales and for the associated sub-scales were examined using Cronbach's alpha statistics. The total academic and personal outcomes scales yielded high internal consistency reliability (Cronbach's alpha = .849 and .884, respectively).

A second survey tool, the Intercultural Development Inventory (IDI) developed by Milton Bennett [6], was used to assess students' levels of intercultural development both before and after the study abroad experience. The IDI, based on Bennett's Developmental Model of Intercultural Sensitivity, has been widely used since 1998 in both corporate and educational settings in the United States, Europe, and Asia. It is a statistically reliable, valid measure of intercultural sensitivity, consisting of 50 Likert-type questions. The IDI has been used frequently in research regarding study abroad experiences, especially in the liberal arts and foreign language fields. However, the IDI has not been used often when assessing cultural competence resulting from participation in STEM-related study abroad experiences. In the current study, the IDI was used to assess the development of intercultural competence of STEM graduate students who participated in study abroad compared to those who did not.

Participants' responses to the STEM Outcomes Survey and IDI were collected approximately one week prior to departure and again, approximately two weeks after their return to the United States. Differences between the participants' pre- and post-trip responses were investigated using the paired t-test statistic in SPSS. Of the 35 participants, 33 completed the pre- and post-trip STEM Outcomes Survey and 31 completed the pre- and post-trip IDI surveys. In the control group, 32 students completed the STEM Outcomes Survey, and 30 students completed the IDI.

Finally, participants were asked to discuss their expectations for the study abroad program in a reflective writing assignment that was submitted prior to their departure. Additionally, students were asked to reflect upon their experiences and their learning outcomes in a reflective writing assignment that was submitted shortly after their return to the United States.

3.2 Results and Discussion

Research Question 1: Examine the self-reported academic, personal, and intercultural outcomes for current graduate students who participate in STEM-related study abroad experiences at the University of Florida.

The results of the paired t-test are reported in Table 2. These results indicated that students experienced significant gains in both academic ($p = 0.006$) and personal ($p = 0.000$) outcomes as a result of their participation in the SEAGEP international programs. These results suggest that the SEAGEP international program was successful in attaining the academic and personal learning outcomes as measured by the STEM Outcomes Survey.

TABLE 2. *Paired t-test comparison of pre- and post-trip responses on the STEM Outcomes Survey and the Intercultural Development Inventory (alpha = 0.05).*

Scale	Degrees of Freedom	t Value	Significance (p)
Academic Outcomes	32	2.954	.006
Personal Outcomes	32	3.958	.000
Intercultural Developmental Orientation	30	0.590	.559

Students' levels of intercultural competence, as measured by the IDI, did not change significantly as a result of their participation in the program ($p = 0.559$). Intercultural development, or competence, was not an explicit objective of this program, but is often cited as a desired outcome for study abroad programs. Other studies have suggested that, to obtain significant increases in the students' scores on the IDI, the program should incorporate intentional intercultural activities, interventions, and assignments. However, this survey tool has not been used previously for the assessment of under-represented STEM graduate students. Therefore, further research is necessary to understand the source of these results for the SEAGEP international program participants and to develop a more effective approach for developing their intercultural competence. Subsets of components of the academic and personal outcomes are currently being analyzed.

Research Question 2: Examine how perceived learning outcomes differ for life and physical science students compared to engineering students.

Of the 33 participants who completed the STEM Outcomes Survey, 18 were defined as engineering students and 15 were studying in the life and physical sciences. Statistical tests of within-subjects contrasts indicated that there were no significant differences between the pre- and post-trip scores for engineering and life and physical science students for the academic learning outcomes (p = 0.118), personal learning outcomes (p = 0.326), or for IDI developmental scores (p = 0.70). Thus, it appears that both engineering and life and physical science students benefited equally as a result of participation in the SEAGEP international programs.

Research Question 3: Examine how learning outcomes for the SEAGEP study abroad students differ from those of underrepresented, graduate STEM students who did not participate in the international program.

The academic, personal, and intercultural outcomes for students in the SEAGEP international program were compared to those of a comparison group of under-represented STEM graduate students who did not participate in the program. A series of independent t-tests were conducted to determine if the participant group responses were significantly differently from those of the control group (Table 3). These results suggest that the SEAGEP international program participants were largely representative of the broader population of under-represented STEM graduate students. Following participation in the program, students' academic and personal outcomes were significantly different from those of the control group, suggesting that the program had a significant impact on student learning.

TABLE 3. *Independent t-tests comparing outcomes for students who participated in the SEAGEP international programs and those who did not.*

Scale	Degrees of Freedom	Pre-trip Participants & Comparison Group p-value	Post-trip Participants & Comparison Group p-value
Academic Outcomes	63	.532	.007
Personal Outcomes	63	.273	.002
Intercultural Developmental Orientation	60	.657	.820

Research Question 4: Examine the extent of alignment between the student learning outcomes and the objectives of the program, as outlined in the syllabus.

The results of the pre- and post-trip assessments were compared to the stated objectives of the program to determine the overall effectiveness of the study abroad experience. Assessment of the student learning outcomes using the STEM Outcomes Survey and IDI indicates some mixed results in relation to these objectives. For example, students did demonstrate significant increases in their level of academic learning and personal growth as a result of participation in the program. However, their intercultural competence, as measured by the IDI, did not exhibit any significant difference between the pre- and post-trip assessments. Participants do appear to have developed an enhanced understanding of the STEM education and research in other countries. For example, their perception of the socio-cultural role of the STEM disciplines in other countries had significantly increased following the international programs.

Specific items were included in the surveys to ascertain the students' perceptions of the four research topics: science and technology, science communication, technology transfer, and education. However, no significant differences between their pre- and post-trip perceptions of these concepts were noted. This suggests that the international programs may have reinforced their existing perceptions or that the itineraries did not adequately address the concepts. Additional analysis of the students' reflective writing assignments is on-going, and it is anticipated that these data sources will provide some explanations for the students' perceptions of the four research topics.

Several students have reported longer-term outcomes as a result of their participation in the program, which provided opportunities to network with students, faculty, and researchers. For example, one student had the opportunity to make contacts for a subsequent Fulbright scholarship to a country in the same region; another student has recently been offered a post-doctoral position at a university he visited during the SEAGEP international program. Although not originally part of the research study, additional follow-up with the SEAGEP international program participants will be conducted to track further long-term outcomes.

4 SUMMARY

This program was developed to add to the knowledge base regarding the efficacy of short-term international experiences for minority STEM graduate students. Students who participated in the SEAGEP international program demonstrated significant gains in both academic ($p = 0.006$) and personal ($p = 0.000$) outcomes. There were no significant differences between the academic, personal, or intercultural development outcomes for life and physical science students compared to those of engineering students. Therefore, students of all disciplines experienced similar learning outcomes as a result of their participation in the SEAGEP international program. Following completion of the program, independent t-tests suggested that students who participated in the international programs were significantly different in most aspects of the academic and personal outcomes compared to those who did not participate in the international programs.

The learning outcomes assessment tools developed will further enable study abroad professionals and faculty to ascertain the effects of study abroad in both the academic and personal contexts. Another result is that the ability of the commercially available IDI survey to assess STEM students' intercultural development as a result of an international experience was not initially evident and will require further investigation.

Keys to the success of the program were carefully scheduled opportunities to expose students to research, funding agencies, laboratory and field sites, and their counterparts in the host countries to provide students with a breadth of experiences in a short period of time. The short length of the program was a plus, as students indicated that a longer trip would not have been feasible for them. Also, providing students with daily debriefing discussions provided them with the opportunity to reflect on their experiences. Completion of the analysis of the students' reflective writing assignments will provide further insights into how best to design programs that will produce globally aware STEM researchers and diversify the pool of students participating in international programming.

5 ACKNOWLEDGEMENTS

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117 FRAMEWORK FOR INTEGRATION OF TEACHING AND R&D IN BSC LEVEL EDUCATION – CASE STUDY ON CHALLENGING LONG-TERM R&D EFFORT

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ABSTRACT

This paper discusses practical solutions for the challenges faced from comprehensive integration of research and education. These challenges are addressed by presenting widely applicable framework for integrating research and education in BSc level education. Teaching is partly implemented as university-industry collaboration. Framework involves curriculum design, course implementation planning, and student mentoring. The framework is illustrated with case study project funded by public funding agency involving large-scale industry collaboration.

Keywords: University-Industry Collaboration, Integrating Research and Education, Student Mentoring and Tutoring

1 INTRODUCTION

The Finnish law on universities of applied sciences defines following tasks: teaching, research and development (R&D), and regional cooperation with industry and commerce. At the moment, Finnish government is planning big changes to universities of applied sciences, which will further emphasize industry-driven R&D activities and innovative practices. Meanwhile, governmental resources for university education will be decreasing heavily. The full-cost funding model was introduced in the last part of previous decade. It requires university own funding at some cases to be even 40% of the whole project budget. All these changes has led to the situation, where integration of teaching and R&D activities is the only possible way to fulfil tasks required by the law and to maintain high-quality education when teaching resources are decreasing.

Fig. 1 illustrates traditional situation in universities, where courses and R&D projects are strictly separated. Key stakeholders for the framework discussed in this paper and their mutual interaction can be described as follows

- Teacher shares the knowledge with student and the student utilizes provided knowledge for learning. Feedback from the student to the teacher is minimal.

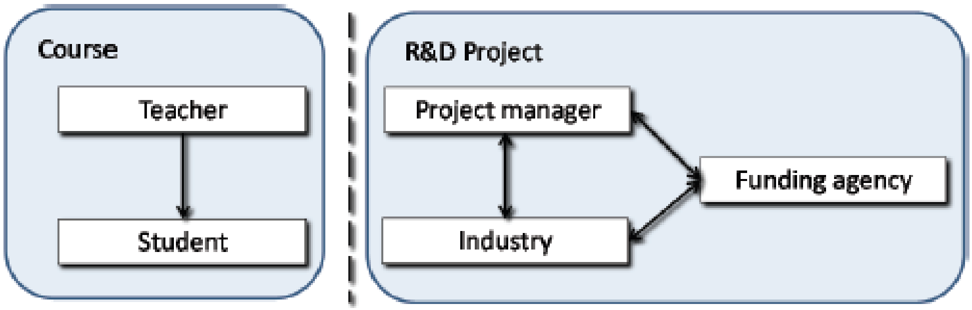

FIGURE 1. *Traditional setting in university environment – courses and R&D projects are strictly separated.*

- Project manager is responsible for the project implementation in the university. Project personnel are working under his/her supervision. This may include also individual students from the university. Project manager may be the same person as the teacher, but conceptually the division is based on the working role. The project manager interacts with industry partners typically in project steering group. Project reporting is performed for funding agency. Also companies may participate in project funding.

This model does not allow integrating teaching and R&D projects. To achieve integration the operation mode must be changed to what is presented in Fig. 2. There, course implementation and R&D project cannot be separated. This is possible if stakeholder interactions are extended to cover all mutual connections. From the university point-of-view only the reporting for funding agency remains with the project manager.

This paper discusses challenges that integrating R&D and education brings in degree program level and for individual courses. Possible solutions are proposed, and approach utilized in Turku University of Applied Sciences (TUAS) degree program Business Information Technology (BIT) within research oriented externally funded project with industry participation is presented.

The rest of the paper is organized as follows: next challenges rising from the integration are discussed in detail. Then, possible solutions to overcome these challenges are proposed in section 3. Section 4 presents case-study project WISE and how the integration is performed in practise. Finally, conclusions are drawn in section 5.

2 CHALLENGES IN INTEGRATING RESEARCH AND EDUCATION

Industry-driven R&D project with also external public funding poses several challenges when considering education and R&D integration. The key question is how to guarantee enhanced learning experience for participating students [1]. From the project point-of-view, granted funding is based on research plan document and teaching is not allowable cost for many public organizations. Also, industry wants to see their support invested in producing innovations rather than giving education to students. In addition, challenging research oriented R&D projects tend to be long compared to duration when student can be involved. Changing personnel creates discontinuity points in project implementation, which may cause problems e.g. in industry collaboration. Traditional way to involve students in R&D projects has been through BSc and MSc theses, but this approach alone is not sufficient in the current situation, since credit points (cp) obtained from the thesis work is only a small fraction of the whole degree.

When high-level of education and R&D integration is sought according to Fig. 2 the role of teacher has to change from traditional lecturer to be more like a mentor. This change requires that the teacher is willing and capable of changing the way the knowledge is shared with students. The role of university is crucial to support and to offer adequate training for teachers, which is required in adapting to the new role.

The mentor and the project manager have two distinctive goals: project sets requirements for results that must be obtained, but as a teacher the mentor has the responsibility that students learn as much as possible. By solving R&D challenges from the industry, the competence of the student should be stronger after participation in the project. In the meanwhile, mentor has the responsibility towards university to take care that student participation in the project does not endanger graduation in time. If the student is highly motivated and competent to work in the project it is easy for the project manager to allow student to work more in the project, which might delay other courses in the curriculum. Actually, teaching and R&D integration should accelerate the graduation process.

Utilizing project funding to teaching activities is not straightforward unless it is explicitly mentioned in the project plan, and if it is allowable cost for the funding agency. In Finland, Tekes is the main funding agency for technology and innovation and there teaching is not allowable cost. Therefore project plan must be carefully designed to be innovative to attract funding agency and industry partners, and in the meanwhile, applicable to produce project goals with student participation. Naturally, project personnel include also senior researchers that will produce project deliverables. These persons may be dedicated project workers or they may be teachers performing education and R&D integration. When students are utilized in producing project goals the project manager must be prepared for a situation where the project goal proves to be too challenging for participating students. For example, it should be considered if back-up reservation of human resources or from the project budget is necessary. There should be competence available to complete project goals in all circumstances. Keyword in project activities towards industry and funding agency is trust. Failing in producing agreed project deliverables will damage the trust, which will make finding further project funding more difficult in the future.

Projects are governed by project consortium agreements. However, these agreements do not bind students unless they are in work relationship to university with project funding.

The ownership of results may be problematic. In principle, student owns right to his or her own work, which may be for example software code. Therefore, project manager must carefully take care of student agreements when they participate in project, which

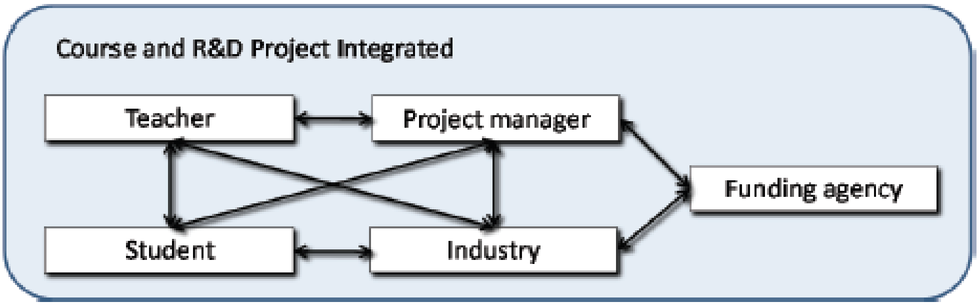

FIGURE 2. *Interaction between key stakeholders when education and R&D project implementation are integrated.*

has project consortium agreement in place. It is important to discuss this matter with students before they start as the issue is not necessarily clear for them.

Challenges discussed in this section are summarized in section 5. Conclusions. Next, possible solutions for the aforementioned challenges are discussed.

3 POSSIBLE SOLUTIONS FOR CHALLENGES IN INTEGRATING RESEARCH AND EDUCATION

In curriculum design, the key issue is the flexibility. Project activities and their volume vary from year-to-year and it can change very rapidly. A good approach is employ modular structure, which allows flexible interaction with project portfolio. Each module should contain high-level theme and broadly defined learning goals. If a project is initiated having connection to theme in study module, the teacher can agree with project manager that students can complete the module within project work.

In project implementations modern pedagogical approaches should be followed. From the learning research the socio-cultural approach [2,3] for teaching is valid for the integration purposes. This approach constitutes of for example learning-by-doing and problem-based learning approaches. The goal is that students work together and also with the teacher (mentor) to produce new knowledge and innovations.

It is project manager's responsibility how to deal with project discontinuity points when students leave the project after completing the course integrated to the project or after graduation. The duration of student participation is very short compared to the duration of the project. Even in the BSc thesis stage the 15 cp corresponds to only 2,5 month full-time work effort, which includes written report of the work. The solution can be found from the knowledge management [4,5] approach.

In TUAS one mandatory course is training period, which is 100 days long and it can be completed also in the project work. If student is motivated, it is possible to combine different courses. That is, first student can take dedicated R&D project course and additionally some extra credit points to optional studies. After this, training period can be started and finally thesis work can be added. In short, student commitment to the project is the key for managing discontinuity points.

4 CASE-STUDY PROJECT

WISE project [6] is part of Trial technology program funded by Tekes (Finnish Funding Agency for Technology and Innovation). The aim of Tekes' Trial Environment for Cognitive Radio and Network programme is to transform Finland into a globally attractive cluster of expertise and unique trial environment for cognitive radios and networks. In WISE project enablers are produced for starting up commercial operation of cognitive radios in so called TV White Spaces.

The objective of the WISE project in Trial program is to construct a testbed for studying the use of cognitive radios on television broadcast bands, which are the first previously reserved frequency bands to become available for cognitive radio allocation. In the project, an open cognitive radio geolocation database testbed will developed, allowing practical studies of the usability, algorithms, and interfaces of cognitive radio systems operating in television broadcast bands. The operation of this database will be verified using a measurement and simulation platform developed in the project. Data from the measurement and simulation platform can be utilized in studying the functional characteristics of cognitive radio devices.

Business information technology degree program role in the project is to develop information security solutions for communication between cognitive radio device and geolocation database allocating frequencies as the connection is made through public Internet.

In the case study project office space is available with permanent seats for students performing thesis work or completing the training period. The project space is available for also students completing course R&D project. Project manager has weekly meetings with students. In addition, thesis workers attend meetings with industry representatives that participate in project steering board. The roles for project manager and thesis supervisors have been kept separate to ensure that both project outcomes and the pure thesis quality were treated equally.

In case study project three different approaches were tested for education and R&D integration in course level [7,8]. In the first phase traditional and the most direct approach was chosen: students were invited to do their BSc theses by completing research and development tasks defined in the project plan. At the time of the writing two theses have been completed, one is in the progress and four more are being prepared.

At the moment, Business information technology degree program does not have modular structure. However, R&D activities have been taken into account with special course entitled simply R&D project course 3cp. There, even the first year students can participate in project activities even though it is scheduled for the second year. During the course students learn also how to manage a project and how the project is documented. Thus, three available credit points is quite a small amount of working hours that students can spend with the project. Fortunately, it is possible to give students more credit points than three. Those credit points will be located in category optional studies in the curriculum, where 15 cp can be placed. Usually students work in groups, which allows to cover larger project topics. In the case study project course R&D

project course has been utilized to build local SW development environment (three students) and a small piece of software to illustrate project results (two students). The same way also exchange students have been participating.

The third tested method in the case study project has been bringing project challenges to regular course implementations as course problems for students to solve independently or in groups. In this approach it is possible to use already solved issues from the project as examples. Here, the expectation is not necessarily to gain new project achievements, but more to introduce all students to R&D challenges that rise from the industry. However, from the project point-of-view this approach allows to get wider perspective on obtained results, and maybe even more efficient solution can be found.

4.1 Evaluation of the case study project

Evaluation of the teaching and R&D integration in the case study project was performed by two different methods. Integration success from the project point-of-view was evaluated with unstructured theme-centered interviews [9] with representatives from the funding agency and from the participating companies. Integration success from the student and learning point-of-view was evaluated using focus group method [9] with the student group that has participated in the project in different roles. Focus group is used widely in marketing research but it is applicable here as the situation is used to investigate the opinions of the group members.

Following themes were raised in the discussion with representatives from industry partners and from the funding agency:

- Were there any prejudices for student participation in achieving project goals?
- Are the results according to original project plan and is the quality according to expectations?
- Has parallel thesis work produced any problems from the project point-of-view?
- Can we continue with the same working method in the future?
- Are there any other considerations from industry-perspective?

The attitude towards student participation was positive. There was not seen a reason to change project implementation strategy. A clear distinction between science university and university of applied science was seen how students are utilized in the project. For the latter the R&D challenges that are chosen for students originate from the industry, while for science university the topic selection for students originates usually more from the university itself.

During focus group meetings students raised following issues

- Participation in the project had provided a lot of knowledge that were not taught during courses.
- Direct industry contacts were a good source of motivation and positive feedback increased self-confidence.
- Project manager should try to explain “the big picture” in the project. This would increase motivation even further.

5 CONCLUSION

In this paper, an approach for tight integration of education and R&D activities has been discussed. This direction is necessity, but it poses several challenges. These challenges have been analyzed in detail and some possible solutions have been proposed. An approach selected in case-study project has been presented and results from its evaluation have been given. Discussed challenges and possible solutions are summarized in Table 1.

TABLE 1. *The summary of discussed challenges and possible solutions.*

Challenge	Possible solution
Enhanced learning outcomes	Socio-cultural approach in teaching
Long-term funding for the integrated approach	Trust from partners and funding agency
Discontinuity points	Detailed work plan with clearly defined subtasks, student commitment
Degree program curriculum	Flexibility, modular structure
The role of teacher	Teacher education, support from the university
Tasks too challenging for students	Reservation of resources and budget
Legal issues	Contract with all students even with minor contribution to the project

The support from the university is naturally necessary to achieve any of the above-mentioned goals.

6 ACKNOWLEDGEMENTS

Case study project WISE have been funded by Tekes in Trial technology programme. WISE consortium, in addition to Turku University of Applied Sciences, is Aalto University, University of Turku, Nokia, Digita, Fairspectrum and Ficora. This R&D and education integration approach has been initiated during studies in Haaga-Helia School of Vocational Teacher Education.

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119 STUDENTS' PERSPECTIVES ON TEAMWORK LEARNING IN ENGINEERING EDUCATION IN CHINA

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ABSTRACT

This paper investigates the perspectives of Chinese engineering students on team working and the way they prefer to learn. A customized survey was conducted in a joint Sino-UK programme based in Beijing. The British input brought more cooperative learning practices into the programme and put more emphasis on professional skills, especially teamwork skills. Survey results showed that majority of the students were satisfied with their team experience; most of them found team projects helped them learn teamwork skills and achieve more academically; almost all students thought teamwork skills were important for the work force; and the majority would welcome group projects in future learning. Students preferred to select groups by themselves, and expressed desire of more advice and checking from the instructor. Nearly 40% students reported that they cannot evaluate team members including themselves objectively because they did not want to make others embarrassed. Students also showed positive and constructive responding to team problems.

Keywords: Students' perspectives, teamwork, engineering education, China.

1 INTRODUCTION

Professional skills or transferable skills has been defined as one of the important learning outcomes for engineering graduates by professional accreditation organizations in America, the United Kingdom, Europe and Australia. Teamwork skills are one of the main attributes to be evaluated as part of these professional skills.

The most effective strategy to teach teamwork skills suggested by researchers is the cooperative learning pedagogy. Cooperative Learning (CL) was firstly introduced to engineering education by Smith in 1981 [1] and the use of this has grown so that about 60% of American college teachers adopted CL in their courses in 2008 [2].

China only started professional engineering accreditation in 2006 in a few pilot universities[3], and it included teamwork skills as one evaluation criterion[4]. However, teamwork skills have not been taken into consideration in curriculum design and assessment nationally, and cooperative learning has not been widely adopted by instructors in classes. Students may study collaboratively in learning communities, but not in structured cooperative groups. Instead, the team-working spirit has often been fostered in after class activities, while technical teamwork is overlooked in academic modules. Prospective Chinese engineers are expected to work together with engineers from other countries and cultures as the economy becomes ever more globalised, but the teaching of professional skills still lags behind that of the "hard skills", which are covered very well. This is a big challenge to engineering education in China.

Abundant research has proved the efficiency and advantages of cooperative learning [5-6] with many suggestions on CL course design, administration and assessment being available [7-11].

However, a teaching strategy can only succeed when it facilitate students' learning. Many educators shed light on students' response to the cooperative learning arrangement and their perspectives on how teamwork can best be learned. Oakley, Hanna, Kuzmyn and Felder [12] conducted a survey to 6435 engineering students to identify the important conditions for teamwork in an academic setting. Aman et al collected data from surveys, class observation and teacher commentary to get a deeper understanding of group functioning, the role of the course structure and the value students put on the CL experience [13].

This paper investigates the perspectives of Chinese engineering students on team working and the way in which prefer to learn. This appears to be the first study with respect to the viewpoints of students on technical teamwork learning in engineering education in the Chinese context.

This work is conducted on a joint undergraduate degree programme (JP) between Beijing University of Posts and Telecommunications (BUPT) and Queen Mary, University of London (QMUL). The programme aims to mix the best of teaching approaches from China and the UK, and it includes more emphasis on professional skills (especially team skills) than is usual in other Chinese degree programmes.

2 THE STUDY

A survey on teamwork study was designed and conducted among the Year 1 (Yr1) and Year 3 (Yr3) students at the end of the second semester of the academic year 2010-2011. Yr1 students took a Personal Development Plan (PDP) module that takes team working as one of its key teaching objectives; Yr3 students had participated a lot in group projects in technical module coursework as well as PDP. An educational experiment was also carried out on 134 of the 500 Y1 students in a PDP course: they were given more introductions about teamwork skills and guidance from instructors, and were administrated by a CL mechanism [14].

