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FROM THE EDITORS

The International Conference on Engineering Education 2012 (ICEE 2012) takes place in Turku, Finland, July 30th – August 3rd, 2012. The event is the 2012 edition of the popular ICEE conference series sponsored around the world by the International Network for Engineering Education and Research (iNEER) with 38 000 members in 98 countries. The ICEE 2012 conference is hosted by Turku University of Applied Sciences together with University of Turku and Åbo Akademi University. All the organizers together with the City of Turku welcome you to the event!

The main theme of the conference is Contributing to Success through Innovations in Engineering Education. This theme is visible in the keynote presentations, topical sessions and workshops. The rich topical program will surely facilitate lively discussions and contribute to further development of engineering education. The event will be devoted to studying various aspects on how to enable the students, future engineering professionals, to utilize their full potential to meet the global challenges. The topical areas contain, for example, categories like Sharing Global Perspectives in Engineering Education, Facilitating Innovation Competences, and Promoting University-Industry Collaboration & Commercialization of New Innovations.

Originally, 260 abstracts were submitted to ICEE 2012. 241 of these abstracts were accepted. The authors of accepted abstracts submitted 174 full papers to the blind peer review process. During the review, 433 review reports were filed by 112 members of the ICEE 2012 International Program Committee. The acceptance decisions were made based on these reviews. Moreover, the reviewers' remarks served as valuable support to the authors of the 160 accepted full papers when they prepared the final versions of their submissions. We want to address our warmest thanks to all the colleagues who participated in the review process.

This publication, ICEE 2012 Proceedings, contains the 149 accepted full papers that will be presented in the conference. These papers are written by 356 authors representing 34 different countries. This book is available as an electronic publication only. The abstracts of the papers are published in the form they were accepted in the first submission phase in February 2012 in a separate ICEE 2012 Abstract Book that is available both as a traditional printed book and in electronic format.

We hope that the ICEE 2012 Proceedings will help you to find the contributions that are most valuable in developing your own research, practice and profession further.

Take the opportunity to discuss and network with your colleagues during the conference. Global co-operation and partnership is of major importance when meeting the challenges in engineering education.

We hope that you will have a fruitful ICEE 2012 experience!

Turku, July 2nd, 2012

Jerker Björkqvist *Mikko-Jussi Laakso* *Janne Roslöf*

Raija Tuohi *Seppo Virtanen*

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PAPERS

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9 ON MOVING FROM STRUCTURED ORAL ASSESSMENTS TO COMPUTER-AIDED ASSESSMENTS FOR VOCATIONAL TRAINING

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ABSTRACT

Included in methods commonly used for assessing knowledge and skills associated with vocational training are structured oral assessments (SOAs) since they can be used to assess knowledge and skills to a depth rarely achieved in other forms of testing. However, SOAs require considerable preparation by the assessors, they can be restricted by time and assessor allocation, it is difficult to cover the course and they can put stress on the examinees. Computer-aided tests have merits and problems. They are efficient and straightforward to run, and they give an assessment environment which is less stressful than SOAs, but, they have a disadvantage in that students will on occasions guess answers when multiple-choice questions (MCQs) are used. Two electronic assessment methods are developed here, one using a scoring method and the other using a set of pairs of MCQs with both designed to counteract examinee guessing. A comparison of the four assessment results follows for three cohorts of students, namely, the results from an SOA, the results of the electronic assessment method using the "scoring method", the results of the electronic assessment method using the "set-of-pairs" method and the results of an electronic assessment method using the traditional "positive-grades-only" scoring rules.

Keywords: Competency-based assessment, Multiple-choice assessment, Oral examinations, Computer-aided assessment.

1 INTRODUCTION

The major features of competency-based assessment are the emphasis on outcomes, specifically multiple outcomes, each distinctive and separately considered, the belief that these outcomes can and should be specified to the point where they are clear and transparent, and the decoupling of assessment from particular institutions or learning programs [1]. Also, competency-based assessment is criterion-based, evidence-based and participatory. Broadly speaking, there are two types of competency, namely the generic competency and the specific or technical competency.