The participants are all registered BUPT and QMUL students, and were recruited through the National Chinese University Entrance Examination system achieving a high score above the top national line (i.e. they met the requirements to attend a national key university).

About 100 questionnaires were distributed , and 93 copies returned: 40 from students in the Yr1 experiment group, 24 from other Yr1 students, and 29 from Yr3 students.

Frequency distributions were calculated and analysed by survey items with comparisons between students from different years, and between the experiment and non-experiment groups, being conducted. Students' commentary to the open-ended questions was examined.

3 SURVEY RESULT

3.1 General perspectives of teamwork and team experience

Regarding the question investigating the students' satisfaction with team experience, we used a Likert five-point scale to calculate the satisfaction mark for each response, from "very satisfied" (4) to "very dissatisfied" (0). Survey results demonstrated that:

(i) 94.6% of the whole group were satisfied or neutral about their experience of working in a team, with nearly 40% being very satisfied (Table 1);
(ii) the average satisfaction of Yr1 students (3.28) is higher than the satisfaction mean of Yr3 (2.83);
(iii students in the experiment group of Yr1 reported the highest satisfaction of 3.35, non-experiment Yr1 3.17, and Yr3 2.83; and
(iv) among the Yr3 students, fewer chose "very satisfied" compared to Yr 1 students, but more chose "somewhat satisfied" and "neutral".

TABLE 1. *Frequency distribution of students' response on satisfaction with team experience.*

% within Grade	Year 1	Year 3	Total
very satisfied	48.4%	17.2%	38.7%
somewhat satisfied	37.5%	55.2%	43.0%
neutral	9.4%	20.7%	12.9%
somewhat dissatisfied	3.1%	6.9%	4.3%
very dissatisfied	1.6%		1.1%
Total	100.0%	100.0%	100.0%

Yr3 students showed more reservations in grading the degree of satisfaction on the team experience. One consideration is that Yr3 students experience more team working as they go through the programme and with the increase of importance and difficulty of technical modules, students care more about marks and more team conflicts occurred.

Regarding the question "do you think it is important to have teamwork skills for the work force", 97.8% of the students chose "Yes". 85.9% of the students reported that they benefit from the group coursework and academically achieve more. In the question "do you feel the group coursework help you learn teamwork skills", 97.4% of the experiment-group Yr1 students reported "Yes", other Yr1 students 87.5%, and Yr3 students 93.1%.

When they were asked whether they prefer to work individually or in groups in future coursework projects, 80.6% of Yr1 students and 89.7% of the Yr3 students preferred group projects.

3.2 Team function conditions

3.2.1 Grouping methods

It was suggested in [15] that affinity-based grouping was more appropriate for Asian students, which is grouping based on existing friendship, geographical origin, or family connections. This allows self-selection as students will choose their groups according to the existing social identity. In the survey, the students also presented their big preference on "self-selection" (54.9%) as shown in Table 2.

TABLE 2. *Students' preferred method to choose their group.*

% within Grade	Year 1	Year 3	Total
by random	22.6%	13.8%	19.8%
self-selection	61.3%	41.4%	54.9%
assigned by teacher	9.7%	10.3%	9.9%
group by academic rank	3.2%	34.5%	13.2%
other	3.2%		2.2%
Total	100.0%	100.0%	100.0%

Yr1 students firstly chose "self-selection" (61.3%) and then "by random" (22.6%); Yr3 students also firstly chose "self-selection" (41.4%) but secondly chose "by academic rank" (34.5%). One of the design courses in Year 3 grouped students by their academic ranks; the instructor explained that this grouping method allowed good students to work together to design really good products and prevented there being a "passenger" in the group. Students in the later years of the programme might find it easier to cooperate and communicate with those of the same academic rank, and they would emphasize more on the other skills like design skills than teamwork skills.

Students of each academic rank showed the same preference order as "self-selection" first and "by random" second. Male and female students reported just the same percentages in each choice, and followed the same order of choice.

3.2.2 Assessment

Regarding the assessment of the team project, Yr1 and Yr3 students showed consistent responses: 37.6% would like to get the same group mark, or an individual mark according to peer evaluation of contribution and teamwork performance, and 24.7% would like to be given an individual mark according to their academic performance in the project.

As illustrated in Table 3, students of different academic ranks have slightly different preferences of assessment methods: "top" students thought "get the same group mark" is best, while the other students (from good to weak) preferred individual mark calculated by peer rating on contribution and teamwork performance. Between genders, male students rated "give individual mark by peer rating on contribution and teamwork performance" more highly whereas female students preferred "get the same group mark" .

TABLE 3. *Which way do you think is better for the assessment of group work?*

% within previous academic rank / gender	previous academic rank				gender		Total
	top	good	middle	other	male	female	
Get a same group mark	58.3%	31.7%	25.0%	50.0%	32.1%	45.0%	37.6%
Give individual mark according to their academic performance in the project	25.0%	22.0%	33.3%		26.4%	22.5%	24.7%
Give individual mark according to peer evaluation of contribution and teamwork	16.7%	46.3%	41.7%	50.0%	41.5%	32.5%	37.6%
Total	100%	100%	100%	100%	100%	100%	100%

The validity and reliability of peer rating have always been a problem. According to students' self-judgement, more than half of the students stated that they would evaluate group members' work objectively, but there were still 39.8% of the students indicating that they would avoid embarrassing others when rating peers (Table 4). People from Confucius Heritage Culture countries often avoid "face-losing" for both themselves and others. If they rate another team member lowly, it will make that person lose face, and they will also find it uncomfortable when relating with that person in daily study and life, especially as they all live on campus in shared rooms (of 4). Yr3 students showed more reservation when rating others, perhaps because they are more mature or because they have closer bonds with other students having known them longer.

TABLE 4. *Will you evaluate your group members' work including yourself objectively?*

% within Grade	Year 1	Year 3	Total
Yes	54.7%	48.3%	52.7%
No, avoid to make some group members too embarrassed	35.9%	48.3%	39.8%
No, evaluate highly on myself	6.2%	3.4%	5.4%
No, evaluate lowly on myself	3.1%		2.2%
Total	100.0%	100.0%	100.0%

3.2.3 Instructor guidance

Among Yr1 students, the experiment-group students were given guidance and instruction, whereas other Yr1 students were let loose after setting up the task without extra guidance or checking. Therefore we only examine the effect of instructor guidance for experiment-group Yr1 students. The result showed that

(i) 60% students found "little help" in having instructor guidance for improving team effectiveness - "Students feel that the skills and guidance is very useful, but often forget to use, or do not know how to use, the skills in practice";
(ii) 30% found it "much help; the guidance is helpful, and students tried to solve problems and improve team performance using the skills introduced"; and
(iii) 10% found it had "no effect; nobody really takes the guidance seriously or use the teamwork skills actually during the team work".

It may be here that the type of instruction given needs to be reviewed for its effectiveness in the light of these comments.

It is noted that 76.4% students wanted the instructor to check work and progress at least once a week, and Yr1 students expressed more demands for instructor to check (81.3%). It may be because Yr1 students have more enthusiasm in improving skills and desire more interaction with instructors to practice skills and resolve problems occurred, and Yr3 students showed more independence and problem solving capability.

3.3 Teamwork practices

The survey result showed that more groups divided their work into parts (65.2%) than working together as a whole, with Yr3 students having a bigger percentage in this respect (75.9%). Though CL does not encourage parcelling, students may find it easier, more convenient and efficient. Yr3 students may be more inclined to get the work done quickly and save time for other commitments.

This survey also collected students' response to the usual team problems. Most students showed a positive attitude and took constructive measures towards team problems. To those members who did not contribute, 74.2% would persuade and help them to do their work (Yr3 students with less patience), which is a very encouraging finding (Table 5). Only a small amount would do nothing or attempt to "carry" them by doing the work for them.

TABLE 5. *What will you do if some members do not contribute?*

% within Grade	Year 1	Year 3	Total
Do their work for them	7.8%	24.1%	12.9%
Ask for mediation, counsel, support from instructors	12.5%	6.9%	10.8%
Persuade and help them to do their work	78.1%	65.5%	74.2%
Switch groups			
Do nothing	1.6%	3.4%	2.2%
Total	100.0%	100.0%	100.0%

For those members who are academically weak, 57% students would let them do what they are good at and 31.2% would help them, with Yr1 students showing more enthusiasm to help (Table 6).

TABLE 6. *If your partner is academically weak, what will you do?*

% within Grade	Year 1	Year 3	Total
Do his/her work for him/her	10.9%	10.3%	10.8%
Help him/her	34.4%	24.1%	31.2%
Let him/her do what he/she is good at	54.7%	62.1%	57.0%
Other		3.4%	1.1%
Total	100.0%	100.0%	100.0%

4

SUMMARY AND CONCLUSION

There are compelling reasons for assigning university students into cooperative groups for coursework projects to learn and practice teamwork skills. However, Chinese students have got used to individualistic and competitive learning, and they care more about the diploma and transcript score. With cooperative learning, students have less control on their work and score, but depend more on team cooperation. When a new pedagogy is imported, resistance and obstacles are inevitable. We can still clearly remember complaints from many students in 2007 about having to have team experience. But over the last 5 years, with JP staff and students working together, we have found that the situation has changed. This survey showed very inspiring results: the majority of students were satisfied with their team experiences; most of them found team projects helped them learn teamwork skills and achieve more academically; almost all students thought teamwork skills were important for work; and the majority of students welcome group projects in future learning.

The results also demonstrated a higher rating of satisfaction for the students in the experiment-group, and nearly all that group of students felt that the group coursework had helped them learn teamwork skills. This means the instruction and mechanism used for the groups were effective and helpful. However, students also reported that although they found the skills given by instructors were very useful, they often forget to use them or did not know how to use them in practice. Indeed most of instructors only gave initial guidance and turned groups loose. Among students' suggestions for future teamwork teaching, one said "if time permits, I hope the instructor can talk with each group and each person more"; the other suggested that instructors should make examples for them and help with the team function during the process. Students conveyed more desire for advice from instructors.

In summary, the students welcome new challenges and showed positive and constructive attitude in relating with others in groups, although some of their inherent cultural values may influence their judgement and preferences. This survey revealed well the students' perspectives on teamwork skills and how they would like to learn. Educators and instructors can use these results for design and construction of cooperative learning for Chinese engineering students.

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120 ESTABLISHING A TRADITION OF MENTORING

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ABSTRACT

The Biomimetic MicroElectronic Systems Engineering Research Center at the University of Southern California has developed an extensive K-12 outreach program. Mentoring is a key component of the outreach initiative. It is interwoven throughout the program and it facilitates the establishment of a culture of connectivity in which mentors pass acquired knowledge and skills onto successively younger generations of students and inculcates the idea of lifelong community service. This integrated mentoring conduit begins with senior university research faculty and proceeds to students at the university, high school, middle school and elementary school levels. It is the goal of the education outreach program that exposure to scientist and engineers as mentors and role models from all levels of the educational pathway will increase both the number and diversity of U.S. students who choose to become scientists and engineers themselves.

Keywords: Mentorship, Outreach, STEM, Education, Precollege

1 INTRODUCTION

The Biomimetic MicroElectronic Systems Engineering Research Center (BMES ERC) is a National Science Foundation sponsored Center of Excellence at the University of Southern California (USC). The strategic research goal of the BMES ERC is to develop implantable prostheses for a growing number of patients with profound, incurable disabilities. The BMES ERC is equally committed to establishing a K-12 pipeline that attracts and supports the nation's youth in the pursuit of Science Technology Engineering and Mathematics (STEM) careers. Science and technology play a critical role in the development, prosperity and security of a nation. And, in order for the U.S. to remain competitive on a global scale, it is imperative that a large and well-prepared STEM workforce is maintained. Understanding the importance of educating the next generation of engineers and leveraging its resources and human capital, the BMES ERC has developed an extensive K-12 outreach program.

Mentoring is a key component of the BMES ERC outreach initiative. A strong mentor-mentee relationship is a win-win situation whereby the student benefits from the experience, knowledge and skills of the more experienced mentor and in turn, the mentor increases his/her communication and managerial skill set. Effective mentoring is about relationship building and interpersonal communication with both parties working together to advance the educational and personal growth of the student. A mentoring relationship can offer significant rewards for the student through contextualization of their learning and also through personal development [1].

Mentors, on the other hand gain significant personal satisfaction. Mentoring relationships also provide networking opportunities that may last throughout one's career. These relationships are especially important for underrepresented and first generation students who often lack role models and professional liaisons that can further one's career [2].

Mentoring is interwoven throughout the BMES ERC outreach programs, facilitating the establishment of a culture of connectivity in which mentors pass acquired knowledge and skills onto successively younger generations of students. This integrated mentoring conduit begins with senior USC faculty researchers and proceeds to students at the university, high school, and elementary school levels.

2 METHODOLOGY

2.1 The Engineering for Health Academy

The Engineering for Health Academy (EHA) was established as a partnership between the BMES ERC and a local public high school in the Los Angeles Unified School District. The demographics of the high school reflect that of Los Angeles urban inner city school (70% Hispanic, 15% Asian, 13% White, 2% Black). The EHA is modelled as a small learning community (SLC). The Small Learning Community paradigm subdivides the comprehensive school population into smaller, autonomous groups of students and teachers, creating a more personalized learning environment to better meet the needs of students. SLCs have a unifying vision, rigorous standards-based curriculum, community engagement, and teacher professional development. Research shows that small learning communities have the necessary elements to counter the inherent negative effects of poverty and poor academic achievement for low-income and/or students of color [3], [4], [5]. The Engineering for Health Academy SLC is focused on biomedical engineering and is comprised of students, teachers, and counsellors from the high school and faculty and graduate student mentors from the university.

Students matriculate into the Engineering for Health Academy as 10th graders and they make a 3-year commitment to the program. They transition through a series of 4 integrated core courses (chemistry, physiology, computer sciences, and physics) in grades 10 through 12. Each EHA course is standards-aligned, rich in relevant hands-on activities, project-oriented and meets college admission requirements. The EHA curriculum has been designed by the high school teachers in concert with BMES ERC researchers and emphasizes the connections between course content and biomedical engineering principles and practices. This collaboration ensures that the high school students are exposed to the latest advances in science, technology and engineering. USC graduate student mentors meet with the high school students on a weekly basis to help them in their core classes. The mentors provide a supportive environment where EHA students receive assistance with their class work and laboratory investigations. Oftentimes, mentors provide a different perspective than the classroom teacher, and this may help the high school students better understand a concept or approach a solution to a problem from a different point of view. Many high school students struggle in chemistry and physics, classes that are fundamental to biomedical engineering. Having mentors available to assist in these courses helps to assure that the students receive a solid foundation in the physical sciences and better prepares them for the academic demands of college.

EHA students are required to design and undertake a yearly science project. They present and defend their findings at an annual Science and Engineering Fair hosted at the high school. Working on a science fair project is initially challenging for many high school students as they typically have only a vague understanding of what research involves. They are generally unfamiliar with concepts of experimental variables and controls, sample size, reproducibility and statistical significance. The university mentors are an important resource to the high school students as they design and implement their science fair project. The mentors can help the students conceptualize feasible projects that are within the technical and scholarly scope of the students and resources available at the high school. The mentors serve as sounding boards and reality checkers as the students bounce ideas off them for their science project. They help the students apply the scientific method to and assist them at every stage of the investigative process from hypotheses formulation, collection and analysis of data, to presentation of findings. Although most students initially report the conducting a science fair project intimidating, they ultimately find the experience enjoyable, rewarding, and confidence building. They credit the mentors with helping them through the process and are grateful for the opportunity to have worked with someone with relevant experience.

In their senior year, EHA students participate in the Research Experience Capstone Class. Students are matched with USC laboratories and become members of research teams. This offers the students the rare opportunity to gain firsthand experience conducting research in a university setting while still in high school, and enables them to utilize the factual information and technical skills they acquired in the EHA core courses and put them into practice. The students spend a minimum of 2 hours every school day in their respective laboratories working under the guidance of a university graduate student mentor. USC mentors help the high school students navigate the challenging transition from a structured high school classroom into a university research environment. In partnership with their mentors, EHA students develop and execute a yearlong research investigation that is integrated with the overall research focus of their respective labs. Mentors train the students in scientific protocols and methodologies, help them collect and analyze data, and draw defensible conclusions. Mentors also serve as role models to the EHA students. All of the mentors have developed the knowledge and skills necessary to gain admission to and be successful at a top tier research institution such as USC. The mentors freely share their own experiences, life stories, and academic strategies with the aspiring high school students. They offer advice on study habits, give tips on time management, and make suggestions related to the college application and financial aid processes. Mentors help the students develop soft skills like time management, communication, teamwork and responsibility. Hence, mentors play a significant role in the EHA students' attainment of knowledge, mastery of technical acumen and development of life skills. Through their example, mentors initiate the young scholars into the culture of the science and engineering communities and their influence will have lifelong positive implications.

3 THE SCIENCE FOR LIFE PROGRAM

The high school students in the Research Experience Capstone Class become mentors themselves and work with elementary students as part of the Science for Life (SFL) outreach program. Elementary school students are naturally curious about the world around them and are inclined to discovery. Typically, however, a disinterest in science begins in the middle school years [6]. A myriad of factors are associated with this turn of events including: a weak foundation in science and math knowledge and skills, students' shifting attitudes toward science as boring and too rigorous, inadequate teacher training, poorly designed curricula, lack of relevant experiential activities and a dearth of role models.

The Science for Life outreach program has partnered with a public elementary school located in East Los Angeles. The school is a Title I school with the majority of the students eligible for the free or reduced lunch program. Many of the students are limited English proficient and come from families where neither parent has completed high school. Typically, this cohort of student does not pursue STEM educational or career pathways.

Many educational research studies show that middle and high school curricula that are inquiry-based and hands-on have a positive impact on students' comprehension of science and mastery of technical skills as compared to students taught using a traditional educational model [7] [8]. In an effort to introduce and motivate students to the excitement and potential of science and engineering at an early age the Science for Life program has developed and implemented age-appropriate, relevant, and interest-provoking educational modules for the elementary students. Each module is composed of a series of lessons which use the research of the BMES ERC as a focal point to make science relevant to the young children. Lesson plans are age-appropriate, standards-aligned, and incorporate multiple-problem based learning exercises demonstrating the discipline of scientific discovery. The classroom is transformed into a virtual laboratory with the elementary students being scientists and engineers and conducting actual experiments. In other words, students learn science by doing science.

SFL lessons are taught during their regularly scheduled science class. These classes typically have 30 students enrolled. However, for the implementation of the SFL program, the class is divided into 3 groups and each of these groups is taught by a pair of SFL mentors composed of one EHA and one USC student. This 5:1 ratio of mentor to students facilitates the mastery of science content and skills and also helps establishes a rapport between mentors and students. Most elementary students do not have direct contact with individuals who have such enthusiasm for and experience in science, let alone someone so close to their own ages. This mentor-student interaction fosters the perception among elementary children that science can be exciting and "cool".

Mentors receive training in the science content and skills covered in the lessons prior to going into the classroom. Mentors are also trained in pedagogy so that they are better prepared to meet the challenges of the classroom. The elementary teachers also speak with the mentors and discuss the dynamics of their classrooms. Each lesson is followed by a debriefing session when mentors offer feedback on what worked during the lesson and what needs attention. This information is used to continually modify the program to meet the needs of both the elementary students and the mentors.

The Science for Life program introduces students, who traditionally are not well represented in the STEM professions, to the excitement and possibilities of science. It prepares the students for success in the challenging learning environments they will encounter as they progress through their K-12 years. This early intervention increases motivation for and literacy in science among a cohort of students who typically drop out of the science pipeline. Keeping them engaged in science offers them opportunities to be active participants in the discovery process throughout their lives.

4 FAMILY SCIENCE DISCOVERY DAY

Research has shown that both teachers and parents are major influences on a child's attitude towards and performance in science [9]. Traditionally, the Latino family is a close-knit group and the most important social unit [10] [11]. In an effort to involve family members in the education of the elementary children the SFL outreach program hosts an annual Family Science Discovery Day. Objectives of this event include: 1. to demonstrate to the parents and other members of the extended family what the children have been learning in the Science for Life modules, 2. to directly engage the entire family in STEM discovery activities that are informative and fun and, 3. to reinforce the idea that learning is a family matter.

Parents, grandparents, aunts, uncles, and siblings of the 5th grade students are invited to participate in Family Science Discovery Day. The elementary children together with their family members, rotated through a series of interactive discovery activities that are adaptations of lessons drawn from each of the three SFL modules. The activities introduce the family members to the concepts and skills taught in the Science for Life modules in a fun and engaging way. EHA high school and USC university students, all of whom are fluent in Spanish facilitate the events. And, since the 5th graders have already been through these lessons and are familiar with the content and skills explored in the activities, they too serve as mentors to members of their own family. They shine in the eyes of their relatives and this in turn builds their self-confidence.

5 CONCLUSION

The BMES educational program has brought the excitement of scientific discovery to hundreds of elementary and high school students as well as to their teachers and extended family members. Leveraging the substantial resources and human capital of the BMES, educational curricula that are experiential, hands-on and aligned with California State Science Standards have been developed and implemented directly into K-12 classrooms. Lesson plans are rich in activities that demonstrate the scientific process thus ensuring that students learn science by doing science. BMES research is used as a focal and reference point so that K-12 science is contextualized, helping to address the perennial question, "Why do I need to know this?

Most K-12 students have limited opportunities to directly interact with scientists, engineers or students who are planning to become scientists and engineers. Thus, the typical elementary and high school student frequently entertains misconceptions of what these professionals look like and what they actually do. To address this situation the BMES ERC outreach program has made mentoring a central tenet and has interwoven mentoring throughout each of its outreach components. The mentoring conduit begins with senior BMES ERC faculty researchers and proceeds through the university, high school and elementary school levels. Individuals from one educational level serve as mentors and role models to the next level thus establishing a culture of connectivity that spans the full educational and professional spectrum. It is the goal of the BMES ERC education outreach initiative that dynamic involvement at all levels of the educational pathway will increase both the number and diversity of U.S. citizens becoming scientists and engineers, thus ensuring the nation's competitive edge well into the future.

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123 EFFECTIVE TEACHING METHODS FOR CAPSTONE DESIGN COURSES : CASE STUDY

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ABSTRACT

This study analyzes the effectiveness of current Capstone Design teaching methods and makes suggestions based on its findings. To reach these conclusions, an university program was chosen and based on course evaluations, an adequate representative case subject was selected. The sample was analyzed based on the course syllabi, topics of study and course contents, teaching methods, course evaluations and learning outcomes.

In this study, we intend to propose how to teach effectively in Capstone Design courses for implementation.

Keywords: Teaching Methods, Capstone Design, Design Courses.

1 INTRODUCTION

Beginning in March 2005, "A" University began to seek accreditation for its Engineering Education programs, based on the 2005 KEC standards for ABEEK accreditation. In December 2008, the Engineering Education programs met KEC standards and all of the programs received accreditation. Further, students who graduated in February of 2009 were considered a part of the accredited program. In 2010, the programs were evaluated based on KEC standards and again received accreditation.

Engineering Design is an application of the various techniques and principles in order to correctly identify appropriate equipment, processes and systems [1]. By doing so, students can improve their skills through participation in various levels of design courses, which will enable them to be more effective in the field. Furthermore as creativity increases in importance in the field of engineering design, it also increases in importance in the classroom [2].

In particular, students need to integrate their knowledge and experience they have learned in Capstone Design courses. Through these courses, students can enhance their design skills. In order to implement effective Capstone Design courses, teachers have to develop optimal teaching methods to support their students.

This study analyzes the effectiveness of current Capstone Design teaching methods and makes suggestions based on its findings.

2 ENGINEERING DESIGN & TEACHING METHODS

2.1 Engineering Design

Design is the process of planned change. Design demands that we plan change so that we end up with the results we want. Engineering design refers to the process used to create something new to solve a problem.

The engineering design process can be complicated. Design process is nothing more than a logical problem-solving technique (Figure 1). It is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to narrow down the possible solutions [2]. A good understanding of problem-solving techniques is useful in all aspects of life, not just designing products. In a design process the goal is to minimize undesired effects and control risk.

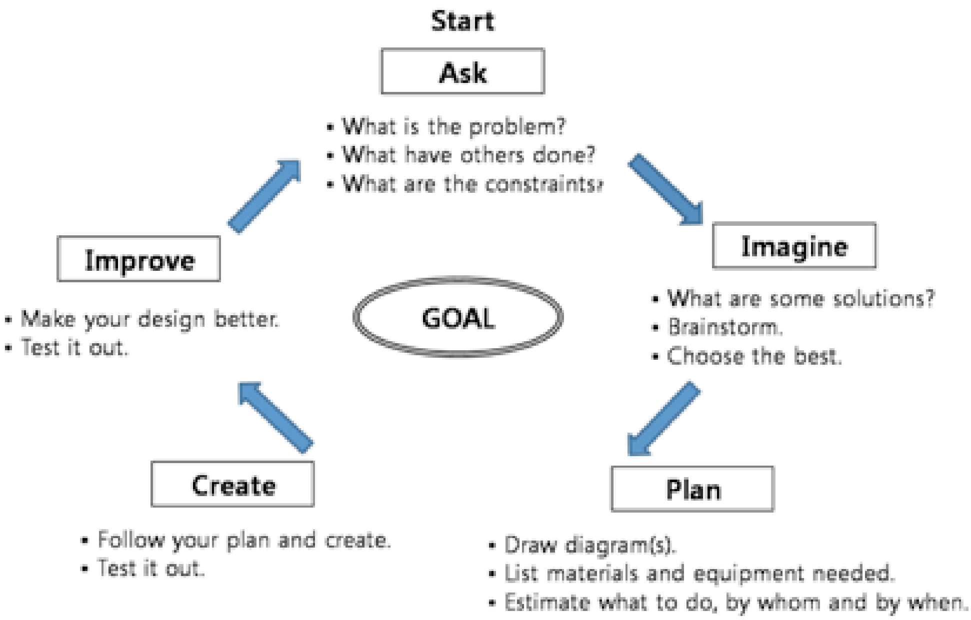

FIGURE 1. *Engineering Design Process.*

Problem solving is the process of understanding a problem, devising a plan, carrying out the plan, and evaluating the effectiveness of the plan in order to solve the problem or meet a need or want [3].

Experienced engineering designers take the time to form a plan that lists, orders, and prioritizes items. However, as design problems get more complicated, you need to increase your planning to solve the problem efficiently. The step of the engineering design process is to Improve. Obtaining additional knowledge through iteration often results in better ideas. Iteration in a design process is analogous to a closed-loop system, allows feedback within the process.

Especially the senior capstone design course is the culmination of the previous three years of the undergraduate curriculum. The goal of this course is to develop students' communication (oral and written), interpersonal, teamwork, analytical, design, and project management skills through a team-based design experience [4].

2.2 Teaching Methods

The theoretical framework of teaching methods is currently characterised by a variety of perspectives and viewpoints on the issues of learning, activity, and knowledge appropriation, as researchers and scientists interested in the complexities of learning in a wide range of research fields.

Project-based learning is a form of contextual instruction that places great emphasis on student problem-finding and framing, and which is often carried out over extended periods of time [5]. Project-based learning places demands on learners and instructors that challenge the traditional practices and support structures of schools. Thus instructors need help to be coaches and facilitators. Instructors have to act as role models, manage multiple projects, consult in areas of limited expertise, guide with feedback, promote teamwork, recognize and intervene when problems arise [6]. Learners need support for taking on the whole project, not just carrying out tasks assigned by the instructor. They also need to make sense of their results and transform project efforts into valued products and results.

Situated learning is a theoretical perspective on the nature of knowing and learning, which emphasises the situatedness of learners in specific environments [7]. These environments or contexts are formed, in part, by the learners and other participants along with available ideas, tools and physical resources. Contexts afford and constrain what learners and other participants can do and come to know. This perspective suggests that knowing and learning cannot be abstracted from the environments in which they take place. Knowing and learning are not processes that transpire independent of context and, therefore, cannot be considered as isolated events that occur in the minds of individuals.

Problem-centered learning environment, students have opportunities to practice applying their content knowledge and workplace skills while working othentic, contextualized problems and projects [8]. The terms problem-centered learning and problem-based learning are often used interchangeably to refer to instructional approaches.

3 METHODS & STRATEGIES

3.1 Participants

This study looked at 50 forth-year students in Program B at a Seoul-based university. Each instructor taught 2 courses each; one course used project-based learning method, and the other used situated problem-based learning method. All students were surveyed at the end of the semester.

3.2 Research Procedure

In this study, an university program was chosen, and based on course evaluations, an adequate representative case subject was selected. The sample was analyzed based on the course syllabi, topics of study and course contents, teaching methods, course evaluations and learning outcomes.

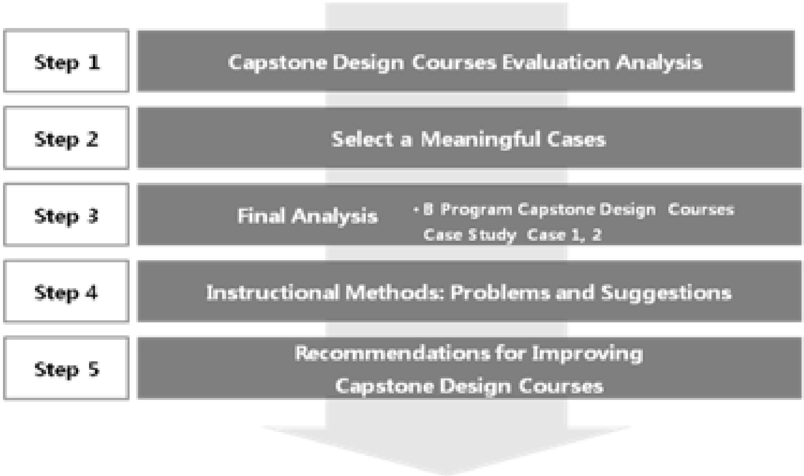

FIGURE 2. *Research Procedure.*

3.3 Class Structures

This class consists of a main professor, supervising professors, and mentors. The latter two guide student groups. The main professor instructs the class while the supervising professors look over the project processes and give feedback to the student groups.

The students must participate in the main professors class and receive guidance from their supervising professors at any time.

During regular class time, students must present their output based on their design notes individually and in groups, and after receiving feedback from the main professor, they must revise and update their final design.

3.4 Course Strategies

A comparison of the project-based learning and situated based learning strategies can be seen in Table 1 below.

TABLE 1. *Courses Comparison.*

Topic	Case 1	Case 2
General Course Syllabus	Outcome-focused	Process-focused
Design Syllabus	Learning Activities Minimum Requirements	Basic Guidelines for each Learning Tasks
Learning Tasks	- Task Selection Process: 1) in teams students select a task 2) professor gives feedback 3) students finalize tasks - Total 1 (team project)	- Task Selection Process: 1) Students form groups and select a supervising professor 2) each group choose a task related to the supervising professor's projects - Total 1 (team project)
Instructional Methods	Project-based Learning Method	Situated Problem-based Learning Method
Specialized Teaching & Learning Strategies	- The main professor helps students realize their creative potential as they work under design constraints in their course	- The main professor helps encourage students to focus on their tasks while placing emphasis on real life application and constraints - Students are also given basic guidelines and are requested to apply engineering processes
Feedback	Give a feedback about learning outcomes	Give a feedback about each process
Evaluation	Quantitative Evaluation	Quantitative & Qualitative Evaluation

3.5 Data Analysis

This study used SPSS version 18.0 to conduct its analysis.

4 RESULTS AND DISCUSSIONS

According to Figure 3, on average, students in Case 2 reported having accomplished more of the desired course outcomes than those in Case 1. Compared to Case 1, Case 2 also demonstrates an upward trend in accomplishing desired course outcomes, as compared to Case 1. In particular, PO (2), (3), (5), (6) and (7) show a significant upward trend in reported results. Furthermore, PO (2) and (7) demonstrates a significant statistical difference in comparison with the other cases. However, the overall difference in results between Case 1 and Case 2 is minimal.

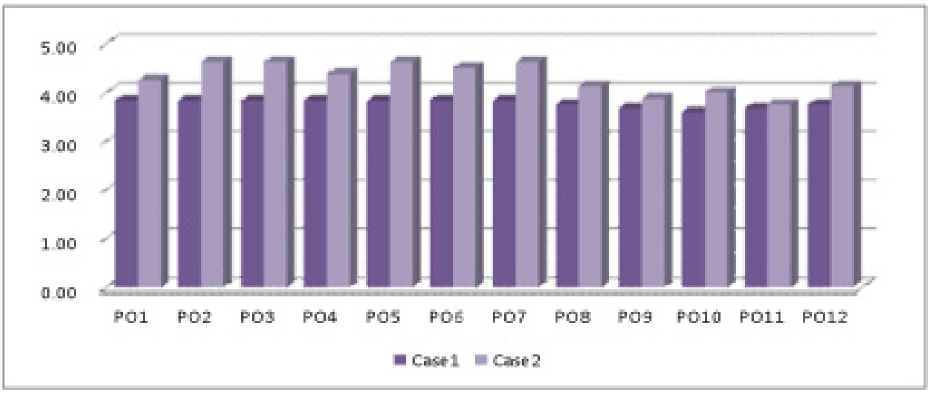

FIGURE 3. *Analysis of Achievement of Program Outcomes.*

TABLE 2. *Program Outcomes.*

PO	explanation
PO1	an ability to apply knowledge of mathematics, science, and engineering
PO2	an ability to design and conduct experiments, as well as to analyze and interpret data
PO3	an ability to design a system, component, or process to meet desired needs within realistic constraints
PO4	an ability to identify, formulate, and solve engineering problems
PO5	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
PO6	an ability to function on multidisciplinary teams
PO7	an ability to communicate effectively
PO8	a recognition of the need for, and an ability to engage in life-long learning
PO9	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context
PO10	the basic knowledge of contemporary issues
PO11	an understanding of professional and ethical responsibility
PO12	an ability to understand in the nation cultures and cooperate internationally

5 CONCLUSION

In our case study we looked into project based learning and situated problem based learning with regards to our findings, we put forward the practical instruction methods for the Capstone Design class. The conclude were as following:

First, situational problem based learning achieved better instructor satisfaction, met more educational goals, and resulted in better program learning outcomes than project based learning.

Second, when the students selected their design theme based on real life situations, they become more interested and motivated.

Third, students applied their practical knowledge and skills in the workplace.

Forth, the students were satisfied with their evaluations because the professor specified the evaluation factors at the beginning of the course.

The following we put forward as methods to improve the Capstone Design class.

First, because there is not enough time for students to finish their project in one semester, there needs to be a bridge between basic and advanced courses.

Second, there needs to be an orientation for supervising professors and mentors in order to enhance their understanding of the course.

Third, students should give fewer presentations in order to reduce the workload.

Forth, professors should provide multimedia material in order to help students solve their problems and raise their interest and motivation for their class.

Fifth, when students give their final presentation, a workplace professional's evaluation should be included. This professional's area of expertise should be related to the student's project.

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124 LOW-COST REMOTE SEMICONDUCTOR DEVICES LABORATORY WITH NI SWITCH

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ABSTRACT

This paper describes the design and implementation of a low-cost semiconductor device characterization laboratory using computer-controlled instrumentation and the Internet. National Instruments (NI) PXI-1042 hardware combined with NI PXI 4130 power SMU and NI PXI 4110 programmable DC power supply, NI TB 2636 and LabVIEW software are used to implement the low-cost laboratory.

Keywords: semiconductor device characterization, remote laboratory, NI PXI4130, NI PXI 4110, experiment scheduling, LabVIEW, SPICE parameter

1 INTRODUCTION

In engineering education, hands-on laboratory experimentation is essential. Advances in the Internet technology, together with the ever increasing computer-controlled instrumentation, have augmented the development of real time measurement-based remote laboratories. In an instructional laboratory course, students perform various experiments that combine measurements, automation, and control where virtual instrumentation (VI) provides an ideal platform for conducting remote experiments.

Micro- and nanoelectronics device and circuit design and fabrication are specialized fields in electrical engineering. The main goal of undergraduate and/or postgraduate level microelectronics teaching is to produce high-quality engineers who are able to make contributions in the context of the rapid change that characterizes integrated circuits (IC) fabrication. In teaching semiconductor devices, characterization of transistors and other active devices are essential to enhance the hands-on experience. Traditionally, microelectronics device courses lack a laboratory component. This is largely due to the high cost and complicated logistics involved in implementing such a laboratory for classes with a large number of students. Over the last few years, development of an online laboratory at IIT Kharagpur makes microelectronics device characterization over the Internet possible [1-2]. Low-cost solutions for laboratory experiments offer more flexibility and thus the virtual tools and laboratories in engineering education are increasingly gaining attention [3].

The success of a VLSI circuit design depends on the device models used to describe the device behaviour. As semiconductor devices shrink, the need for accurate circuit simulation using SPICE model becomes acute. The most important component in an IC manufacturing process is the devices themselves. It is thus imperative that these devices are accurately characterized so that accurate model parameter set for the device under test can be extracted. The device models usually consist of a set of model equations that are either empirical or derived from device physics or a combination of both. Therefore, the design of integrated circuits is heavily dependent on circuit simulation, which needs compact device models. From the measured device characteristics SPICE parameters are extracted. Parameter extraction is also an integral part of compact modelling. The goal of parameter extraction is to determine the values of device model parameters that minimize the total differences between a set of measured characteristics and results obtained by evaluation of the device model.

In this study, we report on the development of an online low-cost semiconductor device characterization laboratory using National Instruments (NI) LabVIEW and PXIs which provide a perfect platform for designing remote experiments. It is organized as follows. Section 2 briefly describes the architecture of the laboratory. Section 3 discusses the educational use of the laboratory for device parameter extraction. Section 4 summarizes the lessons learned from using the online laboratory.

2 IMPLEMENTATION

The device characterization laboratory generally consists of several instruments to characterize semiconductor devices and a group of computer hardware and software components that bring the laboratory on the internet [1-3]. The complete range of semiconductor dc parameters can be quickly and accurately evaluated with Agilent 4156C stand-alone instrument. A switching matrix (Agilent E5250A) allows the remote selection of one device out of eight possible devices that are connected to the system. However, such a characterization laboratory needs to use state-of-the-art characterization equipment; hence the laboratory is rather expensive. In the following, the development of a very low-cost online laboratory using National Instrument (NI) products which provide a perfect platform to design device characterization experiments is described (see Figure 1).

National Instruments PXI 4130, 4110, and Agilent E3631A DC Power Supply hardware along with LabVIEW software is used to implement the low-cost device characterization laboratory.

The National Instruments PXI 4110 is a programmable, triple-output precision DC power supply in a single-slot, 3U PXI module. The NI PXI 4110 has two isolated channels, one from 0 to +20 V and the other from 0 to -20 V, and a single non isolated 0 to 6 V supply, all capable of sourcing up to 1 A per channel. The PXI 4110 has 16-bit resolution for programming the voltage set point and current limit and for using the voltage and current read back measurement functionality. As a case study, we have developed BJT characterization experiment (see Figure 2). The important components of the device characterization laboratory are:

- A web interface handling user authentication, resource scheduling and other administrative jobs, such as maintaining students records, experiments performed etc.,

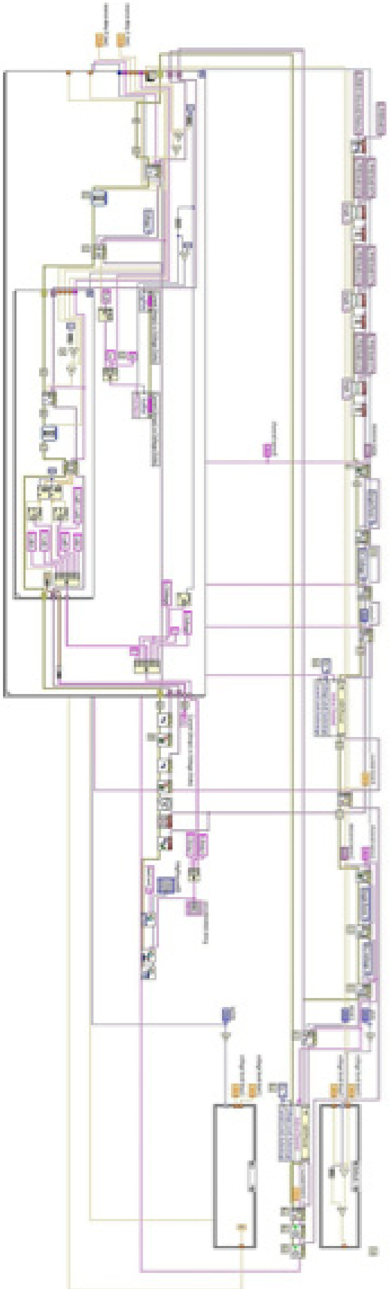

FIGURE 1. *The LabVIEW VI flow diagram.*

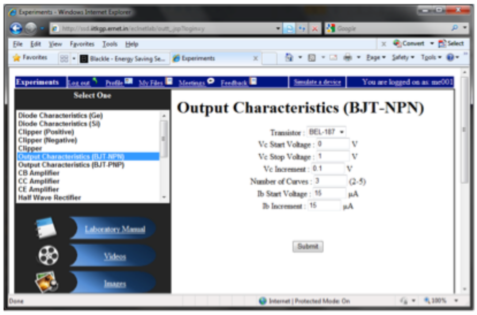

FIGURE 2 *The Input Page for the experiment.*

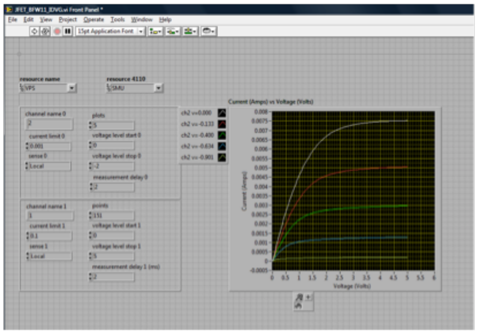

FIGURE 3. *The LabVIEW front panel for parameter setting by the user for device characterization.*

FIGURE 4. *User interface for plot of data from characterization. The data can be exported to the user's PC in text format.*

- An equipment server hosting instrument hardware for experiments, plus a switching matrix. The server software is written in LabVIEW and the instrument drivers are VI compatible, and
- A measurement server handles the requests from the students.

Additionally, the students are made aware of how the instrument actually carries out the measurements. The server checks the desired device before they are passed on to the equipment server. After measurements are complete, the experimental data are passed to the users.

The NI Switch TB 2636 contains a set of rows and columns. Using LabVIEW it is possible to configure connection to a certain pair of row and column i.e., to make a new path for connectivity. VI file may be configured to specify particular row and column to connect a particular device. Also, one can select connection to desired power supply for different types of biasing necessary for different transistors. Individual VI file is needed for each device based on its operating condition for optimal performance. Each VI file contains information on a particular combination of the row/column. There is also a redirector VI file that basically transfers the request from web to a particular device's VI file based on a request parameter.

The NI-1042 and its constituents perform measurements and return the data. For an experiment, parameters are taken from the users, an estimated time is calculated and the request is stored in a queue to be processed when all earlier requests in are done. The results are saved on the server and displayed to the user using special interfaces. The user can collect the data anytime afterwards. The display and processing of the results are carried out on the user's PC.

3 THE EXPERIMENT MODULE

The NETLab system integrates the experiments along with other experiments in the list. The user selects the experiment and can access the following:

a. The study material including text, images and videos
b. Laboratory manuals
c. perform the experiment
d. view the saved data

3.1 Performing the Experiment

The NETLab implements the LONG schedule algorithm [4] to handle the experiments. All the experiments take 5-10 minutes to complete. The NETLab Scheduler does the following:

a. Take a set of inputs parameter (see Figure 2)
b. The parameters are added to the queue
c. A scheduler algorithm runs at the server that picks up the earliest request and starts processing it.
d. Once the experiment is done, the data is taken to the main server and saved.
e. The user can download and see the output anytime they want.

3.2 Data Transfer

The data transfer takes place at two levels. First, there is the PXI chassis acting as the local server that controls the experiment. It is connected to the transistors. The data is transferred from the local server to the main server using a RESTful web service. When the scheduler makes a request it actually calls a web service on the local server. The local server processes the request using a LabVIEW VI file. The data is returned in XML format. The data is read and saved at the main server. When the user wants to view the data, the flex front end application imports the XML data and displays it.

4 LESSONS LEARNED

The flexible nature of the user interface allows students to explore various modes of operation of the device (see Figure 3). After measurement execution, the instruments return numerical results to the user through the server, and the server terminates the connection with the user and making the laboratory available to a different user. There is a great deal of educational value in using the device characterization laboratory.

FIGURE 5. *Home page showing available experiments.*

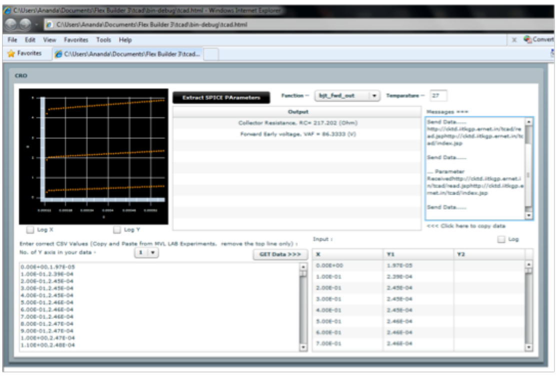

FIGURE 6. *Output characteristics plot for the BJT in the user's PC and SPICE parameter extraction.*

The data can be exported to the user's PC in text format. The first component of the online laboratory educational experience concerns the data display for various device characteristics (see Figure 4). The user interface allows the students to easily select which variables (parameter) to plot in three different axes (one abscissa and two ordinate axes), whether the scales are linear or logarithmic, and the range of all the scales to extract multiple device parameters, for example, for a MOSFET, the threshold voltage, body parameter, surface potential at threshold, channel length modulation parameter, sub threshold slope, and the off current from the data set (see Figure 5). The second educational aspect of the online laboratory experience is offline data manipulation. The user interface allows the export of the measured data to a file in a format that is easily portable to various data analysis software tools. The student uses his or her favourite software package to further process the data, write program for the model based on the equations that describe the device operation, for example, in the case of a MOSFET, the model will involve a set of equations that describe the current-voltage (I-V) (see Figure 6) characteristics of the device in the linear and saturation regimes, extract SPICE parameters, build simple models and compare their findings with the manufacturer's data.

5 CONCLUSION

We have developed and implemented a low-cost online laboratory to carry out real-time microelectronics device characterization through the Internet. The most significant contribution of our device characterization laboratory experiments is that students, particularly the undergraduates, have the opportunity to measure device characteristics, model various device parameters and extract SPICE parameters. Online laboratory offers a new level of convenience that students really value which allows them to focus on the educational issues.

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126 RADAR ENGINEERING AND RADAR METEOROLOGY EDUCATION PARTNERSHIP BETWEEN COLORADO STATE UNIVERSITY, AALTO UNIVERSITY, AND UNIVERSITY OF HELSINKI: AN EXPERIMENT IN CONTENT DELIVERY AND PEDAGOGY

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ABSTRACT

The three universities discussed here, Colorado State University (CSU), University of Helsinki (UH,) and Aalto University, have formed a partnership in electromagnetics and radar programs to support innovative research in remote sensing. A key element of any program is education. All three universities have strong programs in relevant areas such as radar engineering (CSU), electromagnetics (Aalto), and radar meteorology (CSU, UH). The goal of the collaborative program is to bring together the strengths of these programs. The traditional paradigms of exchange visits and seminars were good, but lacked the fully immersed three-way interaction of the students who are the critical part of these programs. This paper presents an innovative implementation of global competence integration.

Keywords: International, Environmental Radar, Education.

1 INTRODUCTION

In order to facilitate an environment to stimulate three-way interactions among the students and researchers at Colorado State University, Aalto University and the University of Helsinki, an advanced course offering was created jointly between CSU and Aalto, using the research facilities of the University of Helsinki. The main objective of this course was to develop a team-building environment among the students and researchers at the three universities. The topic of research is electromagnetics and radars. There are multiple barriers present in this situation. First and foremost is the language and cultural barrier. The second is the time zone difference: there is a perfect nine-hour time difference between Colorado State and Finland. Just as people come in to work at Colorado State, the researchers are about to go home in Finland. The third and major issue is creating an environment that will facilitate people's interaction across national boundaries, time zones and continents, and cultures.

There was significant debate regarding whether to implement this program live across three universities, or present it in a batch mode with recorded video. Simple debate quickly rejected recorded video, and live operation was implemented. Live class instruction was offered (simultaneously) to students at all three universities using online tools, and the students fully interacted over a semester. The students were paired between Helsinki and Colorado and assigned specific projects. This was perhaps one of the most important aspects of this course, as the students learned to collaborate with their counterparts throughout the semester just as they do in industry or advanced scientific organizations. The teams had to prepare joint reports. The level of stimulation and interaction was exemplary and three of these student projects turned into papers that were presented at research conferences. The instructor for the course shared time between the campuses over the semester; thus, the students saw the professor both live and virtually. We are extremely pleased with the success of this experimental course and are thinking of ways to making this experience continue. However, it is a challenge to maintain the same enthusiasm as existed for the first offering of the course.

1.1 Collaboration and instruction technologies

The main collaboration technology used for instruction included Adobe Connect and Skype. Adobe Connect was convenient because all participating institutions had licenses and the software scaled well for multiple student use. This also enabled the students in Helsinki to participate from home (in a distributed environment). When the classes were taught from Helsinki, even though standard classrooms were used, some students from industries from far off cities such as Tampere chose to use the electronic delivery format. The availability of electronic delivery of content made it easy for some students who are also employed to do the business travel required as part of their employment. Thus, the opportunity to work with Colorado State University enabled more employed students within Finland to participate in the class while satisfying their employment obligations. In fact, one active student in the class was from Sodankylä. Another key enabling piece of collaborative software for this course is VCHILL[1][2], which is a virtual radar system. As part of this class, a CSU student travelled to Helsinki to install the VCHILL system at the University of Helsinki radar system. This itself was an important experience for both the student doing the installation and the students in Finland who were learning this system.