A prominent tool in assessing multiple outcomes in mechanical engineering workshop practice is oral assessment which can fall into two main categories, unstructured oral interaction between student and examiner, and structured oral assessments (SOAs). Unstructured oral interaction, although sometimes penetrating and informative for the examiner, can be unreliable and not valid [2].

Structured oral assessments increase reliability and validity in that when a student is examined by more than one examinee concurrently which is often highly desirable, questions can be properly prepared to cover the material adequately, planning is available to avoid repetition or overlapping of questioning and good alternation between examinees can be achieved. All this leads to efficiency when moving to the next part of the material to be covered [3]. A great concern amongst examinees is to achieve consistency when subjective judgments have to be made [4] and for these the use of SOAs leads to better coordination and standards of marking than those found in unstructured assessment conditions. However, both unstructured and structured OAs include the difficulties of large time and personnel allotment and it is difficult to cover all of the practical skills and theory involved in workshop practice as well as other details, for example, knowledge of safety, does the student communicate effectively, and has the student the ability to organize and manage activities and him or herself.

The SOA is replaced here with computer-aided assessment MCQs. MCQs can be administered very efficiently electronically, with many advantages present including simplification of the examination logistics and extraction of statistical indicators of the students' performance [5]. The question bank necessary for MCQ testing can be constructed to cover the teaching material adequately, fairly and quickly, leading to prompt feedback for the student during or after the examination. When replacing SOAs by MCQs as an assessment method however, it has been pointed out [6] – [8] that MCQs present serious caveats concerning the "positive-grades-only" scoring rule leading to concerns that MCQs are in fact a suitable alternative. Therefore, in this work it was decided to incorporate the schemes outlined by [7] [8], who have suggested using a scoring method and pair-wise-scoring rule respectively.

To test for the effectiveness of replacing SOAs with computer-aided assessment, the results of an SOA was compared with results obtained using a scoring method outlined by [7] and the paired MCQs assessment method outlined by [8]. The results of an MCQs examination method using the positive-grades-only scoring rule, are also included.

2 METHODS AND PROCEDURES

2.1 Workshop Course

Included in the course was, safety, responsibility, marking out, scrappers and scraping, key fitting, drills and drilling, the reaming process, dowelling, threading and thread repair, lapping and burnishing, and broaching.

2.2 Examinees

There were 183 students taking the course, in three cohorts ($N_{c1} = 59$, $N_{c2} = 63$, $N_{c3} = 61$). Each student completed one computer-aided assessment which was scored using the three scoring variants already mentioned and further described below, i.e., a scoring method, a pairing of MCQs method and a method which uses positive-grades-only. Each of the students was also assessed using a SOA. It was important to familiarize all students beforehand with the computer-aided assessment package and with the SOA in an effort to eliminate bias.

2.3 Computer-Aided Assessment Package

The computer-aided assessment package was written using the Java programming language. The GUI (Graphical User Interface) was networked to a central server where data could be deposited, stored and retrieved for further analysis. A database was constructed and placed on the server consisting of 300 multiple-choice questions, which covered the teaching material fully. Each question was designated a weighting factor according to its degree of difficulty.

2.4 MCQs' Scoring Methodology

Two schemes to alleviate the effects of guessing by students were tested in this work, the first described by [7] called here Scheme A, and the second by [8] called Scheme B.

Scheme A. Here the examinee is instructed to tick the box relating to the correct response of each MCQ, or if this is unknown, cross any boxes relating to responses known to be incorrect. If however, a tick is placed in a box relating to an incorrect response or a cross is placed in a box relating to the correct response, penalties are involved. Many different reward and penalty structures are possible in which random guessing will only have a detrimental effect on the expected score. For the present work, which has four boxes per question, the structure used is, 3 marks are awarded for a correctly positioned tick and $-P_T$ if the question contains an incorrectly positioned tick, where $1.5 < P_T < 2.0$. No marks are awarded for a blank. A penalty of 1.6 marks [7] is incurred if the question contains an incorrectly positioned cross, and 0.5, 1.5 or 3 marks are awarded for one, two or three correctly positioned crosses respectively within a question. The normalised score extracted from this method was s1.