1.2 Research and instructional facilities

Two radar systems, the CHILL radar [3] located at Colorado State University and the Kumpula radar located at the University of Helsinki, were the two major instruments that were a key part of this international educational experience. Both systems are significant national-level research facilities with a value running into several millions of euros, and were major source of focus and collaboration. Details of CHILL and Kumpula radar can be found at www.chill.colostate.edu and http://www.atm.helsinki.fi/radarlab/instruments.html , respectively. Figure 1 shows a picture of the CSU-CHILL radar and Figure 2 shows the Kumpula radar. The CHILL radar operates at S-band frequency (approx 2.8 GHz) and the Kumpula radar is at C-band (5.5 GHz). These two radars were used extensively both in instruction and in supporting the various projects the students undertook.

1.3 Course projects

The projects were a unique part of the course. Fortunately, there were sufficient students on both sides of the Atlantic to be grouped into small teams. The students went through a "grand electronic meeting" and brainstormed on the projects . Finally, groups of two or three were formed. The main criterion was there should be at least one student from each side of the Atlantic Ocean. In the beginning, the students were overwhelmed and anxious about this arrangement. Essentially, the students completed projects with partners whom they have met only electronically.

While the projects evolved in this environment, the students generally chose projects that could not be finished in a single semester and most of them completed a larger, much more substantive project. This is one area where some limits could be placed if these projects are tried again. Nevertheless, the projects were extensive in nature, and three of them are proceeding for publication.

1.4 Guest lectures and tours

Another important aspect of this course were guest lectures and tours, which were part of the instruction. For example, Professor Ari Sihvola presented a few lectures on dielectric constants of mixtures and Dr Moisseev presented lecture tours of the Kumpula radars. Similar tours were arranged for the CSU-CHILL facility.

2 FINDINGS

The major finding of this class offering is the power of collaborative learning enabled by electronic collaboration tools. The students really enjoyed the joint projects across continents. They were intrigued by the complementary skill sets the different students brought, and the diversity of thinking, driven by the diversity of the different universities. All the projects were very high quality. The course emphasis changed from teaching to "learning" in an internationally collaborative environment. In their feedback, the students said that they learned more from the projects and interaction during homework sessions than they did in the in-class instruction. The overall class was managed by the CSU's electronic class management system, called RAMCT.

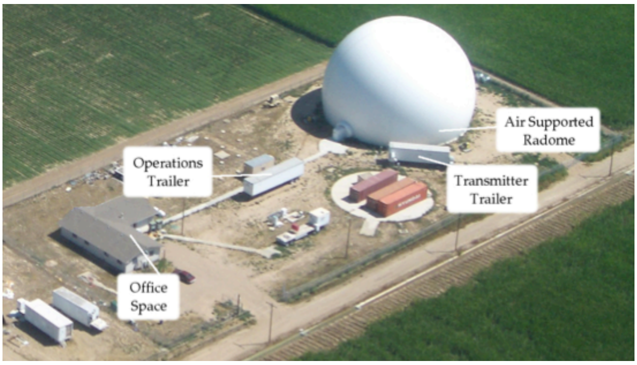

FIGURE 1. *CSU-CHILL radar facility, with labels indicating major features.*

FIGURE 2. *Kumpula C-band weather radar.*

3 FUTURE PLANS

Currently, the authors of this paper are contemplating how to carry the success of this class into the future while capitalizing on the successes and minimizing any risks. This course was a graduate-level course; the students were at an advanced level and were able to capitalize on the project experience. Some options being considered are a project-only course with minimal instruction. Another possibility is to expand the course projects to more areas thematically connected, such as signal processing and RF design. One option that will definitely be explored is bringing this pedagogy to undergraduate-level instruction. These options will be studied jointly by Aalto, the University of Helsinki, and Colorado State University. The findings will be reported in a future ICEE conference.

4 CONCLUSION

The availability of electronic media for communication, and the interface with complex engineering facilities, are breaking down barriers in educational experiences and providing new opportunities. While these new opportunities are exciting, university curriculum committees are historically very conservative and examine change very carefully to ensure that the fundamentals of education are not compromised. There will thus be a natural set of checks and balances as these new forms of education and collaboration are explored. The type of education described here also raises many instructional boundary questions and brings the concept of cross-listing courses to a new level. It also raises procedural questions such as, where do the students register for these courses? These issues will be addressed as part of the agreement that will be signed by all the instructional partners.

6 ACKNOWLEDGEMENTS

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128 ENHANCING STUDENT PARTICIPATION IN ENGINEERING EDUCATION: AN ALTERNATIVE APPROACH TO PRACTICAL WORK SESSIONS

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ABSTRACT

A new approach to student practical work sessions was applied to the automotive engineering and logistics engineering laboratory exercises in line with the innovation pedagogy as applied by the Turku University of Applied Science. Innovation pedagogy notes that constantly improving your know–how in turn leads to further know-how, new ideas and practices. Group work at its best can provide students with tools for working life team work, enhance the learning of a subject matter, motivate and create group dynamics and ideas more innovative and numerous than when undertaking the work on an individual basis.

Group participation and group dynamics were examined within the automotive and logistics department, in particular in the automotive laboratory group assignments. Of particular interest was if the two fold objective of simultaneously teaching a subject matter and team work was clear to all participants. Another aim of this study was to determine the optimal size of the teams within the practical group sessions, optimal size in terms of learning the subject matter as well as group cohesion and equal participation of all group members. All the aforementioned aim to increase student involvement, in particular by paying emphasis on the student fraction with a lesser degree of involvement. In conclusion this approach aims to provide teaching staff with new hands on tools how to enhance group work within the syllabus. Students benefit of this approach by understanding the two fold objective of group work as well as increased cooperation and group cohesion. This study also highlights issues to be addressed in further studies.

Keywords: group participation, student involvement, innovation pedagogy.

1 INTRODUCTION

Innovation pedagogy is applied by the Turku University of Applied Science (hereafter TUAS). [1] The underlying idea in this approach is that constantly improving your know-how in turn leads to further know-how, new ideas, practices and possibly also innovations. In particular, TUAS applied a new approach to the student practical work session within the automotive and engineering laboratory exercises. Group work when at its best, can provide students with tools for working life team work, enhance the subject matter studied, motivate and create group dynamics and ideas of more innovative in nature and more numerous than when undertaking the work on an individual basis.

The needs of today's working life are also addressed by the inclusion of group work in the syllabus. Working life increasingly required team members in an increasingly complex world. The engineering accreditation agency ABET, includes teamwork in its list of essential professional skills for engineers to have in today's working life. [2] Interpersonal skills are also improved by using the teaching method. In summary the inclusion of group work within the student practical work sessions enhances team work, interpersonal skills, creative as well as critical thinking skills and also problem solving skills.

In this paper group participation and group dynamics were examined in particular in the automotive laboratory group assignments. Of particular interest in this study was if the two fold objective of simultaneously teaching a subject matter and team work was clear to all participants. Another aim of this study is to determine the optimal size of the teams within the practical group sessions, optimal size in terms of learning a subject matter as well as group cohesion and equal participation of all group members. The aforementioned are aimed at increasing student involvement, in particular by involving and paying special attention to the student fraction which is participating less.

1.1 Group work and participation

Group work is used widely in teaching engineering. Large student numbers and the limited amount of class room taught time, as well as the industry's call for an increase in interpersonal skills and team work skills has created pressure for more efficient teaching methods, methods encompassing all the aforementioned aspects. A shift from teaching individuals to teaching groups and using group teaching methods has occurred as a response to working life's expectations that graduates are team players as well as lifelong learners/students. [3]

A large number of studies have been undertaken to assess the benefits and weaknesses of group work, the results of which are both negative and positive. [4] The critical findings note that in a group assignment free-riders, excelling students or groups dominated by a bully are assessed by the same standards as groups functioning effectively. The allocation of work between group members can vary greatly. Students with a lesser work load often contribute less and subsequently learn less than those with a greater work load. [5] When at its best the dual purpose of group work is achieved: group members learn and understand the assignment they have been given and team work skills are enhanced and practiced. [6]

2 EXPERIENCES OF GROUP WORK SESSIONS

The automotive and logistics study line at TUAS the first two years concentrate on learning the theory of the so called general engineering studies. Specialisation lines begin during the third year. In this study, the second year engineering students from the intake group of 2009 were examined, and in particular the first practical work session taking place over the spring term of 2011.

The intake group of 2009 examined consisted of 8 male students, all with a high school background. The intake group was grouped into four small groups during the first session i.e. working pairs. The grouping was undertaken on a voluntary basis. A further student from an earlier intake year was added to the class after this session. The course is normally taught by one teacher, the laboratory engineer. During this study an additional teacher supervised the course as part of his teacher training studies.

One of the hidden objectives of the first group assignment and practical work session is that the students acquaint themselves with the facilities and working practices of TUAS. It has to be noted that both the equipment and methods used as well as cars were unfamiliar to the majority of the intake group. A clear objective which was covered during the class room sessions was the importance of team work capabilities. A total of six group assignments were undertaken. The team leader and the person in charge of reporting on the assignment alternated for each assignment so that each team member was in charge of three assignments and also reported on three assignments.

Problem based and action centred laboratory teaching requires participation of each student and also completion of written work specifications. The outline of the course is agreed upon at the start: timetables & deadlines, work instructions, assessment criteria and possible compensation procedures. The assessment is based on the preparation undertaken for the contact sessions, undertaking the work and the quality of the written reports.

The study collected from the students written course feedback by using a self- assessment form. The reason for using a self-assessment form was to highlight student's course reflections and to examine, how the actual execution of the course corresponded with the study module goals.

2.1 Results

The self-assessment form was completed by students, excluding one, who attended all practical session but returned none of the written material required for the completion of the study module, thus failing the course. In general the students filled in the self-assessment form conscientiously, some admittedly at a rather rapid pace. Only one reply was received from the free comment session noting that the work could better be tied to actual situations, e.g. what a client needs the information for. Below is the self- assessment form with all the eight replies.

TABLE 1. *Self-assessment form & student replies.*

ASSESSMENT/SUMMARY FORM

Automotive laboratory A, spring 2011, 131AS09
Name:

Self-assessment

	1	2	3	4	5
1. Do you find that you have achieved the goals that were set for the course?			1	7	
2. How demanding did you find the course to be?			8		
3. Did practical work support theoretical studies?		2	1	5	
4. Was the workload distributed equally to members in your group?			1	4	3
5. Was the scheduling suitable?		1		6	1
6. Did you find the subjects of the assessment as appropriate?			2	4	2
7. Do you think that you received enough guidance?		1	1	4	2
8. Do you believe that laboratory work improved your group work skills?			2	6	
9. Which grade would you give to your pair?			1	2	5
10. Which grade would you give to yourself?			4	4	

(1 = strongly disagree, 5 = strongly agree)

In hindsight, option number three reflecting the notion "no opinion/cannot say" should have been eliminated, as it is the easiest answer. It should be noted that no "completely different opinion" i.e. number one answers, were received.

Noteworthy is that the question "did the practical work session support the theoretical studies" replies dispersed, albeit in a positive direction. The division of the work load between group members was strongly agreed upon. All but two students believed that their team working skills had improved during this study module. Only one student was disappointed in the scheduling/ timetabeling of the course.

Almost all of the critical replies were from one reply form. At the end of the form the students own contribution as well as the group members contribution was asked to be graded. The results indicated that the working partner was given a higher grade, mostly grade 5. The results of the self-assessment form were mostly in line with the teacher's assessment. This finding is in line with previous studies. [3] [7] [8]

The answers to the question of adequate supervision were dispersed, more so than any other answers. This is an interesting phenomenon, as there were two teachers guiding a group of nine students. It is most likely, that students only remember the last few contact sessions when completing the questionnaire. Furthermore the preconceptions may wary as to degree of independent initiatives required. Nearly all the respondents perceived that they had reached the goals set for this study module well. The course was perceived as average in difficulty.

3 DISCUSSION

Practical work has been integrated into the syllabus from the beginning of the studies in the automotive engineering and logistics study line at TUAS, in line with innovation pedagogy since year 2008. [1] Innovation pedagogy encourages flexible syllabus structures and accreditation methods. It is a process of constantly improving your know-how, in turn leading to further know-how, new ideas and practices. In practice this means that students during their basic automotive theoretical studies dismantle different parts of car wrecks. The exercise is undertaken in mixed groups of ten students. Some of the group members are more experienced than others, thus the work to student members is allocated based on prior knowledge i.e. more demanding task to more experienced students.

The work undertaken is diversified, students have the possibility to work in a real life car repair shop with real tools and actually observe technical solutions. Simultaneously insight is obtained among others as to the life cycle of cars, recycling of car parts and numerous other things. The group work outside the class room forms a solid basis for group formation and bonding purposes. Thus students have practical project work from the beginning of their studies. This study aims to highlight how students perceive project work and also to highlight the fact that the project work has a dual goal: to teach the subject matter covered and also to teach team work.

It should be noted that the sample here is rather small, and future studies should be undertaken with a larger amount of student groups and to differing study subjects to establish if project work could also act as an effective way of teaching more difficult subject matters. The motivational factor could also be included in future self-assessment forms: i.e. examine if the group work sessions are perceived as more motivating than the lecture-based learning. [4] A further aspect that should be included in future studies is the inclusion of group participant time accounting activities, which would directly highlight the degree of participation per group member.

In general the findings of the study highlight the importance of group work as a way of teaching interpersonal skills, team work as well as leadership in a controlled environment, thus providing graduates better equipped to face the team work and rapidly changing working environment demands.

4 CONCLUSION

In conclusion this self-assessment study aims to provide teaching staff with a greater understanding of how to enhance group work within in the syllabus. It also highlights the importance of clear assessment criteria, timetables and adequate guidance. Students benefit of this approach by understanding the two fold objective of group work increasing cooperation, group cohesion and interpersonal skills as well as the objective of learning and fully understanding the subject matter in question.

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130 ENERGY ENGINEERS THROUGH DISTANCE LEARNING – COOPERATIVE TEACHING AND LEARNING APPROACHES

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ABSTRACT

Corporate communication and many training courses are already web-based. A wide variety of communication is possible without direct face-to-face contacts. Social media has become very popular. Distance teaching and learning methods provide extensive opportunities. This article deals with cooperative teaching and learning in energy engineering education aiming at degrees and introduces some successful practices.

Adult education aiming at degrees poses a significant challenge to most universities. Adaptable learning conditions should be arranged with reasonable efforts and costs. In 2009, Kymenlaakso University of Applied Sciences (KyUAS) started a B.Sc. degree programme in energy engineering, based on distance learning. Moodle was chosen for organizing course contents and Adobe Connect for on-line communication. The proper preparation of electronic teaching materials became increasingly important. Colleagues exchanged experiences and supported one another. Students learned to deal with download links and recordings. Gradually also peer groups were formed.

In most cases the learning of novel contents is very motivating for students but may be frustrating for teachers. Co-operative teaching can be an efficient way to organize education. Together with Lappeenranta University of Technology, KyUAS started a cooperative course in 2011. The pilot course ran with 4 lecturers from Lappeenranta and 3 from Kotka using Moodle and Adobe Connect. The versatility of the pilot course was appreciated by students. KyUAS Energy Engineering as an ERASMUS Intensive Program partner has been cooperating for several years with FH Stralsund, UAS, in courses on renewable energy supply. Both students and teachers are cooperatively involved, and the learning outcomes are encouraging.

Keywords: Distance learning, Cooperative teaching, Energy engineering.

1 INTRODUCTION

The world-wide-web provides us with many opportunities. Corporate communication and many training courses are already in the web. Most of the communication in the internet is possible on-line and off-line without direct face-to-face contacts. Social media has become very popular, and people have got used to it. Also degree-oriented teaching and learning are possible in the web. Distance learning has become increasingly popular. Web-based learning and teaching are mostly independent of time and space. Students and teachers living in dispersed locations may also participate without frequent and time-consuming travelling. However, it is rather difficult to organize practical hands-on training with complicated hardware and software tools in the web, and some contact learning is therefore also needed. Furthermore, personal social contacts are often expected for motivation.

Study arrangements in degree education should be adapted to busy lifestyles and fast-changing conditions. Student groups are not homogeneous. Many students like to combine studying and working, and this may have an adverse effect on learning outcomes. The increasing demand for networking and international communication skills has necessitated cooperation with foreign students and teachers. The implementation of appropriate distance learning tools and facilities would support these efforts. The organizing of distance teaching and learning in degree education calls for well-prepared curricula, clearly defined learning outcomes, versatile e-learning materials, and consistent evaluation.

Adult education aiming at degrees in engineering poses a significant challenge to most universities. Flexible learning conditions should be arranged with reasonable efforts and costs. While teaching and learning should be appealing, time is very limited, both for teachers and students. Many students have full-time jobs and need to do shift work. Although teachers cannot be expected to work round the clock, there is frequent need to communicate with students and to update teaching materials. At the moment, there are significant political controversies about funding the education in Finnish universities of applied sciences. Many different kinds of pressures are placed on teachers, while financing is decreasing.

2 COOPERATIVE TEACHING AND LEARNING APPROACHES

Good and effective teaching and learning have, for example, following characteristics:

- In constructive learning, a facilitator helps the student to get her or his own understanding of the content.
- Learning is cumulative, and the teacher should identify the learners' backgrounds.
- In self-directed learning students are able to manage and develop their learning.
- Learning is target-oriented. Learning sessions should have clear intended learning outcomes, and learners should understand the significance of them.
- The contextual approach recognizes that learning is a complex process, and learning can be improved by taking the learning process to learners' own framework.
- In cooperative learning and teaching environments participants promote each others' learning success, and new learning outcomes may grow up. [1]

There are plenty of research results on cooperative teaching and learning. Cooperative teaching and learning leads to better qualitative and quantitative results compared to competitive learning. In cooperative learning, students take care of other participants and are interested in their success. In peer groups, participants are also encouraged to challenging topics. Gradually, the participants themselves develop new learning outcomes, and the motivation will increase. [1]

3 DISTANCE LEARNING IN ADULT EDUCATION

In 2009, KyUAS started a Bachelor Degree Programme in Energy Engineering, based on distance learning. This special curriculum was designed for adult education. The annual syllabus schedule consists of ten contact learning weekends including Fridays and Saturdays at the university and sixty evening sessions of a few hours online in the internet. Every month, there is a full week of on-line lectures in the evenings. This kind of scheduling required new practices and tools. Moodle, a well-proven learning environment at KyUAS, was set up for course contents and for off-line communication. Adobe Connect, a web-based communication user interface, was chosen for on-line activities (Fig. 1). Teachers had to be trained for Adobe Connect in advance, and the training started about six months before the actual courses. At first, some everyday computer problems caused difficulties at the university as well as in students' homes and working places. These were mostly connected to incompatibilities with different hardware and software versions, varying settings and lack of appropriate headsets. Some teachers started to use their personal computers at home in order to ensure stable working conditions. The students made adjustments in their computers and acquired new ones.

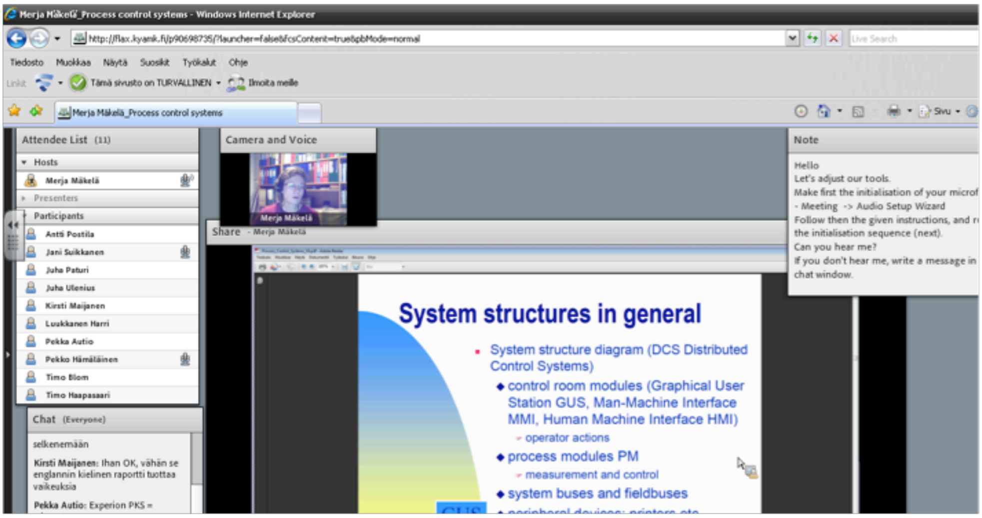

FIGURE 1. *Using Adobe Connect in distance learning.*

The curriculum of Energy Engineering at KyUAS provides educational qualifications for a power plant supervisor and leads to energy engineering careers in the fields of automation and process engineering, operations and maintenance, and machine and plant design. The current adult curriculum includes the following study modules:

- Basic Studies 60 cr
- Professional Studies 72 cr
  - o Basics of Energy Production
  - o Mathematics and Natural Sciences for Energy Engineering
  - o Operation of Power Plants

  - o Measurement and Control Technology for Energy Production
  - o Components and Processes of Power Plants
  - o Sustainable Development
- Specialization Studies 48 cr
  - o Electronics and Electrical Engineering or Machine Technology
  - o Process Technology, Wind Energy, Bio Fuels or Structures and Strength
  - o Communication Networks of Production Lines and Plants, Maintenance or Machine Design
  - o Automation Engineering, Maintenance Methods or Design of Machines and Plants
- Free-choice Electives 15 cr
- Practical Training 30 cr
- Bachelor's Thesis 15 cr.

This B.Sc programme totals 240 credits, with one credit implying 27 hours of efficient student work. The adult curriculum required the arrangement of a variety of learning sessions, and about 90 % of them have been made available in the internet. On average, the supervised contact learning pro one credit consists of 3 hours of studies in classrooms and 2 hours at on-line internet sessions. This implies that students should do plenty of activating exercises and essays.

The proper preparation of electronic teaching materials became increasingly important. The intense lecturing and supervising called for well-organized online sessions and clearly outlined presentation materials. A wide variety of ready-made e-learning materials for basic courses are available but the costs of licences are rather high. Case-specific teaching materials, tailored to students' needs, have to be prepared, anyway. Compared to traditional contact teaching in classrooms and auditoriums, most effort in distance teaching has to be put on developing materials and making preparations. The time-limited on-line sessions and very few contact lessons should be utilized very effectively.

In process of time, experience forced some change in certain practices. Already during the first study year, the number of online learning session had to be increased so as to enable the students to achieve the intended learning outcomes. However, the number of promised contact weekend sessions was not increased afterwards, for tactical reasons. In the beginning, many teachers tended to reserve the contact teaching weekends for lecturing. After a few months it started to seem easier and more meaningful to use the on-line internet sessions for lectures and exercise supervision, thus leaving the contact weekend sessions for supervised practical training of machinery and tools unavailable for students at home. At first, many teachers complained about too few contact sessions. With available materials and presentations, the teachers could not deal with the intended contents within the given schedule. Teaching materials had to be reprocessed and applied to distance teaching. The teachers supported one another. The workload in commenting and evaluating the activating exercises was enormous.

The first on-line session of every teacher with Acrobat Connect was exciting. During the first year on-line sessions, some support was available for those teachers who needed help with technical virtual tools. The technical support of Kymiedu, the supporting organization of virtual activities at KyUAS, was utilized with enthusiasm. The teachers learned to sort materials in Moodle, and students learned to deal with download links and recordings. Gradually, peer groups were formed in both teaching and learning.

4 COOPERATIVE TEACHING WITH OTHER UNIVERSITIES

Flexible learning conditions should be arranged with reasonable efforts and costs. Despite the decreasing funding, universities should be able to organize versatile learning environments. Given the small population and the geographically dispersed location of universities in Finland, many universities cannot offer a wide variety of curricula. Sometimes it is practical to make a common cause in national and international cooperation. Cooperative teaching arrangements between universities expand study offerings and may improve joint efforts in research and development activities. Available learning contents should be updated frequently. Novel learning contents can be developed and adapted to curricula without long delays if several teachers combine their expertise and resources.

Lappeenranta University of Technology (LUT) and KyUAS started a basic Bachelor-level course on Wind and Solar Energy Technology and Business in 2011. The pilot course was taught by 4 lecturers from Lappeenranta and 3 from Kotka combining the expertise of both universities. The personal working efforts with the challenging tools and new teaching contents could thus be limited to a reasonable level. The students and teachers of both universities had an access to the course web pages in Moodle (Fig. 2). Adobe Connect was chosen for on-line communication. LUT lecturing on wind and solar energy ran in an auditorium, while KyUAS lecturing took place in various locations. The participating students could either join the sessions in the lecture room, or attend them through the internet. However, this pilot course lecturing did not encourage students to get involved in very active discussions during the online sessions. The sessions were recorded and linked in Moodle for later viewing. All the learning materials were made available in Moodle both for students and teachers. The activating exercises were supervised locally in both universities. A visit to a wind turbine manufacturing company was organized jointly. The teachers of both universities worked as a peering group in Moodle which enabled a better coordination of the contents. The teachers could easily participate in other teachers' sessions. In evaluations, the versatile contents of this pilot course were appreciated by the students.

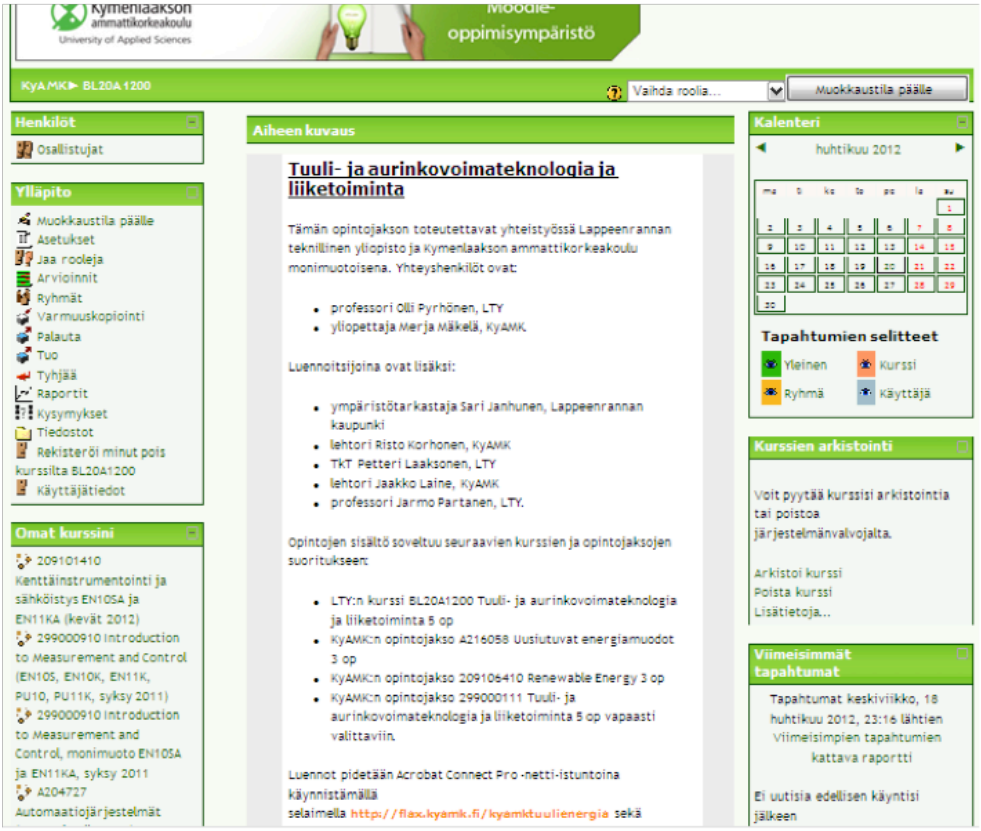

FIGURE 2. *Cooperative course on Wind and Solar Energy Technology and Business in Moodle.*

FH Stralsund, UAS, started an international intensive course on Hydrogen Technology and Fuel Cells as early as in the early nineties. In the beginning, a few international partners participated in this cooperative teaching and learning project. Gradually, due to active contacts of the Stralsund colleagues, the cooperative activities with other universities expanded. The scope of contents was extended to related subjects, and consequently the course gained more attention and popularity. Today eight European partners, with Stralsund University as the coordinator, have joined an ERASMUS intensive program called Future Sustainable Energy Supply in Europe – Based on Renewable Energy and Hydrogen Technology (IP FUSES). The IP FUSES aims at the increasing utilization of renewable energy sources applied to the use of special resources in each European country [2]. This IP program introduces the infrastructure with its key components such as electric grids, pipeline systems for petrol and natural gas, as well as required future conversions. It presents hydrogen as a new and important balancing energy carrier with climate-friendly and sustainable solutions, and focuses on hybrid systems by combining solar and wind energy with hydrogen technology.

Both students and staff members of universities are trained for renewable energy supply. Five students and one teacher from every participating partner university come to Stralsund every spring. KyUAS Energy Engineering has been cooperating for many years with Stralsund University in these intensive courses on renewable energy supply. Both students and teachers are cooperatively involved, and the learning outcomes are encouraging. Some of the curriculums and learning contents of the KyUAS Energy Engineering have been updated based on the cooperative activities in Stralsund. After international intensive courses, students are often more willing to participate in international student exchanges than before. International learning experiences emphasize cooperative working. Students have to be active themselves if they like to achieve learning outcomes in varying teams. There are plans to include distance learning sessions in the FUSES intensive program. This would give students some more time for learning, and the scope of the course could be extended with reduced costs. Some pilot lectures have already been given between participating universities by using Adobe Connect.

5 CONCLUSIONS

Preparing a distance teaching and learning curriculum necessitates big changes in widely-used traditional teaching and learning methods. Teachers and students may think that distance teaching and learning require less work. In fact, the workload may initially be even higher due to different teaching and learning methods. It takes some time to get used to utilizing the new tools. According to our experiences, cooperativeness in teaching and learning is not dependent on the duration of contact learning. The effective utilization of supporting virtual tools may help to organize versatile and cooperative teaching and learning experiences in engineering disciplines. Some students in the adult distance learning program in Energy Engineering offered by KyUAS have already graduated, with good results.

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131 DISCOVERING THE LEARNING STYLES OF ENGINEERING AND NON-ENGINEERING STUDENTS

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ABSTRACT

The objective of this study is to discover and compare the learning styles of undergraduates in different parts of the world; Malaysia, Finland and England. Three universities are involved in the study; Universiti Teknologi PETRONAS (Malaysia), Turku University of Applied Sciences (Finland) and Brunel University (United Kingdom), with more than four hundred first year engineering and business students as participants. The instrument used for data collection is the Memletics Styles Quiz containing seventy items. Microsoft Excel and Statistical Package for Social Sciences are used for the analysis of results and graphical representation of the findings. This research seeks to answer the question: "Are there differences in learning styles between engineering students who study in different parts of the world, between engineering and business students and between male and female students?"

Keywords: Learning styles, Memletics Styles Quiz, comparative research

1 INTRODUCTION

The provision of an optimal educational environment is a healthy mix of effective teaching and learning. Furthermore, it is not extraordinary to assume that effective teaching can be shaped by, amongst other things, an interest in and an understanding of students and how they learn best. Students have different learning styles and as a result may have different learning preferences. Some prefer to learn on their own, while others prefer working in groups. Some learn better through more visual stimuli whilst others thrive when engaging in hands-on tasks. Learning styles are "characteristic cognitive, affective, and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" [1]. It is important for students to know their learning styles [2]. Without this knowledge it is difficult to improve learning habits. It is as important for teachers to know their students' learning styles.

Knowledge and understanding of student learning styles can help educators hone their teaching styles in a way that facilitates optimal learning and minimizes the mismatch between learning styles and teaching styles. Identifying the learning styles of the students is deemed necessary if appropriate strategies were to be determined to provide a more effective education delivery approach. Are the learning styles of engineering undergraduates at different geographical localities any different from those in the non-engineering disciplines? This paper reports on a study that explores the learning styles and preferences of first year male and female engineering and business students at Universiti Teknologi PETRONAS or UTP (Malaysia), Turku University of Applied Sciences or TUAS (Finland) and Brunel University (United Kingdom). This study is an extension of research conducted in 2011 on the learning styles of engineering students at the UTP, the Cape Peninsula University of Technology or CPUT (South Africa) and TUAS [3].

2 RELATED LITERATURE

According to Capretz [4], "Learning style is a term that refers to an individual's characteristic and consistent approach to perceiving, organizing and processing information". Felder [5] sees learning styles as "...characteristic strengths and preferences" in how students take in and process information. It is acknowledged that students learn in different ways [6, 7], therefore, their learning styles differ. It is also the case that teaching styles of teaching staff differ. This reality has implications for the classroom. Firstly, in any one class there will be a diversity of learning styles. Secondly, certain teaching styles will be more appealing to learners whose learning styles are compatible with a particular teaching style. Furthermore, students whose learning styles are not accommodated may have a negative learning experience.

The phenomenon of learning styles that are not aligned with teaching styles is often referred to as a mismatch [4, 6, 7]. Kapadia [6] attributes mismatches in the engineering context to several factors relating to the organisation of the engineering curriculum and the traditional style of teaching. A presentation of theories and principles will suit intuitive learners who work well with abstract concepts [8]. However, sensory learners who prefer concrete, practical, procedural information and look for facts [8], may not find this so appealing. Mismatches also impact on student and staff retention, and satisfaction [4].

The importance of accommodating students' different learning styles is supported in the literature [4, 5, 6] with a call for improved teaching strategies that aim for effective teaching. Capretz [4] suggests that in order to reach all students, teaching staff should consider varying their teaching styles from time to time. This can be done gradually by incorporating activities that will advance an increase in student learning style preferences [9]. Felder [5] points out that students need to be able to function professionally and that this "...requires working well in all learning style modes". Thus, teaching staff should aim to develop the learning styles that students prefer and those they do not [5]. Capretz [4] recognises that learning styles have strengths and weakness, but cautions that "...a person locked exclusively into one style is never going to be an ideal learner" [4].

In order for teaching staff to acknowledge different learning styles and to work toward ways that accommodate student differences, they need to know what the learning styles of their learners are. To this end several learning styles models and instruments that assess learning styles exist for this purpose. According to Felder and Silverman, "A learning-style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information" [7]. The models often referred to include the Myers-Briggs Type Indicator (MBTI), Kolb's Learning Style Model, Felder-Silverman Learning Style Model, Dunn and Dunn, Herman Brain Dominance model and the VARK model. We may ask if learning styles really matter. Learning styles are viewed as an important factor that can determine the quality of student learning [10]. Studies show a significant correlation between student learning styles and academic performance [11, 12, 13]. However, there are also studies that report no significant correlation in this regard [13]. Nastansky and Slick [14] examined the learning styles preferences of 344 online business students from a south eastern university in the United States using the Kolb Learning Style Inventory; Assimilator (think and watch), Accommodator (feel and do), Diverger (feel and watch) and Converger (think and do), to find out if there are any significant differences in course grades and course completion rates between students according to their learning style preferences. The findings from the study indicate that those with the Diverger Learning Styles preference earned a lower mean grade point as compared to the rest and that there is no significant difference in learning preference among those dropping the course.

3 METHODOLOGY

3.1 Participants

Three universities namely UTP, TUAS and Brunel participated in this study. A total of 486 students completed the Memletics Styles Quiz (MSQ) [15]. Table 1 shows the numbers of participants with genders. The genders are not known for 32 UTP students.

TABLE 1. *Participating institutions, degree programmes and numbers of participating students.*

Institution	Number of participants	Female	Male	Degrees Programmes
Brunel	50	17	33	Information Systems, Computing and Mathematics
TUAS	173	17	156	Information Technology, Electronics
TUAS	54	18	36	Business, Business Information Technology
UTP	177	52	125	Chemical Engineering, Mechanical Engineering
UTP	17			Business Information System
UTP	15			Information Computer Technology
TOTAL	486	117	369	

3.2 The Instruments

The participants completed the MSQ electronically. Participants responded to 70 statements by indicating one of the following score ratings: 0 – the statement is nothing like me, 1 – the statement is partially like me or 2 – the statement is very much like me. A completed MSQ generates a learning styles graph that indicates seven learning styles, namely, Visual (using pictures, images and spatial understanding), Aural(using sound and music), Verbal(using words in writing and speech), Physical(using body, hands and sense of touch), Logical(using logic, reasoning and systems), Social (learn in groups) and Solitary(work alone) [15]. An example of a student's MSQ result is given in Table 2. The maximum result is 20 for each learning style.

TABLE 2. *An example of a student's Memletics Styles Quiz result.*

Visual	Aural	Verbal	Physical	Logical	Social	Solitary
10	7	5	12	14	10	7

4 RESULTS

4.1 Overall results

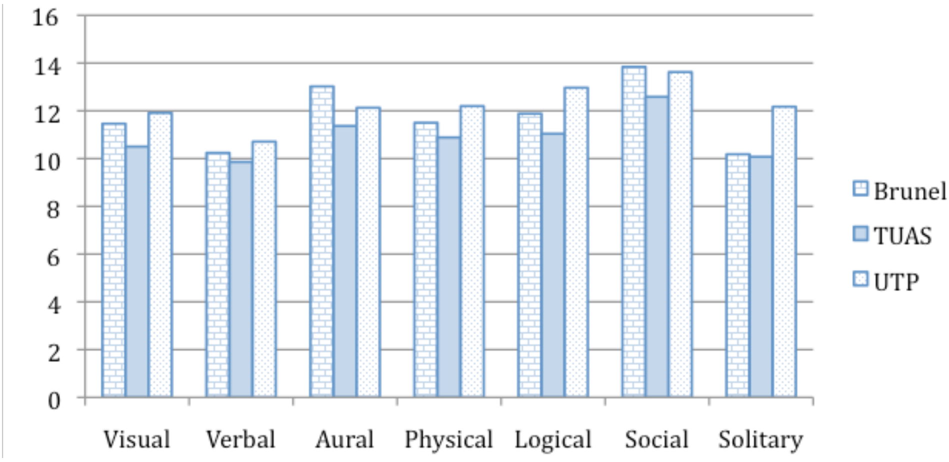
The overall results show close similarity with [3]. The most preferred learning style or PLS is the social style and the least PLSs are the verbal style and the solitary style (Table 3).

Graph 1 shows the overall results separately for all participating universities. The preference order of learning styles according to mean values of result points is the same at Brunel and TUAS except for the two least PLSs. The solitary style is the least preferred at Brunel and the verbal style is the second least preferred.

TABLE 3. *Mean values and standard deviations of students' learning style results.*

	Visual style	Verbal style	Aural style	Physical style	Logical style	Social style	Solitary style
Mean	11.21	10.26	11.86	11.51	11.95	13.16	10.99
Stand. Dev.	3.812	3.376	3.833	3.291	3.400	3.301	3.126
Total N	486	486	486	486	486	486	486

At TUAS the verbal style is the least preferred and the solitary style is the second least preferred. UTP results show that the verbal style is the least preferred learning style and the solitary style is fourth in the preference list. At Brunel and TUAS the most PLSs are social, aural, logical, physical and visual style, in preference order. The learning styles preference order at UTP is social, logical, physical, solitary and aural style.



GRAPH 1. *Mean values of students' learning style results separately in Brunel, TUAS and UTP.*

The mean values of learning style results of students at Brunel and TUAS differ significantly in aural learning style (P-value 0.007) and social learning style (P-value 0.024). The mean values of learning style results of participating students at Brunel and UTP differ significantly in logical learning style (P-value 0.037) and solitary learning style (P-value 0.000). The mean values of learning style results of participating students at TUAS and UTP differ significantly in all learning styles (P-values vary from 0.000 to 0.038).

In this study the PLS was found for each participating student by finding the highest test result or results if a student had more than one style with the highest result. For Brunel 80.0 % of all participating students had one PLS, 12.0 % had two preferred styles and 8.0 % had three preferred styles. The corresponding figures for TUAS were 81.5 %, 13.7 % and 3.5 %. Interestingly, one participant at TUAS had four preferred styles, one student five and one seven PLSs. At UTP 79.4 % of participants had one PLS, 15.8 % had two, 3.3 % had three and 1.4 % had four PLSs. Table 4 shows preferred learning styles at Brunel, TUAS and UTP.

Table 4 shows that, for example, 6 % of participants at Brunel prefer the verbal style. The respective figures for TUAS and UTP are 8 % and 5 %. There are small differences between the percentage figures of the three universities that relate to visual style, verbal style and physical style. At Brunel 34 % of participants prefer the aural style and the respective figures at TUAS and UTP are only 23 % and 20 %. For UTP, 24 % of participants have maximum results in the logical style. Figures for TUAS and Brunel are 19 % and 14 % respectively. The percentages of participants who prefer the social style are as follows: Brunel 42 %, TUAS 36 % and UTP 30 %. Pearson's Chi-square tests do not show statistical dependence between universities and the preference of aural, logical or social style. There are greater differences in percentages with regard to the solitary style. The percentages of participants who prefer the solitary style at the different universities are as follows: UTP 20 %, TUAS 12 % and Brunel 4 %.Chi-square test shows that university and preferring solitary style are dependent (P-value 0.003).

TABLE 4. *Number and percentages of students' PLSs at Brunel, TUAS and UTP.*

		Brunel		TUAS		UTP	
		N	%	N	%	N	%
Prefer visual style	no	40	80.0	188	82.8	176	84.2
	yes	10	20.0	39	17.2	33	15.8
Prefer verbal style	no	47	94.0	209	92.1	199	95.2
	yes	3	6.0	18	7.9	10	4.8
Prefer aural style	no	33	66.0	176	77.5	167	79.9
	yes	17	34.0	51	22.5	42	20.1
Prefer physical style	no	46	92.0	197	86.8	183	87.6
	yes	4	8.0	30	13.2	26	12.4
Prefer logical style	no	43	86.0	185	81.5	159	76.1
	yes	7	14.0	42	18.5	50	23.9
Prefer social style	no	29	58.0	146	64.3	147	70.3
	yes	21	42.0	81	35.7	62	29.7
Prefer solitary style	no	48	96.0	201	88.5	167	79.9
	yes	2	4.0	26	11.5	42	20.1

4.2 Learning style differences between female and male students

Do female and male students prefer different learning styles? Table 5, which combines all students involved in the study, shows that the differences are rather small considering visual, verbal, aural, physical, social or solitary style. Of the participating female students 10 % prefer the logical style compared to 22 % of male students who prefer this style.

TABLE 5. *Number and percentages of female and male students' PLSs.*

		Female		Male	
		N	%	N	%
Prefer visual style	no	82	78.8	296	84.6
	yes	22	21.2	54	15.4
Prefer verbal style	no	98	94.2	326	93.1
	yes	6	5.8	24	6.9
Prefer aural style	no	81	77.9	271	77.4
	yes	23	22.1	79	22.6
Prefer physical style	no	90	86.5	305	87.1
	yes	14	13.5	45	12.9
Prefer logicalstyle	no	94	90.4	273	78.0
	yes	10	9.6	77	22.0
Prefer social style	no	67	64.4	228	65.1
	yes	37	35.6	122	34.9
Prefer solitary style	no	88	84.6	300	85.7
	yes	16	15.4	50	14.3

Chi-square test shows that gender and favouring the logical style are dependent (P-value 0.005). More detailed study shows that this is due to the results of UTP. If we consider PLSs by gender we notice that at Brunel and at TUAS there is no statistical evidence of dependence between gender and preferring any learning style. At UTP the situation is the same except for preferring a logical style. The logical learning style is favoured by 10 % of female participants and 26 % of male participants at UTP. Chi-square test shows that at UTP gender and preferring logical learning style are dependent (P-value 0.013).

A study of mean values of female and male students' results at Brunel does not show statistically significant differences. In TUAS the differences between female and male students' results are significant with regard to visual learning style (P-value 0.028) and physical learning style (P-value 0.011). In both cases female mean value is greater than male mean value. At UTP the differences between female and male students' results are not significant except for solitary learning style (P-value 0.010) with female mean (13.08) greater than male mean value (11.90).

4.3 Learning style differences between Engineering and Business students

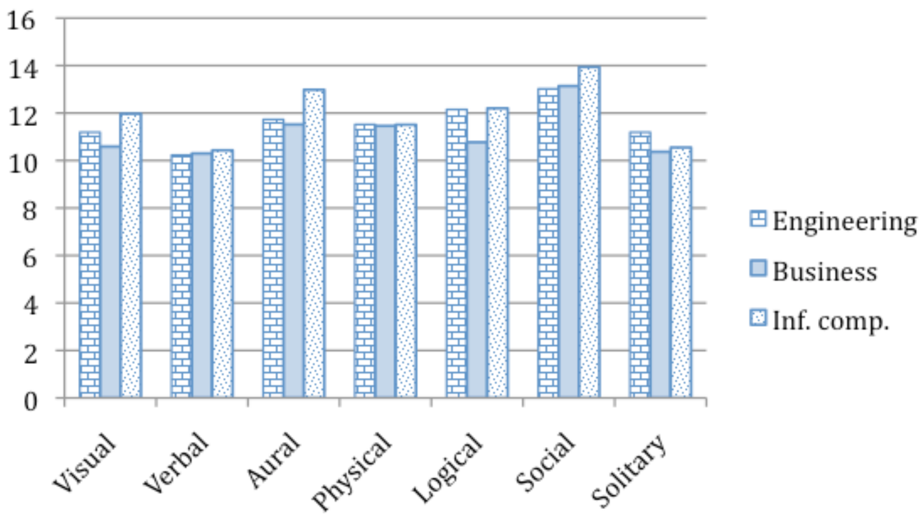
Do Engineering students prefer different learning styles than Business students? The students in the TUAS degree programmes in Electronics and Information Technology are considered as Engineering students as well as UTP students in degree programmes in Chemical Engineering and Mechanical Engineering. The TUAS students in the Business and Business Information Technology degree programmes and the students of the degree programme in the Business Information System of UTP represent Business students in this study. Brunel students from the degree programmes in Information Systems, Computing and Mathematics and Information Computer Technology students from UTP are classified to a third area of study, marked as Inf. comp. Examining the numbers of students in Engineering and Business favouring different learning styles shows that the differences are very small and there is no statistical evidence of dependence between study area and favouring of a certain learning style.

Table 6 and graph 2 show the mean values of students' learning style test results according to study areas. Engineering and Business students' results are close to each other. Logical learning style results give the mean value of 12.15 for Engineering students and 10.77 for Business students. The difference is statistically significant (P-value 0.007). Solitary learning style results give the mean values of 11.19 for Engineering students and 10.37 for Business students. This difference is not statistically significant with a 0.05 level of significance (P-value 0.074).

TABLE 6. *Mean values and standard deviations of students' learning style results by programs.*

Program		Visual	Verbal	Aural	Physical	Logical	Social	Solitary
Engineering	Mean	11.19	10.23	11.73	11.52	12.15	13.02	11.19
	Stand. Dev.	3.764	3.405	3.717	3.314	3.262	3.384	3.034
	N	350	350	350	350	350	350	350
Business	Mean	10.59	10.30	11.52	11.46	10.77	13.14	10.37
	Stand. Dev.	3.831	3.305	4.452	3.162	3.961	3.086	3.606
	N	71	71	71	71	71	71	71
Inf. comp.	Mean	11.97	10.43	12.98	11.51	12.20	13.94	10.55
	Stand. Dev.	3.976	3.335	3.582	3.355	3.251	2.999	2.958
	N	65	65	65	65	65	65	65

The results of students in the group Inf. comp. differ significantly from the results of Engineering students with regard to the aural learning style (P-value 0.012) and social learning style (P-value 0.042). The results of students in the group Inf. comp. differ significantly from the results of Business students with regard to the visual learning style (P-value 0.042), aural learning style (P-value 0.036) and logical learning style (P-value 0.023).



GRAPH 2. *Mean values of students' learning style results according to study areas.*

5 CONCLUSION

This study shows that at Brunel, TUAS and UTP most students prefer the social learning style and that it is the preference of both female and male students. Roughly, every third student has the social style as his/her most favored learning style. Also, the findings show that amongst Engineering, Business and Inf. comp. students, the most PLS is the social learning style and the least preferred being the verbal style. Verbal is also the least PLS amongst female and male students. The logical learning style is more preferred amongst Engineering and Inf. comp. students than Business students. At UTP the logical learning style is also more preferred amongst male than female students. At UTP the solitary learning style is significantly more preferred than at Brunel and TUAS. The overall results show that more UTP students chose "the statement is very much like me" when completing the MSQ than Brunel and TUAS students. The overall mean values are the smallest for TUAS and indicative of more students having chosen "the statement is nothing like me" and "the statement is partially like me" than students at Brunel and UTP. Regardless of discipline of study; engineering or non- engineering, the study has revealed consistently similar findings as [3]; the most preferred learning style is social and the least preferred is verbal learning style. These findings may suggest that to best address a social learning style preference would be interaction-based approach of teaching such as to encourage group discussion or assigning team-based projects.

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133 FACILITATING & ENHANCING INNOVATION COMPETENCES AND STUDENT INVOLVEMENT: AN EXAMPLE OF INTRODUCING REAL LIFE PROBLEM SOLVING AS WELL AS TECHNOLOGIES TO TEACHING PRODUCT DEVELOPMENT AND PLANNING

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ABSTRACT

Turku University of Applied Science uses innovation pedagogy in its teaching practices, which on a practical level refers to an approach to learning and teaching that emphasises working life skills. The automotive engineering and logistics degree programme offers a course called Product development and planning. Since 2008 the course structure has changed to include real life case studies. In 2011 the course was altered to include teaching technology, a virtual environment where the product development skills obtained throughout the course are put into practice providing the student an insight as to the importance of the R&D activities in relation to profitability. Student feedback after the inclusion of the simulation aspect greatly supported the inclusion of the technology. In conclusion, the inclusion real life case studies increased the number of students taking the course and also had a direct impact on student feedback. The teaching technology has further improved student feedback. Furthermore, by including real life case studies this course also provides students with hands on experience of R&D project work. Most students complete their thesis on product or service development for which this course provides a good basis.