Scheme B. First a set of 25 MCQs $\{q_{1a}, q_{2a}, \ldots, q_{ka}, k = 25\}$ were randomly selected taking care to cover the material appropriately and a weight was assigned to each question, depending on the level of difficulty. Using the first set of questions as reference, a second set of new MCQs $\{q_{1b}, q_{2b}, \ldots, q_{kb}, k = 25\}$ was generated, with each question qib having similarities to question qia (i = 1, ..., k), using the criteria, that each question was from the same topic, and the knowledge of the correct answer for question qia, from a student, who had proceeded to a systematic study and was cognizant of the topic, implied the knowledge of the correct answer for q_{ib} and vice versa. Also each question in a pair had the same weight w_i in the final score and the 50 questions that a student had to answer were given in random sequence, taking care that each question qib was presented following a lapse of 5 questions after the presentation of q_{ia}. To penalize guessing, the normalised scores s_2 were computed as follows:

$$S_2 = \sum_{i=1}^{k} (q_{ia} + q_{ib}) \cdot w_i \quad (a) \qquad s_2 = \frac{S_2}{\sum_{i=1}^{k} 2.5 w_i} \cdot 100 \quad (b) \qquad (1)$$

where,

$$q_{ia} + q_{ib} = \begin{cases} 2.5 & \text{if both } q_{ia} \text{ and } q_{ib} \text{ are correct} \\ 0.5 & \text{if either } q_{ia} \text{ and } q_{ib} \text{ are correct} \\ 0 & \text{if both } q_{ia} \text{ and } q_{ib} \text{ are wrong} \end{cases}$$

Positive-Grades-Only. So as not to impose a penalty to the student by negative marking for incorrect answers s3 was calculated using Equation 1(a) and normalised as

$$s_3 = \frac{S_2}{\sum_{i=1}^{k} 2w_i} \cdot 100 \qquad (2)$$

where, $$q_{ia} + q_{ib} = \begin{cases} 2 & if\ both\ q_{ia}\ and\ q_{ib}\ are\ correct \\ 1 & if\ either\ q_{ia}\ and\ q_{ib}\ are\ correct \\ 0 & if\ both\ q_{ia}\ and\ q_{ib}\ are\ wrong \end{cases}$$

Structured Oral Assessment. For each SOA the mark range was 0 to 100 with the average assessor score s4 calculated as the mean of the two assessors' marks. Questions were prepared in advance, two assessors were concurrently present during the assessment and each assessor graded a given student independently during the assessment. The questions were chosen to avoid overlapping and set at different degrees of difficulty. There were six versions of this examination in an effort to avoid students subsequently relating to other students what they had been asked. Also, the examiners prepared themselves for marking with intensive discussions on the grading policy in an effort to keep their marking as compatible as possible, by deciding what constituted what was a complete answer and what answer was worth a pass. The oral assessments lasted no more than 30 minutes per student.

2.5 Hypotheses

The aim is to show that the scores obtained by either or both Scheme A and Scheme B are statistically the same as the scores obtained by the SOA method. This can be summarized with the following null hypotheses:

$H_{0,1}$: The mean of the distribution of scores $_{s1}$, obtained using Scheme A, the mean of the scores, s_2, obtained using Scheme B, the mean of the scores, $_{s3}$, using the "positive-grade-scores" assessment method and the mean of the distribution of scores, $_{s4}$, obtained using the SOA method, are equal.

If hypothesis Ho,1 is rejected, then the following secondary null hypotheses are tested:

$H_{0,2a}$: The mean of the distribution of scores, s1, obtained using Scheme A, is equal to the mean of the distribution of scores, s_2, obtained using Scheme B.
$H_{0,2b}$: The mean of the distribution of scores, $_{s1}$, obtained using Scheme A, is equal to the mean of the distribution of scores, s_3, obtained using the "positive-grade-scores" assessment method.$H_{0,2c}$: The mean of the distribution of scores, $_{s1}$, obtained using Scheme A, is equal to the mean of the distribution of scores, $_{s4}$ obtained using the SOA method.
$H_{0,2d}$: The mean of the distribution of scores, $_{s2}$, obtained using Scheme B, is equal to the mean of the distribution of scores, $_{s3}$, obtained using the "positive-grade-scores" assessment method.$H_{0,2e}$: The mean of the distribution of scores, $_{s2}$, obtained using Scheme B, is equal to the mean of the distribution of scores, $_{s4}$, obtained using the SOA method.
$H_{0,2f}$: The mean of the distribution of scores, $_{s3}$, obtained using the "positive-grades-scores" assessment method, is equal to the mean of the distribution of scores, $_{s4}$, obtained using the SOA method.

3 RESULTS

The descriptive statistics for each of the assessments using MCQs and the equivalent SOA are summarized in Table 1, with the calculated values for mean $(\bar{x})$, median (m) and standard deviation (σ) of the normalised data collected for each cohort of students and when the cohorts were combined.

TABLE 1. *Descriptive statistics of the four assessment methods.*

Student Cohorts	Assessment Methods			
	Scheme A	Scheme B	PGS	SOA
C_1 ($N_{c1} = 59$)				
$\bar{x}$	6.71	6.99	7.22	6.78
m	6.72	7.01	7.10	6.76
σ	2.01	1.99	1.97	1.93
C_2 ($N_{c2} = 63$)				
$\bar{x}$	7.18	7.23	7.65	6.99
m	7.16	7.24	7.37	7.02
σ	1.94	2.13	2.00	1.95
C_3 ($N_{c3} = 61$)				
$\bar{x}$	7.02	7.16	7.43	7.10
m	7.03	7.14	7.42	7.10
σ	1.98	2.15	1.95	1.98
Total ($N_T = 183$)				
$\bar{x}$	6.97	7.13	7.57	6.96
m	6.97	7.13	7.29	6.96
σ	2.12	2.34	2.21	2.17

To test the null hypothesis $H_{0,1}$ repeated measures ANOVA [9] are used as this is suitable when subjects of the same cohort (sample) are measured under a number of different conditions. As the sample is exposed to each assessment in turn, the measurement of the dependent variable is repeated with one within-subjects factor, i.e., the method of examination at four levels. The F ratio for this hypothesis calculated was very high for the three cohorts and for the total, F_{C_1} (2.967, 65.1 = 568, p < 0.001), F_{C_2} (2.954, 71.1 = 668, p < 0.001), F_{C_3} (2.907, 70.5.1 = 468, p < 0.001), F_{Total} (2.899, 68.9 = 772, p < 0.001). This means that the hypothesis $H_{0,1}$ was rejected at p = 0.001 level of significance for the individual and combined cohorts.

For each of the null hypotheses, $H_{0,2a}$ to $H_{0,2f}$ a one-way paired t-test was used because the data collected for each of these hypotheses were within-subjects. Table 2 shows the results using a one-tailed t-test for dependent samples. Column one specifies the assessment methods being compared, column two represents the Cohen effect size, γ, column three the degrees of freedom, column four the t-value of the study, column five the critical value for the significance value a = 0.10 and column six lists the associated *p*-value.