Keywords: Product development, business simulation, real life case studies.

1 INTRODUCTION

Turku University of Applied Science (hereafter TUAS) applies innovation pedagogy in its teaching practices, which on a practical level refers to an approach to learning and teaching that emphasises working life skills. It moves from the traditional theoretical learning to the application of learned skill to practical development challenges [1]. At TUAS the automotive engineering and logistics degree programme offers a course called Product development and planning. Since 2008 the course structure has changed to include real life case studies.

TUAS innovation pedagogy applied in its teaching practices and also the programmes principals to motivate students to take more active part in their learning – active learning form the underlying reasons for the development of the Product Development and Planning course (hereafter PDP) [2].

The PDP course is primarily aimed at engineering students (Degree Programme in Automotive and Transportation Engineering). The course extent is 5ects (European Credit Transfer and Accumulation System) points and is classified as optional studies [3]. The course spans over the entire autumn period; the first part of the course consisting mainly of the theoretical background lectures (project management and planning and also different kind of innovation methods). The second part consisted of participating in development projects mainly given by the faculty. The course concluded with a final seminar where all projects were presented.

Even though the feedback given from the students was quite good the turnout, in other words the number of students participating actively, was clearly descending over the time span covering years 2008 to 2010 (Figure 1).

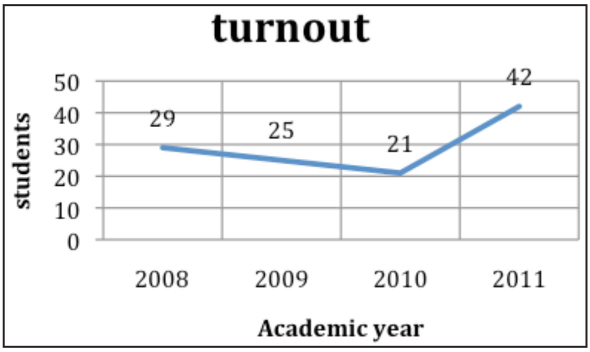

FIGURE 1. *The turnout of the students at Production development and planning course at TUAS.*

2 APPROACH AND METHODOLOGY

2.1 Year 2010 development

From the beginning of the academic year 2010, the course was altered by changing the projects from faculty given to development project assignments from the local enterprises. These company driven development projects were allocated an increased amount of time achieved by condensing theoretical lectures. This required new thinking as regards to the material distribution. The material was originally distributed via the discentum optima eLearning solution. Now the degree of automation on the website was increased, thus the enabling students to study more of the material on their own.

The course duration was 13 weeks. During the first three weeks the theoretical background was lectured. During week 4 the project development teams were established and briefed. Teams were able to choose from either the faculty given subjects or alternatively suggest their own subject, which has to be approved by the lecturer.

Year 2011 Turku was the European Capital of Culture and one of the events was the Turku Grand Prix – Downhill Racing [3]. The pre-race was held in 2010 and so the faculty given subject was to design and build the racing vehicle. Three of the six project teams choose to design a downhill vehicle. The other chosen subjects were the motorized kick sled given by an elderly private person, the development of trash pallet given by a local enterprise and car expo witch was a subject given by a student co-operative. For the three downhill teams there was a race at the end of the assignment. Only the best design was going to be built and the winner was picked by peer assessment.

The given PDP project time during was eight weeks, during which the product development process was experienced. During these weeks only a minimal amount of lectures was given. The subjects given were connected to development projects covering topics such as industrial design, immaterial rights, team work etc. Week 13 was the final week during which the teams gave a presentation in the form of a final seminar and also submitted the final documents. The assessment of the course was based on tree parts; seminar peer assessment, self-evaluation and closing report faculty assessment.

The feedback given by the students was mainly very good, however, they evaluated the courses learning influence only average 3.1 on the scale of 1-5 where 5 was the best. Consequently, the obvious conclusion that was drawn was that the course needs further development. The results obtained from the self-evaluation forms as regard to the projects themselves, are presented in Figure 2 and 3 and can be observed positive.

FIGURE 2. *The winning team from TUAS in Turku Grand Prix downhill competition 2010.*

FIGURE 3. *The Car Expo was developed during the 2010 course and is jet to come as this is written.*

2.2 Year 2011 development

From the feedback given by the academic year 2010 confirmed that the basics of the course are on track. Nevertheless the learning influence must be reinforced. It has to be noted that the R&D department at TUAS has been developing Product Development Simulation software –ProDesim. ProDesim is a business simulation software designed for work communities and teaching organisations operating in the field of product development [4]. It was decided to include ProDesim a new element in the course to enhance the learning influence of the course.

The good feedback from the 2010 students enticed a record number of students to participate in the 2011 course. The number of the teams rose up to 11, in other words, over 80% of the potential students chose this PDP optional course. During 2011 all of the development projects were enterprise given, unlike year 2010 where a number of subjects were faculty given. The first project team task was to obtain a subject for their development project. Some of the teams had already a preselected subject, the others enquired from the local enterprises for suitable subjects. The 2011 course subjects were; Cross kart, new design for the suspension of L6e vehicle [5]; new design for the automotive engineering and logistics degree programmes truck; excel based spare part list for a local enterprise; sponsor calendar for a student's cooperative; Best-Hall layout, warehouses new layout for the local forwarding agency's; marketing plan and strategy for students cooperative; new inlet manifold design for Toyota Celica's 18RG motor for a of the students; new business model for the student's cooperative; new ergonomic design for the truck belt for the local enterprise; business plan for car escort service for student's cooperative; heating system for the hot tub for a local citizen.

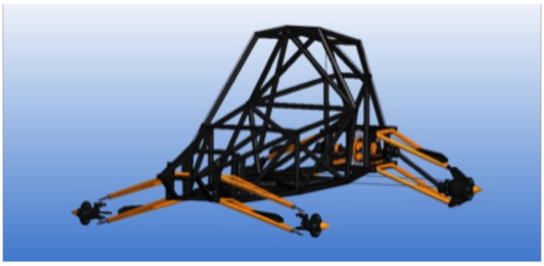

FIGURE 4. *Cross kart, new design for the suspension of L6e vehicle was developed during course 2011.*

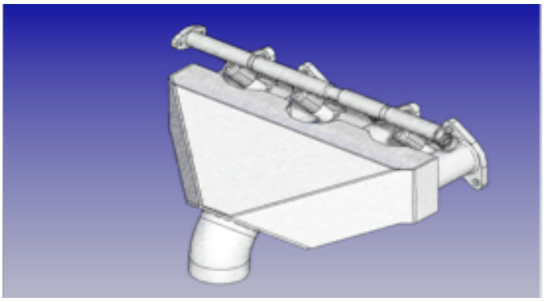

FIGURE 5. *New inlet manifold was design for Toyota Celica's 18RG motor during course 2011.*

The virtual product planning simulation in the enterprise environment was undertaken at the end of the course just before the final seminars. The idea was that the product development skills obtained throughout the course are put into practice providing the student an insight as to the importance of the R&D activities in relation to profitability. During the game the students played against each other in teams of eight. The game session was 4 hours which in the game lifecycle amounted to a three year period. In short, to keep the business running you have launch new products at appropriate intervals.

FIGURE 6. *The virtual simulation of product planning in enterprise environment was brought to 2011 course to reinforce the learning influence.*

3 DISCUSSION

After the inclusion of the virtual planning simulation to the course the students were asked to give feedback about the course itself and from the ProDesim simulation session separately. The feedback obtained from the 2011 course was generally good, as was the case of the 2010 feedback, however, the learning influence average rose 3.7 from the previous 3.1. In 2011 course feedback the average level rose as compared to 2010 feedback as shown in Figures 7 and 8.

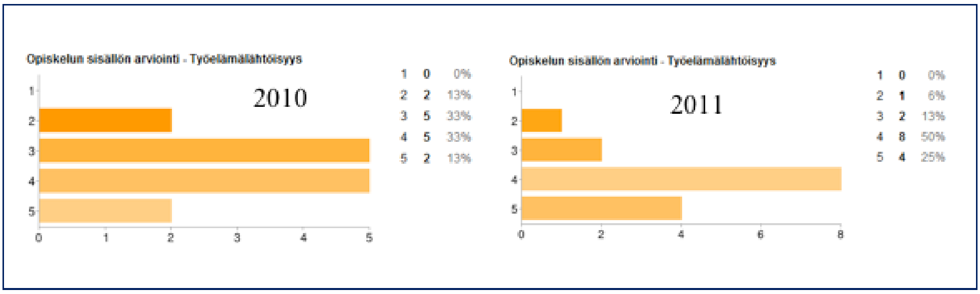

FIGURE 7. *Student's feedback on course working life connections. Average rose from 3.5 in 2010 to 4.0 in 2011.*

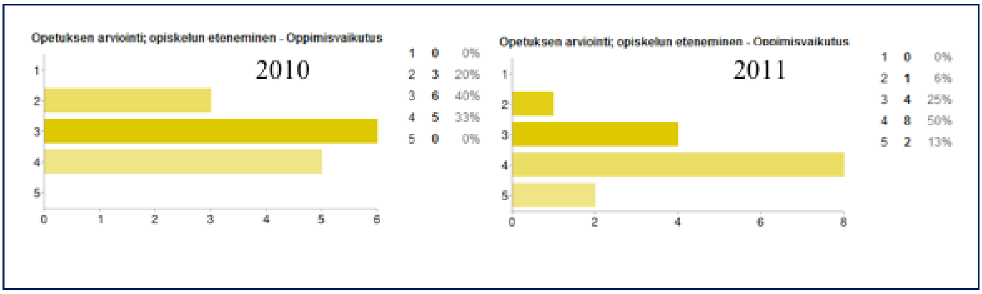

FIGURE 8. *Student's feedback on courses learning influence. Average rose from 3.1 in 2010 to 3.7 in 2011.*

The feedback from the simulation session was of great interest. The student feedback obtained was positive as demonstrated in Figure 9: Student feedback from the ProDesim simulation session. According to the students the simulation helped to realize the importance of the R&D activities in relation to profitability. Furthermore, students recommended using simulation as a part of the course also in the future. The written feedback was also good, for example one particular student wished for a longer simulation, so that the whole five years period could have simulated.

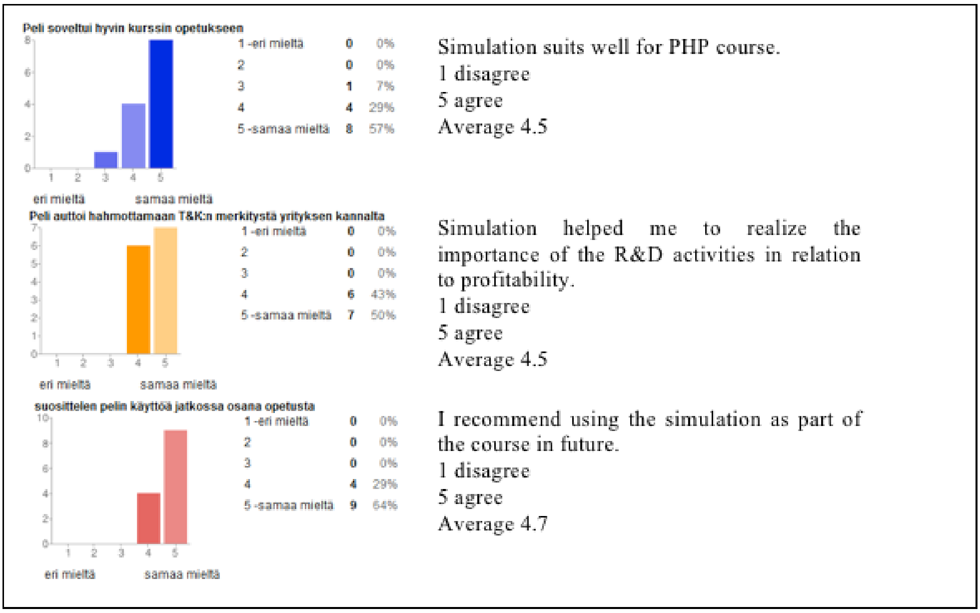

FIGURE 9. *Student feedback from the ProDesim simulation session.*

4 CONCLUSION

In conclusion the inclusion of development project assignments from the local enterprises enhanced student involvement. To gain the time needed theoretical lectures had to be concentrated, which was successfully undertaken by raising the automation level of eLearning material. Taking the simulation as part of the course has reinforced the learning influence and highlighted the importance of R&D work in running a profitable and successful business enterprise, giving students a better understanding of the prerequisites of running a profitable business.

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134 THE COSMOS PROJECT – AN ATTEMPT TO INCREASE THE EMPLOYABILITY OF FOREIGN STUDENTS

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ABSTRACT

This paper stems from the Cosmos Project (2010 – 2012) which focuses on engineering education in a multicultural environment at Turku University of Applied Sciences. The purpose of the project is to improve the employability of foreign students so that they would stay in Finland and give their contributions for the business in Finland.

The focus of the study is on the students in the Degree Programme in Information Technology. The majority of the students at the programme are from countries outside Europe and the major challenge for these students is to find a suitable job for the practical training period. They also face problems when they look for jobs after graduation.

The problem has been studied by interviewing students, employers and staff members. Furthermore, benchmarking of other programmes has been done. According to this study there are many obstacles for the foreign students to integrate into the Finnish labour market. It seems that they first need to adapt to the Finnish culture. It would include both the language skills, the rules of the working life and the most importantly everyday habits.

Keywords: Multicultural, Employment, Integration.

1 INTRODUCTION

The internationalization of the Finnish universities and high schools started at the beginning of the 1990's and the number of foreign students increased rapidly from some hundreds to several thousands. The Erasmus and Socrates Programs financed by EU made it easier to go abroad and terms like globalization, internationalization, networking and network economy emerged in the strategies of the Finnish Government and the Ministry of Education [1]. The internationalization strategy defines five goals for the higher education sector:

(1) to create a truly international higher education community, where the amount of international teachers and students has increased to 2015 significantly,
(2) to increase the quality and the attractiveness of higher education
(3) to promote the export of expertise,
(4) to support a multi-cultural society which supports graduates to stay in Finland
(5) to promote global responsibility.

Another challenge of 2010's will be the labor supply. For Finland, the year 2010 was a turning point in terms of population, as the number of people in active working age began to fall. This decline will continue despite anticipated immigration. The basic reason for this development is the ageing of the post-war generation and those born in the 1950's, which will have many different impacts on the economy and on society in general. It is essentially a question of how well the economy and society can adapt to the changes this will bring [2]. One way to adapt to these challenges is increasing immigration. The emphasis of the Government's immigration policy program [3] is in employment-based immigration.

The adaptation of the foreign students into the Finnish society was a rather recurrent research subject at the beginning of the 21st century and it was intensified when the authorities realized that the integration did not take place without problems. [4]

The pioneering research on this subject was made by Taina Kinnunen ("If I can find a good job after graduation, I may stay", Ulkomaisten tutkinto-opiskelijoiden integroituminen Suomeen, 2003) [5], funded by CIMO (Centre for International Mobility).

In her summary of the results Kinnunen states (p. 109) that the main reason to come to Finland has not only been the high standard of the Finnish system of education but also free education. The foreign students do not plan to stay in Finland beforehand – if they stay, it depends on the possibilities for further studies and the situation in the Finnish labor market. [5]

Most of the students say they have managed well in their studies but have also made many interesting observations and reflections about the Finnish culture and society. Equality and informality can be seen both as a possibility and a challenge.

Most of the foreign students were working alongside their studies and as regards to the part-time work opportunities all kinds of networks and contacts were seen as the most important ways of getting work. It was a general belief among the international students that the Finnish culture is very reserved, frigid and that the Finns are not so easy to approach. On the other side, the Finnish people were characterized as honest, solid and trustworthy. [5]

The majority of the interviewees expressed that the most important reason to move abroad had been that they wanted to become acquainted with a foreign culture – Finland had only been one possibility or alternative of many. They carried with them some kind of ideal of cosmopolitanism.

The language skills and the difficulty of the Finnish language (the language barrier) were experienced as the cause of isolation, unemployment and difficulties of getting part-time work. The foreign students met also racism and other kind of segregation, but generally they had positive impressions of Finland. [5]

2 THE DEGREE PROGRAMME IN INFORMATION TECHNOLOGY

The Degree Programme in Information Technology at Turku University of Applied Sciences was founded in August 1999. It is a four year, 240 ECTS credit, Bachelor's program in Engineering. 40 new students yearly start their engineering studies in this program. The total number of students studying in the program in 2012 is 172. They represent 26 different nationalities, see Figure 1. As seen in the figure about one third of the students come from Nepal.

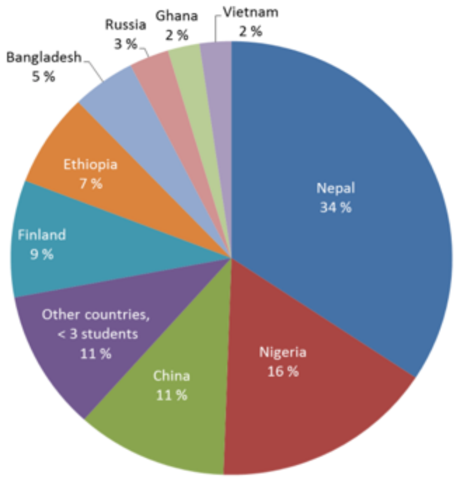

FIGURE 1. *The pie-chart shows the distribution of the countries from which the students at the degree program origins.*

Students who want to study in the Degree Programme in Information Technology at Turku University of Applied Sciences submit their application electronically through the national admissions portal, www.admission.fi, and mail copies of their certificates to the university admissions office. All eligible students, in 2011 about 71% of all applicants, are called to an entrance exam. Entrance exams are held in Finland and abroad in about 17 different countries arranged by the Finnish Network for International Programmes, FINNIPS (www.finnips.fi).

The curriculum for this programme is grouped in five categories, namely Basic studies, Professional studies, Optional studies, Practical training and Bachelor's thesis. The first year is focused on basic engineering knowledge and integration to the Finnish society. The second year still focuses on the basics but is more directed to and applied on information technology.

During the third and fourth year the students emphasize their main subject, Internet Technology, in the Cisco Networking Academy or in the Education Support Centre. In the latter one, students work with Microsoft Server technologies in an environment that resembles a company.

All students have two compulsory period of practical training, all together 30 credits. The first period is scheduled at the end of the second spring semester and the second period at the end of the third spring semester. The final Thesis ends the studies at the end of the fourth academic year.

3 THE COSMOS PROJECT

The Cosmos project was established 2010 to meet the challenges that the international students face when they try to integrate to the Finnish education and labor culture. The aim of the project is to create a mechanism to decrease the barrier for foreign students to connect with companies during their studies and promote graduated students to find a job.

Within the Cosmos Project the following actions have been taken:

1. Benchmarking successful cooperation models between higher education institutions and employers in certain European universities and companies.
2. Enquiries and theme interviews of students and faculty members.
3. Development of the curriculum for the Degree Programme in Information Technology.
4. More efficient marketing and briefing for the employers.

The last benchmarking activity will be in May 2012 and the results are expected to be ready at the beginning of the fall semester 2012. In this paper, results from the enquiry and interviews are presented. The curriculum development will be based on the results from these studies. Some changes e.g. two courses to support students in their attempts to find a position for their work placement have already been included into the curriculum. However, the impact of these changes cannot be seen yet as the first implementation will be during the spring 2013.

3.1 The enquiry and interview study

A study concerning the integration of foreign quest students at TUAS was made by the Degree Programme of Library and Information Services in 2010 and 2011. The research consisted of three parts, i.e. an enquiry among the foreign students was completed with a qualitative interview directed to the staff of Degree Programme of Information Technology with an expert interview.

The enquiry among the foreign students showed the same obstacles or barriers of integration as Taina Kinnunen's study 10 years earlier, it was in other words, a follow-up study. The target group was the first year students of the Degree Programme of Information Technology and it consisted of 24 respondents from different countries, most of which came from Nepal.

The preliminary results of the enquiry show that some of the first year students have already got part-time work but that they find it difficult to get information (culture, studying, residency, work opportunities) because of language barriers. As to the student counselling, the most used source of information were the fellow students also in other groups that had started earlier.

The majority of the informants planned to stay in Finland after graduation and the most common reason for this was further studies. As mentioned above, the major challenges are the language skills and the culture that differs a lot from the Nepalese one.

The target of the interviews consisted of teachers, managers, engineers, student counsellors, and other support persons. The aim of the interview was to get proposals for improving the degree programme and the main focus was the overall integration of the students with foreign origin. Twelve persons were interviewed and asked about the most important obstacles in this respect.

According to the preliminary results the unfamiliar culture and poor language skills are the main barriers, but also the lack of communication with Finnish people, youngsters and students. This leads to the foreign students building their own communities. When asked in which way this could be improved, the most common answers were intensive courses in Finnish language, initiation into the Finnish culture, and most importantly, intensified student counselling. It was also asked that if the degree program got an extra funding, what would be the best way to use it so that it would be most useful to the foreign students. An extra investment on counselling gained a lot of approval, but most of the respondents would use the money for different ways of integrating the students into the Finnish working life (working practice, practical training, visits to enterprises etc.).

TABLE 1. *The table shows the results from the swot analysis. The table is translated from the original Finnish table.*

Strengths	Weaknesses
no tuition fees ICT house The location of Turku Cisco Over 10 years of experience We have all pieces that we need English as tuition language Internationality Multiculturalism We try to develop the programme Foreign students are in general well motivated The possibility to recruit from the whole world	Marketing Fragmented Lack of focus and a joined interest Multiculturalism Southwest Finland is a small economic area Lack of resources
Possibilities Marketing in Finland Tuition fees Possibilities to develop the programme To educate foreigners living in Finland	**Threats** Resources The commitment of the staff Threats against UAS as education institutions Heavy development processes Tuition fee The new government Justification of the degree programmes Negative public discussions

Six experts, three of them having been involved in the management of the degree programme, were also interviewed in three pairs. The topic was the same as above, however more general, i.e. how to improve the degree programme. They were asked about the quality of the degree programme (compared with other degree programmes in Finland), the marketing, the resources, specialization, co-operation with enterprises and other universities, how to get the students to graduate in an optimal time, how to get more funding for R&D, and moreover, whether they could give proposals and ideas of improvement of their own. They also made a SWOT-analysis about the strengths, weaknesses, opportunities and threats of the degree program, Table 1. It seems that most interviewees would like to invest in e.g. marketing. Many strong points included education, such as, expertise, know-how, experience and routine. Ideal and central location of the faculty belongs to the strengths together with the internationality and multiculturalism.

4 CONCLUSION

Not surprisingly, the preliminary results from this study show that language skills, i.e. not adequate Finnish language skills, are the major barrier for effective integration to the society.

Furthermore, the interviews show that there is a strong will to improve the program. Lack of a joined interest and consensus of the development direction has slightly been limiting the development. However, this project seems to give a good ground for further development.

A comprehensive report for further development will be made later.

5 ACKNOWLEDGEMENTS

The Cosmos Project started in 2010 and will be finished by the end of 2012. The project has been financially supported by the European Social Fund. The authors wish to acknowledge all students and staff members who have participated in this work.

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135 INFORMATION SYSTEMS PROFICIENCY AREA

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ABSTRACT

The demands of working life for future employees are constantly changing. The financial situation of Finnish Universities of Applied Sciences is becoming increasingly difficult. The number of applicants is decreasing. The quality of education must be maintained or even improved with ever reduced resources. These are some of the reasons for rethinking higher education; environments, course of actions, resources, assessment. This paper describes several Kajaani UAS based methods to meet the aforementioned challenges and includes minor literary research on learning by doing and changes in the teacher's role.

Keywords: Integration, Curricula, Curricula work, Project studies, Teacher's role.

1 INTRODUCTION

The integration of Business Information Technology (BBA(IT)) and Information Technology (BEng(IT)) studies at Kajaani University of Applied Sciences (UAS) started with the establishment of the Centre for Measurement and Information Systems (CEMIS) joint centre [1] in 2010. CEMIS is a contract-based measurement and information systems research and training centre. The other organizations in CEMIS are VTT Technical Research Centre of Finland, the Universities of Oulu and Jyväskylä and the Centre for Metrology and Accreditation (MIKES)

Kajaani UAS' strategic aim to be Finland's most proactive university by 2020 focuses specifically on learning by doing and its promotion. Pioneering work has been done e.g. in the Field of Natural Sciences, which is ready to be "copied" in Engineering.

2 INTEGRATION OF BBA(IT) AND BENG(IT) STUDIES

The first steps toward course content integration at Kajaani UAS in autumn 2010 included the integration of first year programming teaching and the transfer of staff from the School of Business to the School of Engineering. One part of staff integration was the allocation of curriculum work leadership to one person instead of two separate heads of degree programs.

As a result the overall number of students increased and teachers were able to stream students according to their knowledge. In practice a test was arranged after the first week of teaching and some of the students were awarded credits for the whole course and the remaining students were divided into three different groups: beginners, intermediate and advanced. More teacher resources were thereafter designated to the beginners group and less to the advanced group. The amount of students who passed the programming course at their first attempt increased from

77% to 85% and the average grades rose from 2.8 to 3.9 on a scale of 1 (lowest) to 5 (highest grade).

2.1 Finding Courses to Integrate

In December 2010 meetings of different subject groups were held, aiming for more integrated studies in the curricula of students starting their studies in autumn 2011. In preparation, all the courses of certain subjects were collected from the curricula of both schools. Subject teachers of both schools were then invited to a meeting to discuss how such subjects could be integrated.

The number of credits of different subjects in the curricula 2010 of both schools can be seen in Table 1 (2nd and 3rd columns). As a result of subject group meetings and curricula work, BBA(IT) and BEng(IT) student groups starting their studies in autumn 2011, have integrated studies in Maths, Physics, ADP, Programming, English and Swedish, in total 31.5 credits out of 210/240. This can also be seen from Table 1 for each subject (4th column).

TABLE 1. *Credits of particular subjects in curricula.*

Subject	BBA(IT)	BEng(IT)	Integrated
Maths	6 credits	18 credits	3 credits
Physics	6.5 credits*	15 credits	3 credits*
ADP	3 credits	3 credits	3 credits
Programming	34 credits*	31 credits*	15 credits*
English	11 credits	8 credits	4.5 credits + test
Swedish	6 credits	6 credits	3 credits + test

* For programmers

2.2 Role of Integration

One of the first reasons for starting teaching integration was to motivate students. It is difficult to implement the differentiation of subject matter in a context where one teacher works alone with one group. Instead the new integrated system includes more students and teachers and groups can be organized according to the level of skills and knowledge of the students. When the student group consists of same level learners, teaching becomes easier and students are more motivated. The first year engineering student dropout percentage has dropped from 28 to 25 %.

Kajaani UAS is a small-scale institution and the integration of BBA(IT) and BEng(IT) studies provides better opportunities for using the teacher's knowledge. It is also important to find special areas of education and teaching methods that are attractive to applicants. Schrey-Niemenmaa and Yli-Pentti state "one of the attempts to lower the dropout rate is to try to establish a stronger connection between theory and practice." Through this connection students will be "charmed" by engineering and find the joy of learning. [2] This is why the good practices of BBA(IT) curriculum project studies will also be transferred to engineering studies.

3 LEARNING BY DOING

Every teacher has an opinion on learning by doing and what it involves. Some might think that it is where students learn by doing practical work and solving problems instead of theoretical lessons. On a larger scale and from an external point of view, learning by doing is actualized when R&D -activity is a binding part of teaching.

The demands of working life justify increasing interaction and collaborative learning in the curriculum. Today almost all employees must possess co-operation and interaction skills. The challenge for teachers is how to organize interaction that assists learning because expertise alone is no longer sufficient. We have to create a community that promotes the communal learning process and we also need to acquire community learning methods. A positive and open environment can aid learning; the students must be made to feel that they are good enough. [3]

3.1 Factors that Promote Learning

Learning environments have undergone a large amount of development and construction in recent years. The University of Applied Sciences transformation in the 1990s and the transition that followed towards competence-based curricula in the 2000s have both greatly influenced teaching and learning environments.

Factors that are important for student's learning are presented in Figure 1. Learning environments (LE) are an important element of learning by doing. LEs should be as similar to working environments as possible - both physically and socially. The teacher's role is to ensure that the LE is psychologically functional to enable the implementation of elements such as trust, support, humanity, and the ability to co-operate. Reflection and dialogue are also important parts of this type of learning. [4]

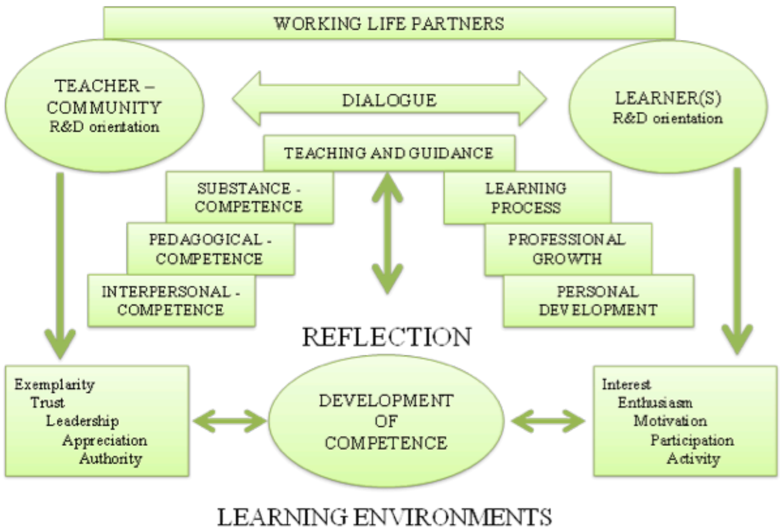

FIGURE 1. *Factors that promote learning. [4].*

3.2 Project Studies

From the beginning in 2009, Kajaani UAS' BBA(IT) game studies have included a large amount of project studies. The idea was to create situations where students learn independently by creating games in teams, as well as normal classroom teaching. This idea has evolved and taken shape and next autumn BBA(IT) students will have 38 credits and BEng(IT) student 45 credits of project studies. The majority of these studies will be common to both schools (engineering and business) and consequently there will be students from both degree programs in the project teams.

This model also supports Kajaani UAS strategic aim to be Finland's most proactive university in 2020. One step towards this has been the teachers' "learning by doing activator" –training. During this course of training a considerable amount of discussion between teachers from different fields has arisen. Some of this discussion has already led to cooperation in creating student projects.

Project studies have an important role in technology subject teaching. Through projects students can experiment with different working methods and activities in an authentic working environment. They also develop the ability to work in groups and apply skills and knowledge in problem solving. [5]

3.3 Practices and Experiences

Project studies in Kajaani UAS involve team work where each group member takes responsibility not only for his/her own part but also for the work of the whole team. Project assignments and game ideas are based on the interest of the student, on-going projects or the needs of companies. Each project studies course has its own profile: the project must fulfill certain requirements that have arisen from the objectives of other courses. The project assignment mentions the learning goals for the project in question. Project studies raise the student's self-awareness concerning resources (knowledge, skills and experience), work abilities and how they can achieve the task requiring the application of their resources and capabilities.

In addition to learning by doing, project studies can also be considered as a form of collaborative learning. Students work together in groups using each member's unique knowledge and skills. Collaborative learning demands active work, good communication skills and taking responsibility. It teaches social interaction and brings together different types of learners in class. [5]

Project studies help students to learn and achieve more during their studies. However, such learning also demands a lot of preparation from the teacher involved, as well as a thorough understanding of the teaching method and the changing the role of the teacher to that of tutor.

The BBA(IT) students' experiences of project studies have been promising, showing that the studies motivated the students. The first year average credit achievement total has risen from 55 to 61 credits per year. The students have proceeded well in their studies and the amount of dropouts has been low. In practice, the students have spent working hours (8am-4pm) at school and traditional classroom lessons have been restricted to the beginning of the week. The students are then expected to use their remaining time working on projects Practice has also shown that project days require a certain amount of supervision resources, for instance a few hours in the timetable and information as to where teachers can be found if needed.

4 THE CHANGING ROLE OF STUDENT AND TEACHER

Every learning institution forms its own community and practices. The differences in the practices and social structures of vocational sectors can be seen in education. Certain forms of behavior are expected depending on status and position in society. Such behavioral roles bind individuals in many ways. The differences between the individual are significant from an educational perspective. [6]

The role of today's Higher Education (HE) teacher is, in many respects, challenging with the various demands of regional development, research and pedagogy. Adding learning by doing to teachers' every day work involves complications. Fear of the new, the difficulty in abandoning old habits, and many other normal human reactions can emerge. In the hub of such change we must remember that responsibility for learning is in the learner's hands, but educational responsibility and the choice of pedagogical solutions lies with the teacher. [4]

4.1 Guidance and Assessment

Another challenge in integrating different fields and in learning by doing is that the teacher's role has to change. The teacher has to set aside the tradition of working alone instead to encourage the growth of students' expertise in close cooperation with colleagues. This means that different roles have to be clear and there must be commitment to decisions made. The importance of creating a good and positive learning atmosphere is particularly emphasized in new types of learning environments. [4]

Project studies can be organized in the form of inquiry-based learning. Components of inquiry-based learning can be seen in Figure 2, which is also a good course foundation.

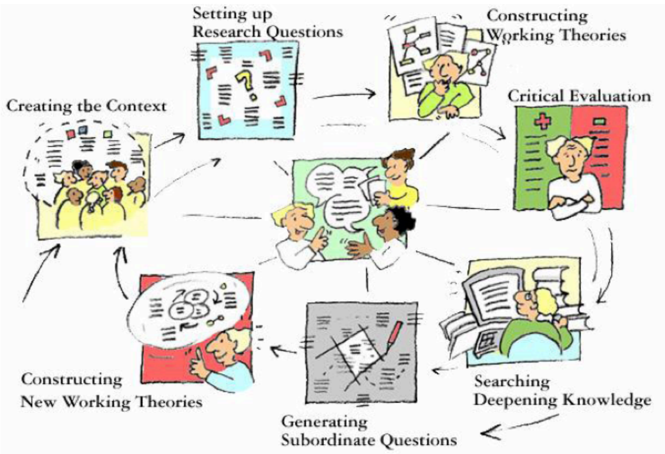

FIGURE 2. *Elements of inquiry-based learning. [7]*

When teaching methods change, assessment must also be rethought. If traditional assessment methods are used, such as written examinations, they may be unrelated to the students learning outcomes. The assessment of inquiry-based learning courses is not straightforward and a large amount of literature exists on the subject. Some workable assessment methods could be: presentation (group or individual), portfolio, essay, self or peer assessment and reports. The teacher's role in assessment is important; assessment should be reasonable. Some questions to contemplate when designing assessment are: [8]

- Why are we assessing?
- What are we assessing?
- When are we going to assess?
- Who is going to carry out the assessment?
- How are we going to assess?
- How are we going to grade?
- What feedback will students receive?

5 CONCLUSION

Curriculum work around the integration of Business Information Technology (BBA(IT)) and Information Technology (BEng(IT)) studies at Kajaani UAS has proved to be the right decision. The number of applicants to both degrees increased this year; from 1.45 applicants per study place to 2 in BEng(IT) studies.

Joint studies can benefit from using the same resources and environments facilitating the division of students into level based study groups. Project studies seem to be the right way to increase the students' interest and motivation and working life and companies also appreciate such study methods.

The teacher's role is changing: guidance and assessment rules have to be agreed to make sure that learning by doing works efficiently. It is not easy to change the way teachers have worked before, but change can also be seen in a positive light. Change is the opportunity to learn something new and to work alongside students as their mentors.

6 ACKNOWLEDGEMENTS

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137 TEAM EDUCATION SUPPORT OF THE TECHNICAL SUBJECTS AT THE FACULTY OF MECHANICAL ENGINEERING

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ABSTRACT

The current development of modern machinery and equipment requires the cooperation of a wide range of experts. Practically, this means that today's research and development carried out almost exclusively by a team. Working in teams, but has its own specifics. It requires not only good organization, methodology, rules, etc., but also the ability to work as a team member. Unfortunately, the standard conception of teaching not only at technical universities does not reflect this fact. Students during their studies almost don't meet with teamwork approach. Graduates coming into practice without the necessary knowledge and experience that often gets up in the form of learning from mistakes. Research team of the project "Training of human resources for advancement of teams in the development and research" undertaken in the Faculty of Mechanical Engineering VSB-TU Ostrava is acting to modify unflattering fact. The result is a range of innovative courses, student team competitions and a range of support equipment and systems.

Keywords: education, student, team, Lego Mindstorms

1 INTRODUCTION

After many changes and re-analyzes of teaching the subject "Technical calculations" for all bachelor students of the Faculty of Mechanical Engineering in the first semester focused on teaching basics of algorithms and programming, we have repeatedly regarded the question of how to effectively lead teaching this subject with different input knowledge of students and also to encourage talented individuals [1].

Level of algorithms and programming knowledge of students of Faculty of Mechanical Engineering is very unbalanced. On the one hand there are students who know the issues very well either due to the high emphasis of secondary school or individual interests, on the other hand, there are on the faculty of Mechanical Engineering students who have this issue very far. The causes are many and if we were to choose one, we quoted a student, "If I wanted to study programming, I did not apply to study the faculty of Mechanical Engineering."

Of course, we successfully argue for the fact that modern machinery can't do without computer technology and that the knowledge bases of programming and algorithms is as important as knowledge of foreign language, however it does not change the fact that there is a strong representation of complete beginners from the students.

Needless to say this corresponds to the key concepts of the subject, the issue that discusses algorithms and programming from the very basic with a strong emphasis on practical examples. In addition, examples are focused so as to be usable during the first year of study.

On the other hand, this approach ignored the students, who already have mastered these skills. Instead, we encourage them, and develop their knowledge; they were "forced" to be taught the lessons that are not move them forward. Especially in the case of students in the first semester, who has yet to adapt the university education system, this situation left a negative impact.

These facts led us naturally to think about the overall concept of the subject. There was another problem, and it was not ready graduates to work as a team. In this context was established, the project "Human Resources Training for Team Cooperation in the Research and Development Area" co-financing from ESF resources and budget of the Czech Republic [2]. This project posed as one of the goals the upgrade the teaching of team competencies issues. And here the idea to modify the concept of the subject to capture outstanding students through creative and fun is both familiar with the problems of working in teams and is motivated to a deeper study.

2 THE CONCEPT OF EDUCATION

The main idea of an innovative new concept of course is to filter out students who have sufficient knowledge of the specific problems and offer them an alternative form of self study that is motivated to a deeper interest in the issue of algorithms, while also introduced them the issue of teamwork.

Since the selected students have satisfactory knowledge of algorithms and programming they can go immediately to the solution of team tasks. From the connection of algorithms and programming with a focus on engineering tasks clearly result oriented team in mechatronics area. According the saying "school where to play" we are bought MINDSTORMS LEGO ® Education NXT construction sets [3] within the project "Human Resources Training for Team Cooperation in the Research and Development Area" . For this construction sets we devise the team tasks and create study support and prepare special program of teaching, which has five milestones:

1. Selection of students - candidates
2. Introductory seminary
3. Building the teams
4. Period of work teams and consulting activities
5. Team Competition

The highlight is a team competition for prizes and one-time Dean's Scholarship, which has a distinctive motivation character.

FIGURE 1. *Lego Mindstorms Construction Set.*

2.1 Selection of students

Experience and repeated surveys in previous years, we have confirmed that about 10% of students already have adequate knowledge of subject matter. The method of finding helped us very current concept of student assessment.

Students are assessed on the basis of points scored from the three tests. Tests are conducted and evaluated electronically via e-learning system Moodle. Powerful questions can quite objectively assess student's knowledge, without the need for personal contact.

We have created a new eliminated test for selection of candidates for special teaching; the questions were carefully selected from all three evaluation tests. Some questions were modified to remove factors dependent on the programming language taught.

All students complete thus prepared test the very first week of education. For most students the test is merely a form of exploration of their knowledge and in principle the only way to try out way of the testing. But around ten percent of the students in the test will succeed. Specifically, the test 28-point scale. Students who can do the test over 20 points (more than 71% success rate), are addressed and are offered an special form of teaching.

2.2 Introductory seminary

Immediately following the week of lessons, lecture seminar takes place in which students are introduced to team roles, kits, training program and competition rules. Great attention is paid to the principles of technical problem solving. Although this seminar is primarily intended for the addressed students are also welcome other students, which proved to be very beneficial.

Lego Mindstorms ® Education NXT allows students to implement many various tasks.

In the pilot phase was created role for three-member teams to build a robotic vehicle that will carry out two tasks:

1. Separately track passes delimited by a black line with a width of 12-18 mm with numerous turns on a white background and a closed circuit.
2. Separately passes maze consisting of wooden bars with blind paths.

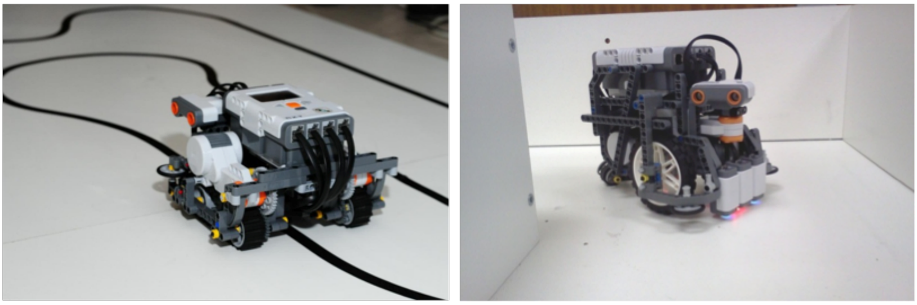

FIGURE 2. *Robotic Vehicle Tasks of Student's Competition: Track – left figure and Maze –right figure.*

The seminary is concluded with a lecture about teamwork and finally introduction of selected student's teams and demonstration of the web site for registration and student support teams and starts the registration teams.

2.3 Building the teams

Creating of student teams is very difficult stage. Some teams are formed very quickly, especially if the members knew themselves from secondary school, or from one study group. Even more complicated is the case when the students do not know the others. We need take into consideration the situations when some students scared of situation and refuse to participate in special version of teaching.

Very important is the introductory seminar, thanks to which there is a mutual acquaintance, and often students have already formed a team. Another very important element is a web portal to which students have access and where the teams are registered. Each student with ambition of team leader can create a design of the team, which other students will see. Those interested in membership can then get in touch with the team leader (the portal also offers a chat functions). By mutual agreement the leader introduces the team members.

Stage of team's assembly is limited (for a maximum period of two weeks). Next starts the consultation of teachers, for the remaining individuals who organize meetings and help build teams. The meeting also invited alternates who have been with just did not pass the placement test filter, and expressed interest to participate in special education. The objective is to build teams or reduce the number of teams. Other students then continue with standard lessons.

2.4 Period of Teams Work and Consulting Activity

The following phase is the longest, taking the time until week of the credit. During this phase several meeting for small teams (about every two weeks) is organized thematically related lectures focusing on technical aspects of the chosen solution. This meeting also serves as the control days when teams show the status solution. In addition, each team may use up to four consultations.

During all semester is available the room with computer equipment, test tracks and lockable space for construction and developed solutions for the student's teams. Access to rooms is according the prepared rules. Teams should in advance contact the administrator of classrooms and arrange the terms of work. Administrator unlocks the classroom, the team passes the kit with a developed solution and again after work and take the kit room locked.

Consulting is organized similarly. For these purposes, two lecturers or Ph.D. students are allocated as a consultant. Teams can contact the consultants and arrange a meeting. All activities of the team are recorded and keep at the simple document that has at its disposal.

During that period it may happen that an individual leaves the team or the team still does not contact. In this case, this student transferred to standard form of education, with all the consequences.

The period ends with teams meeting each other, where teams demonstrate the functionality of its solutions.

2.5 Teams Competition and Evaluation of Students

The final stage is the teams competition, which result in the getting a credit. Competition is usually associated with open doors on the faculty. The contest rules are as follows:

1. The entire vehicle must be composed of only one set of modular components, which is assigned to the team.
2. Each team creates its own control algorithms.
3. Sum of achieving times at both disciplines (track and maze) is determining for competition placement, the winner is the team whose robotic vehicle exceeds the sum of the times in both tasks the fastest of all.
4. Competitors may touch the vehicle without penalization only at the start and after passing the target.
5. Any correction of vehicle while driving is penalized five seconds. Not allowed are corrections that will lead to shorter paths.
6. Weight or size of vehicle is determining for the placement decision when the teams achieved the same time at the target. The less weight means the better position and at the same weight, the shorter total length and width of the vehicle means better position.
7. In the event of any dispute, the referee appointed by the head of the competition says the verdict. Judge oversees the competitors according the rules of competition, measures times, penalizes, determines the order of competitors, etc.

The first three teams will receive prizes; the winning team will receive one-time scholarship. Financial reward divides the team leader.

But the results of the team's competition are independent of credit and/or exam. Teams are evaluated only on the basis of solving or not solving the problem. Specifically, the student may receive a total of 100 points. This one for solving the task of each team member gets 36 points. In total, for the solution of both tasks, each team member gets 72 points. The remaining 28 points is the maximum that could be obtained in firs eliminated test. As usual minimum 20 points, students receive more than 92 points. The other five bonus points automatically get the team leader.

3 EXPERIENCES FROM THE PILOT RUNNING OF TEAMS EDUCATION

To date, a special education program has had two successful runs, which brought valuable experience. Perhaps the most interesting is the approach of students to education. We finally started to divide students into three categories: Enthusiasts, Restrained and Rejectionists.

- The first group of „Enthusiasts" is students who willingly and enthusiastically accept an special form of education. Among them there are also students who did not achieve a good result at the preliminary test and therefore were not included in the program, have continued to show interest Even they are also willing to undergo a standard education and pass an special version without the extra advantages. Here, however, we need to be very careful; it happens that both of education forms simultaneously seem to fail eventually. Students are also very active in assembling the teams. On the other hand, they often very quickly lose their motivation in the case when they cease to be successful in solving the tasks. Teams composed only of these students need to more motivate and watch. But in the end result will be achieved.

- The second group of "Restrained" is largest. These are students who like a special education form, but are concerned that they do not master. However, when they involved, achieved the best results. They evaluate themselves their participation as very beneficial, which gave them the confidence and motivation. Initial hard work with challenging and motivating their teams is worthwhile at the end. Their approach to work is very responsible, but they have a problem working as a team. They often take the work on themselves. On the other hand, they well aware of the situation and even more then deal with teamwork.

- The third group "Rejectionists" represent a student who does not want to do anything other than he must. Experience has shown that there is no point in any way to persuade or engage them in the program. If you still involved, usually the only team in number and they are useless. They often not completed the first year of study and leave the team. The biggest problem here is to recognize those students and don't mistake them with students of the second group. Good idea is to ask them directly for preference of their studies, they are usually very honest.

It is very important not to underestimate the introductory seminary. The beneficial is the fact if the students meet with the construction set during the seminary by creating of simple tasks. It has a positive effect to the second group of students when their concern is getting tight. It is also important to pay attention to mutual meeting of students, thus strongly facilitate the subsequent assembly of teams.

The biggest complications of special form of education were just assembly of student's teams. In the pilot course took us for half term all the teams assemble. However, the structure of some teams in the competition changed. The paradox was that the winning team eventually formed by individual student from the second group of students. Other members of the team cancelled their study; they belonged to the third group of students.

Very useful are also offered consultation. It often happens that students begin to look for more advanced procedures, such as they want to use different types of controllers [4]. During the consultations, it is possible to suitably guide the teams. On the other hand, it is necessary to limit the number of consultations. Otherwise, the consultation may be counter-productive so that teams consult with each performed step.

FIGURE 4. *Winners of Student's Competition.*

Also competition has interesting impacts. It is very important to separate evaluation of students from results of the competition. Students from the second group are often unnecessary competition concerns. On the other hand, competition strongly motivated to find better solutions. It is interesting to observe the consequences meeting of student teams closely before competition, during which each other demonstrate their solutions and basically get credit. Student's team often significantly improved throughout the solution until the time of competition.

4 CONCLUSION

The introduction of special forms of teaching despite initial fears proved to be very beneficial.

Positive is crucial encouraging of promising students in the first year of study. The involved students increase their self-confidence and motivation to study and also professional and soft skills. They can acquire small, but valuable experience with working in a team. Some find in themselves leadership skills, while others reveal their weakness, the need to better communicate, etc. In particular, we recognize the different specifics of teamwork that must practically deal, which motivates them to study the issue.

Interesting is also the impact on other students who were not involved in special form of education. Students of both groups are of course often speaking together about teaching. They discuss the algorithms used, methods, principles, sensors, etc. Participants of special form of education clearly demonstrate the practical usefulness of acquired knowledge. Other students can see how their colleagues managed to solve the defined objectives, the problems encountered and of course they casually growing interest in the issue from both the technical aspects as well as by the teamwork.

The only negative with which it is necessary to count are significantly increased demands on the educational team that takes care of part of a special education.

5 ACKNOWLEDGEMENTS

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138 A STRATEGIC PARTNERSHIP: DEVELOPING A NEW APPROACH TO UNIVERSITY-INDUSTRY COLLABORATION

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ABSTRACT

Innovation pedagogy is applied in the teaching of the Turku University of Applied Science (TUAS). On a practical level, innovation pedagogy refers to an approach to learning and teaching that emphasises working life skills. It moves from the tradition theoretical learning to the application of learned skill to practical development challenges. Innovative teaching methods improve both the quality of teaching and the students' awareness of the innovation process. The automotive engineering and logistics study line has included as part of the studies of the car inspection intake group work practice carried out at one on Finland's largest car inspection companies.

Car inspection graduates are by law required to undertake 60 car inspections during a two week work practice period. Traditionally the car inspections were carried out within the facilities of the TUAS. A qualified teacher supervised these car inspections included in the syllabus. In 2005 a strategic partnership began between a car inspection company and TUAS, whereby students undertake their two week practice period/carry out 60 car inspections at a jointly determined location of the inspection company in Finland. The agreement furthermore states that TUAS is compensated for each inspection undertaken by a student. Students gain hands on work experience and an understanding of how the systems of the particular employer. For the company this is a way to assess and obtain possible employee candidates and to familiarise future prospective employees with the organisational structures and technical systems in place. In conclusion, the strategic industry collaboration has numerous advantages for university of applied science and business. Students gain hands on experience, teaching staff stay up to with industry developments and companies obtain a contact with possible future employees.

Keywords: industry collaboration, strategic partnership, innovation pedagogy.

1 INTRODUCTION

Innovation pedagogy, the process of continuously improving your know-how, in turn amounting to further know-how, new ideas or practices has actively been applied to the traditional syllabus of automotive engineering and logistics at the Turku University of Applied Science (TUAS). [1] [2] The implementation of innovation pedagogy provides students with a better understanding of business practices and provides graduates with hands on work experience, interpersonal and team working skills. [3] Furthermore, it increases both the quality of teaching and the students' awareness of the innovation process as through the implementation of project work or service work within the curriculum in close contact with companies. This method allows students to apply the methods and equipment used by the companies, in other words taught and learned skills are applied to practice. The automotive engineering and logistics study line includes as a legal requirement work practice as part of the studies of the car inspection intake group by forming a strategic partnership with one of Finland's largest car inspection companies.

Students gain hands on work experience and an understanding of how the systems of the particular employer. For the company this is a way to assess and obtain possible employee candidates and to familiarise future prospective employees with the organisational structures and technical systems in place.

2 THE STRATEGIC PARTNERSHIP

TUAS formed a strategic partnership with a car inspection company in 2005, whereby the students of the automotive engineering and logistics study line undertake a number of car inspections for the strategic partner company. The partner company was chosen using the contacts of the teaching staff and rests on the close relationship between the strategic partner and the teaching staff at TUAS.

2.1 Project Backgroud

In 2005 a change in the Finnish law allowed for engineering students to specialise in car inspections and to carry aout car insepctions with a temporary permit. The temporary perimit is valid until the end of the engineering studies, however, at the most for a period of one year. To obtain the termporary permit, students have to carry out 60 supervised car inspections.

Previusly car inspection was taught to graduates only. The first intake student to whom the new option was available was the intake of 2005. The first practical car inspections could thus be carried out in 2007 and the students graduating in 2008. The curricula includes by law that car inspection students complete sixty car inspections during a two week work practice period to obtain the temporary permit.

As the number of students in the car inspection study line amounts to approximately 20 students per annum, the total amount of car inspections as to be completed by students to comply with the legal requirements amounts to 1200 car inspections. TUAS has it's own car inspection facility with a qualified teacher. The capacity of TUAS' own car inspection facility was however considered inadequate to allow for students to graduate on a timely basis thus an alternative approach was sought out actively.

2.2 The strategic partnership

TUAS contacted a car inspection company and after negotiations formed a strategic partnership agreement in 2005. The agreement states that the car inspection company provides for and jointly agrees with student's locations at which the students can undertake their two week work practice sessions during which sixty car inspections are carried out. The students undertake the car inspections independently, a supervisor confirms the inspection and enters it into the register. It has to be noted, that a normal term of work practice in Finland is that the organization providing the practitioners normally pays the company a "practice fee". Here, however, a clause was negotiated that the car inspection company reimburses a set amount to TUAS for each car inspection undertaken by a student. The table below shows the number of students that have undertaken car inspections at the facilities of the strategic partner. (Table1: student intake and student car inspections).

TABLE 1. *Student intake and student car inspections.*

	2004	2005	2006	2007	2008	2009	2010	2011
student intake	60	55	55	55	55	55	55	55
graduates					54	38	46	40
car inspection students					20	14	16	14
% of graduates					37 %	37 %	35 %	35 %
% of intake					33 %	25 %	29 %	25 %

From the table above it can also be observed that the number of students choosing car inspection as their field of specialization varies from year to year. It can, however, be estimated that approximately 35% of the intake will choose car inspection as their specialization field.

Approximately one quarter of the students specializing in car inspection and undertaking their practical legally required work practice are actually employed by the strategic partner. Three quarters of the annual graduates are employed either by other car inspection companies or by insurance companies as accident inspectors.

In the beginning, the participating strategic partner needs to appreciate the fact that it will have to incur extra personnel costs to transfer some of the company culture and company specific technical knowhow to the students. On the other hand, the strategic partner has firsthand access to the future possible recruits. It also allows strategic partner company to a work force which can for example be used during peak seasons or to cover holiday or other permanent staff absences.

Furthermore, the successful completion of a project of this type requires long term commitment from both parties: the company and the higher education organization. It furthermore requires continuous communication of both parties involved.

3 DISCUSSION: ACHIEVEMENTS OF THE STRATEGIC CO-OPERATION

The extensive use of student labour has been the underlying idea in the strategic co-operation process from the start. Since the strategic co-operation commenced in year 2005 car inspections have been carried out regularly by TUAS students on the premises of the strategic partner. Approximately 80 students have part-taken in the inspections carrying out 4800 inspections.

Students have gained knowledge of a specific company culture and have also been acquainted with the technology and it-programmes used by one industry player. They have also been given the chance to observe closely how a prospective employer functions ad what the actual working conditions are. The knowledge and experience gained throughout this co-operation has not been addressed here, however, this aspect of the co-operation forms a further issue to be examined through questionnaires to students, future employees as well as the strategic partner company.

The strategic partner on the other hand obtains firsthand knowledge and firsthand access to future employees. They are also provided with an employee pool, which they are able to use to fill in for example pre planned vacation periods or other staff absences. The cost to the company is also small, approximately 10% of the actual fee charged from the customer, i.e. the strategic partner has a direct economic benefit from the strategic partnership. TUAS has through this strategic partnership continuous and direct contact with the industry and is thus kept up to date with new industry trends.

It has to be noted that a long-term confidential relationship between the partners acts as the basis for this kind of strategic partnership and form the foundation for the work to be carried out. For the co-operation to be successful, the strategic partner company as well as the teaching staff will have to communicate on a regular basis, in particular during the first implementation phase of the practical work session and also throughout the entire practical work experience session, so that any feedback can be addressed immediately and the teaching staff has a constant up to date understanding of the strategic partners current and future needs as well as the technologies applied by the partner.

4 CONCLUSION

The most important objective of the strategic partnership arrangement is to provide students a way in which they can acquaint themselves with working life. The core idea of innovation pedagogy is to combine external working life needs to the internal needs of TUAS to create working environments that result in better learning possibilities for students. In such environments students develop their innovation capabilities consisting of both the substance-related knowledge as well as intuitive knowledge produced in the actual learning situations, here primarily the practical work session. [4] [5] [6]

In conclusion, the strategic partnership between a leading car inspection company and a higher education has numerous advantages for students, the teaching staff and businesses. Students are provided with hands on experience and companies with future employees well acquainted with company culture and procedures. Students gain hands on work experience and an understanding of how the systems of the particular employer function. For the company this is a way to assess and obtain possible employee candidates and to familiarise future prospective employees with the organisational structures and technical systems in place. Furthermore continuous information exchange between the strategic partner and TUAS enhances and deepens the knowledge base of both partners in particular on aspects such as particular technical problems and car inspection procedures in problematic cases.

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139 EMPLOYMENT OF OPENFOAM IN TEACHING AND RESEARCH

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ABSTRACT

In this paper, the authors are going to show how the usage of OpenFOAM® can be advantageous in teaching computational fluid dynamics (CFD). At first, a short introduction on the OpenSource CFD toolbox OpenFOAM® and its handling is given to familiarize the reader with this software. In the second part of this paper, an example of application of OpenFOAM® is shown by an easy step by step method on the hand of a simple physical problem. The handling with text files and working with terminal commands shall be demonstrated. In this context, a closer look on the governing analytical equations will be taken, followed by the numerical realization in OpenFOAM® and the set up a simulation run. In order to display the results, the visualisation program "Paraview" is used. The aim of this approach is to give an understanding of the potential of OpenFOAM® in supporting lectures on computational fluid dynamics and with this bringing the students to a higher level of knowledge.

Keywords: OpenFOAM®, Computational Fluid Dynamics, Finite Volume Method.

1 INTRODUCTION

In research areas on universities as well as in companies in the industry the employment of the Open Source CFD (Computational Fluid Dynamics) software OpenFOAM® is of growing importance. The reasons are mainly the increasing license fees of commercial CFD software and their inflexibility towards developing new or adjusting existing solvers. Hence it is of advantage for students to already know the usage of OpenFOAM® when starting their diploma or PHD thesis. Moreover, it is a very appropriate tool to give students an understanding of the application of fluid dynamics and its numerical implementation of the finite volume method. In many cases students attend theoretical fluid dynamics courses or theoretical numerical mathematic courses, where no link to a real working life application is shown. In case they use commercial software such as ANSYS FLUENT® it is not possible for them to observe what the program is actually doing in the background. At this point OpenFOAM® comes in handy as it is possible to view the whole underlying programming code at each point of interest. The programming language is the object-oriented C++, which makes it easier to understand the implementation and connections of the equations. As OpenFOAM is highly sensitive on input values a "trial and error method" in order to start a simulation run by random clicking on present buttons will be hindered. By this means, through the use of OpenFOAM® as teaching assistant it is possible to achieve a higher level of knowledge in contrary to working with commercial software.

2 WHAT IS OPENFOAM®?

2.1 General introduction

OpenFOAM® (Open Source Field Operation and Manipulation) [1] is a so called CFD toolbox, which is applicable for a wide range of problems in continuum mechanics. It provides the user with standard solvers, utilities and libraries, whereas libraries are repositories of function related software tools that can be accessed by solvers and utilities. All can be specifically selected according to the governing physics of the problem. The source code of the program has been made Open Source and thus is publicly available to anyone under the constraints of the GPL [2]. It allows easy and direct implementation of new software modules at any point in the program. Further on, it is easy to automatize with the help of scripts and it extensively uses generic features (Templates). These advantages make OpenFOAM® highly efficient and a very flexible tool, which in addition is free of license costs. One disadvantage of OpenFOAM® is that it is not provided with a Graphical User Interface. This means that all inputs have to be provided by means of text files, which requires a higher effort for familiarising oneself with the software and a significant amount of prior knowledge of physics and programming techniques.

2.2 Possibilities of usage

- Use of an existing solver:

This represents the common way of usage. Solvers for nearly all prevalent physical problems are available and ready to use. The main disadvantage in contrary to its commercial alternative is that it has a lower degree of comfortableness as there is no graphical user interface available. However, it requires no extensive programming knowledge, an expertise in CFD modelling is sufficient. For further information see [3]

- Creating a whole new solver/Modification of an existing solver:

In some cases, no available solver fits to the given physical problem in an appropriate way, i.e., it needs further development or has to be created fully new. For modification, in commercial programs it is possible to write user subroutines, but only to some extent. In contrary to them, OpenFOAM® provides the possibility to interact at each point of the code and change whatever is necessary without any limits. Therefore every aspect of the underlying source code can be altered as required by the user, which even permits the creation of whole new solvers, if necessary. In this case, it requires a higher level of programming knowledge from the user. This type of usage is the main power of OpenFOAM®, which makes it important for all research areas. For further information see [4].

2.3 Structure of OpenFOAM®

In OpenFOAM® the data in and output is handled over text files, called dictionaries. Every case consists of three main directories as it can be seen in the following figure.

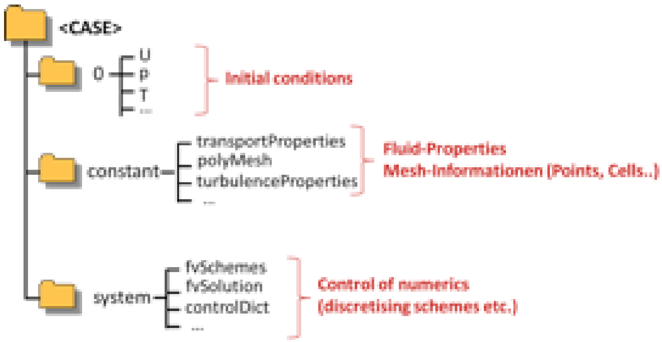

FIGURE 1. *Structure of an OpenFOAM case.*

The first folder "0" contains all the information about the initial conditions, i.e. for pressure and velocity. The "constant" directory comprises information about fluid properties (i.e. fluid density and the kinematic viscosity) and the computational mesh. In this directory the subfolder called "polyMesh" contains a full description of the fluid mesh, such as point coordinates cells and boundaries. Further on, in the main tree, the folder called "system" entails all the parameters necessary for the solution procedure. In this directory, in the text file "controlDict" all control parameters are set, for example time step size, start/end time of the overall simulation and the write accuracy. In "fvSchemes" and "fvSolution" discretisation schemes, equation solvers, tolerances and all other algorithm controls for the run are set.

3 EXAMPLE OF APPLICATION OF OPENFOAM IN TEACHING COMPUTATIONAL FLUID DYNAMICS (CFD)

In this chapter, a short step by step method is shown how OpenFOAM can be used in teaching. The task is to investigate the flow behaviour in a backward facing step. The geometry of the the fluid region is shown in the following figure.

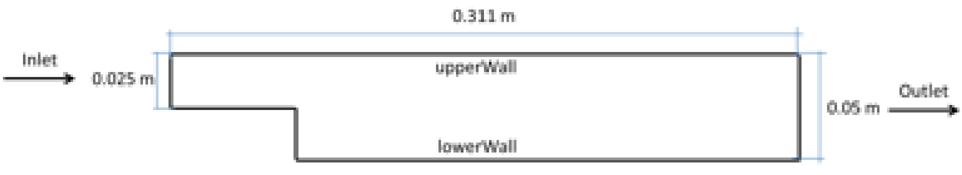

FIGURE 2. *Given geometry of a backward facing step.*

Two different scenarios are given. The first one relates to an inlet velocity of uinlet = 0.2 m/s and the second one to a uinlet = 10 m/s. Both situations shall be investigated. At first the flow regime has to be determined in order to analyse the governing equations. Further on, for their numerical evaluation an OpenFOAM® case will be set up and its results will be shown by the visualisation program Paraview [5].

3.1 Case 1: Laminar flow

The fluid which is flowing through the geometry shown in Figure 2 is a certain type of oil with the following properties (Table 1).

TABLE 1. *Fluid properties of the backward facing step.*

Symbol	Physical name	Value
ν	Kinematic viscosity	1.5e-5 [m²/s]
ρ	Density	820 [kg/m³]
u_{inlet}	Velocity at the inlet at t = 0 s	0.2 m/s

In order to classify the flow regime, the dimensionless Reynold's number (Eq.1) has to be calculated.

$$\mathrm{Re} = \frac{u_{inlet} \cdot L}{\nu} \qquad \text{Eq.1}$$

whereby ρ is the density, ν is the kinematic viscosity, u_{inlet} the inlet velocity and L the characteristic length.

For the given geometry, which has a quadratic inlet area, the characteristic lengh can be read as 0.025 m. In combination with the given values of Table 1 the Reynold's number results in a value of 333. This number lies within the range of laminar flow (0 < Re < 2300). Further on, due to its nature, the oil is considered to be incompressible. In this case the Navier-Stokes equations are valid. They are shown in the following equation.

$$\frac{\partial(\rho u_i)}{\partial t} + \frac{\partial(\rho u_i u_j)}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{\partial^2(\eta \cdot u_i)}{\partial x_j^{\,2}} \qquad \text{Eq.2}$$

Where ui and uj are the velocities along the coordinate directions xi and xj, p is the pressure and η is the dynamic viscosity, which can be calculated by $\eta = \nu * \rho$. [6]

The Navier-Stokes equations are solvable analytically for special cases only. Hence, in order to calculate the fluid flow, the CFD toolbox OpenFOAM is used. First, an appropriate solver has to be found. Information can be found in the user's guide [2]. For the present physical problem, which is incompressible and laminar flow, the solver called "icoFOAM" is chosen. It is ready to use and does not need any modification. The underlying programming language is the object oriented language C++. The syntax is similar to the notation of the differential equations being solved. For example Eq.2 is implemented into the source code as following:

```
solve
(
fvm::ddt(rho, U)
+ fvm::div(phi, U)
- fvm::laplacian(eta, U)
==
- fvc::grad(p)
);
```

where $\phi = \rho \cdot U$ (written as "phi" in the code)

More information about the programming syntax can be found in the official OpenFOAM® programmer's guide [4].

In the next step, a case as shown in Figure 1 has to be created. The easiest way to do so is to copy an existing case from the tutorials and extend the text files for the needed parameters. Further on, the geometry and mesh is created in any preprocessing program and written into the case. Some necessary input files are shown in Figures 3 and 4. For further information see [3].

pressure

```
boundaryField
{
    outlet
    {
        type            fixedValue;
        value           uniform 0;
    }

    inlet
    {
        type            zeroGradient;
    }

    upperWall
    {
        type            zeroGradient;
    }

    lowerWall
    {
        type            zeroGradient;
    }
```

velocity

```
boundaryField
{
    outlet
    {
        type            zeroGradient;
    }

    inlet
    {
        type            fixedValue;
        value           uniform (0.2 0 0);
    }

    upperWall
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }

    lowerWall
    {
        type            fixedValue;
        value           uniform (0 0 0);
    }
```

FIGURE 3. *Initial conditions for pressure (left hand side) and velocity (right hand side).*

```
nu              nu [0 2 -1 0 0 0 0] 1.5e-5;
rhof            rhof [1 -3 0 0 0 0 0] 820;
```

FIGURE 4. *Fluid properties according to Table 1.*

These text files can be altered by typing the desired value into the text file and save it. Following this, the simulation run can be started by typing into the command line of a terminal (<casename> is chosen by the user):

C:\Users\Username> icoFoam –case <casename>

After the simulation run has finished, the results can be displayed with the help of Paraview. The results can be observed in the next figure.

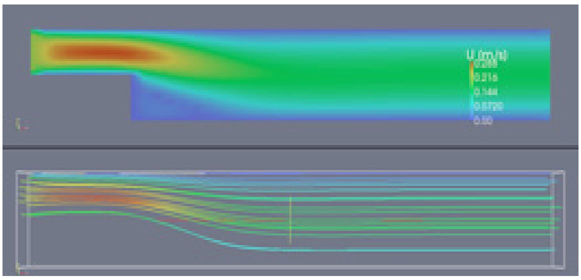

FIGURE 5. *Results of the simulation run of an incompressible, laminar fluid flow in a backward facing step.*

The picture above in Figure 5 shows the distribution of the velocity through the channel, where the red colour marks regions with high velocities. In the second picture, the streamlines are shown. From this it is clearly visible that laminar flow is prevailing.

3.2 Case 2: Turbulent flow

In this case, the same geometry and the same fluid properties as in case 1 are used. The only difference now is the inlet velocity. It is set to u_{inlet} = 10 m/s, which is 50 times higher than in case 1. This results in a Reynolds number of ~16700. This value lies far in the range of turbulent flow, which is classified as Re > 2300. Modelling turbulent flow is a nontrivial topic. Due to limited space, only a short explanation of turbulence modelling is shown here. More information can be found in [6].

For turbulent flow, the Navier-Stokes equations are no longer valid. Turbulent flow is characterised by complex structures of eddies, strong change in velocity and pressure and a chaotic and dissipative behaviour to name but a few. These properties make it impossible to find an analytical solution. Therefore, turbulence models are used. Here, the common k-ε Modell is chosen.

In this turbulence model, the fluctuations are averaged and inserted into Eq. 2. This results into an exact equation for turbulent fluctuation (Eq.3), which is again not solvable in an analytic way.

$$\frac{\partial \overline{u_i'u_j'}}{\partial t} + \overline{U_l}\frac{\partial \overline{u_i'u_j'}}{\partial x_l} = -\left(\overline{u_i'u_l'}\frac{\partial \overline{U_j}}{\partial x_l} + \overline{u_j'u_l'}\frac{\partial \overline{U_i}}{\partial x_l}\right) + \frac{1}{\rho}\overline{p'\left(\frac{\partial u_i'}{\partial x_j} + \frac{\partial u_j'}{\partial x_i}\right)} - \frac{\partial \overline{u_i'u_j'u_l'}}{\partial x_l} + -\frac{1}{\rho}\frac{\partial \overline{p'u_i'}}{\partial x_j} - \frac{1}{\rho}\frac{\partial \overline{p'u_j'}}{\partial x_i} + \nu\left(\overline{u_i'\frac{\partial^2 u_j'}{\partial x_l^2}} + \overline{u_i'\frac{\partial^2 u_j'}{\partial x_l^2}}\right) \quad \text{Eq.3}$$

where $\overline{u'}, \overline{p'}$ represents the averaged velocity (pressure) fluctuation and $\overline{U}, \overline{P}$ the averaged velocity (pressure) with the following connection: $u = \overline{U} + \overline{u'}$, where u is the actual velocity and $p = \overline{P} + \overline{p'}$, where p is the actual pressure.

By replacing

$$k = \frac{1}{2}\overline{u_i'u_j'} \quad \text{and} \quad \varepsilon = \upsilon\overline{\frac{\partial u_i'}{\partial x_j}\frac{\partial u_i'}{\partial x_j}} \qquad \text{Eq. 4 and Eq.5}$$

two equations are found:

The first one for the turbulent kinetic energy k:

$$\frac{\partial k}{\partial t} + u_j\frac{\partial k}{\partial x_j} - \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] = P_k - \varepsilon \qquad \text{Eq.6}$$

and the second one for the dissipation rate ε:

$$\frac{\partial \varepsilon}{\partial t} + u_j\frac{\partial \varepsilon}{\partial x_j} - \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] = C_1\frac{\varepsilon}{k}P_k - C_2\frac{\varepsilon^2}{k} \qquad \text{Eq.7}$$

Where νt is the turbulent kinematic viscosity, P_k the production term σ_ε, σ_K, C_1 and C_2 are empirical constants.

For simulation of this type of flow a new solver was chosen. It is called simpleFOAM. Showing the implementation of all underlying equations would go beyond the scope of this publication. Therefore the author refers to [1,3,4] for more insight on this topic.

In the next step, the case has to be set up. Again, the best way would be to search for an existing tutorial for modelling turbulent fluid flow and adjust the input text files. In addition to case 1, some new text files are included. For example, in the folder constant a text file called turbulenceProperties is added. In this text file, the turbulence model is chosen and its empirical values, which may be taken from literature, are fixed. Further on, also for k and ε the initial conditions have to be set in extra text files. They can be calculated by the following set of equations [6]. For evaluation of k at time step 0:

$$k = \frac{3}{2}\left(u_{initial} \cdot I\right)^2 \qquad \text{Eq.8}$$

Where uinitial is the initial inlet velocity magnitude and I is the initial turbulence intensity defined as I = 0.16Re-1/8 with Re being the calculated Reynolds number.

For evaluation of ε at time step 0:

$$\varepsilon = C_\mu^{\ 3/4} \cdot k^{3/2} \cdot l^{-1} \qquad \text{Eq.9}$$

Where Cμ is an empirical turbulence model parameter, k is the initial kinetic turbulent energy and l is the turbulence or eddy length scale given by l = 0.07L with L being the characteristic length.

The simulation run can be started by typing into the command line of a terminal:

C:\Users\Username> simpleFoam –case <casename>

The results can be observed in the following figure.

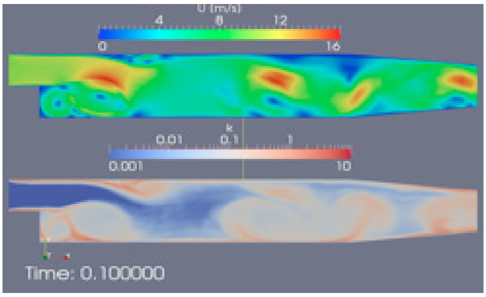

FIGURE 6. *Results of a simulation run of an incompressible, turbulent fluid flow in a backward facing step.*

In the upper picture of Figure 6 the velocity of the fluid is mapped onto the fluid region. It can be seen, that there are high fluctuations are occurring. In the lower picture the turbulent kinetic energy is shown. It is a measure for the grade of turbulence in the fluid region.

4 CONCLUSIONS

In this paper, the authors demonstrated the advantages of using the OpenSource CFD toolbox OpenFOAM® as a supportive teaching material on the basis of a simple physical problem. In many cases, students do not catch a link between the analytical equations they learn during classes and their application in working life. OpenFOAM® covers this gap by permitting insight into the whole underlying programming code. This allows the direct demonstration of the numerical realization of those equations, which will bring students to a higher level of knowledge within the same lecture.

Furthermore, OpenFOAM® is also highly valuable in research areas. Its main power is its possibility to enable interaction with the underlying source code of the used solver. If the given physical problem does not fit exactly into the framework of an available solver, the programming code can be altered at every point of interest. Moreover, it is possible to write a whole new solver and integrating it into the framework of OpenFOAM®. This is in direct contrast to commercial programs, which to not allow any interaction with the basic source code with exception of additional user subroutines. Through this, OpenFOAM® becomes a valuable tool in modeling newly discovered physical phenomena.

REFERENCES

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[2] http://www.gnu.org/licenses/gpl.html, GNU General Public License: 2010

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[5] J.Ahrens; B.Geveci; and Ch.Law: Paraview: An End-User Tool for Large Data Visualization, Handbook, Edited by C.D.Hansen and C.R.Johnson, Elsevier, 2005

[6] H.K. Versteeg, W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", second edition, ISBN: 978-0-13-127498-3, 2007.