TABLE 2. *Comparisons of the four assessment methods.*

Comparisons	γ	df	t-Value	Crit. $t_{0.90}$	p-Value
Scheme A v. Scheme B ($H_{0,2a}$)					
C_1	0.0998	58	0.7668	1.296	0.2232
C_2	0.0173	62	0.1377	1.295	0.4455
C_3	0.0487	60	0.3800	1.295	0.3526
Total	0.0506	182	0.6850	1.286	0.2471
Scheme A v. PGS ($H_{0,2b}$)					
C_1	0.1827	58	1.4036	1.296	0.0829
C_2	0.1749	62	1.3884	1.295	0.0850
C_3	0.1499	60	(1.1710)	1.295	0.1231
Total	0.1150	182	1.5551	1.286	0.0608
Scheme A v. SOA ($H_{0,2c}$)					
C_1	0.0254	58	0.1950	1.296	0.4230
C_2	0.0246	62	0.1888	1.295	0.1888
C_3	0.0102	60	0.0796	1.295	0.4684
Total	0.0033	182	0.0446	1.286	0.4822
Scheme B v. PGS ($H_{0,2d}$)					
C_1	0.1485	58	(1.1409)	1.296	0.1293
C_2	0.0801	62	(0.6360)	1.295	0.2636
C_3	0.0930	60	(0.7265)	1.295	0.2355
Total	0.1367	182	1.8492	1.286	0.0330
Scheme B v. SOA ($H_{0,2e}$)					
C_1	0.0161	58	0.1239	1.296	0.4509
C_2	0.0288	62	0.2284	1.295	0.4100
C_3	0.0205	60	0.1603	1.295	0.4366
Total	0.0533	182	0.7206	1.286	0.2360
PGS v. SOA ($H_{0,2f}$)					
C_1	0.1608	58	(1.2350)	1.296	0.1109
C_2	0.2363	62	1.8754	1.295	0.0327
C_3	0.1200	60	(0.9374)	1.295	0.1762
Total	0.1877	182	2.5332	1.286	0.0061

Testing for the normality assumption, analysis to detect outliers and the non-parametric tests of Wilcoxon and the Mann-Whitney U test were carried out for the hypothesis $H_{0,1}$ and for the hypotheses $H_{0,2a}$ to $H_{0,2f}$ respectively. It was found that no normal distribution of the variables could be assumed and that all the data lay within the ±2 standard deviations around the sample means. The non-parametric tests did not show any difference from the results of the t-tests.

It can be seen from Table 2 that the results for Scheme A when compared to those of Scheme B achieved a statistically and practically significant result for all three individual cohorts and when the cohorts were combined. This was also the case when Scheme A was compared to the structured oral assessment results. When Scheme A was compared with the "positive-grades-only" the anticipated result of achieving a non-significant result wasn't found with Cohort 3, although a strong practically and statistically non-significant result was found when the three cohorts were considered as a whole.

For Scheme B, the results were more mixed. This method of scoring did achieve statistically and practically significant results for all three cohorts and their combination when compared to the structured oral assessment method. However, when compared with the "positive-grades-only" results, the three individual cohort results also showed statistically and practically significant results which was not anticipated. When the "positive-grades-only" results were compared with the SOA results again the picture was mixed. Two of the individual cohorts showed significant results, although Cohort 1 was approaching the critical point value. When the cohorts were considered in total there was a strong non-significant result. Further analyses of these results were carried out by comparing the linear regression lines of s_1, s_2 and s_3 to s_4.

From these results it was found that assessment of the students using the "positive-grades-only" gives a bias in the sense of greater success rates and scores than the SOA and both Schemes A and B. This may be due to having no controls on the student tending to guess when they did not know the answer. The bias is reduced by the use of the scoring method (Scheme A) and the paired MCQs assessment method (Scheme B) with Scheme A alleviating the bias best.

4 DISCUSSION

This study focused on the replacement of SOAs by MCQ assessment methods, one using a scoring method designed to eliminate the effect of guessing and the other using a set of pairs of MCQs also designed to counteract examinee guessing. From the results it can be deduced that it is possible to replace an SOA successfully with the scoring method proposed by [7]. The paired MCQs assessment method outlined by [8] also appears to reduce the effects of guessing but with less success.

When it comes to the MCQs assessment method it must be pointed out that further work would need to be done to fully remove any concerns regarding the credibility of the results. First the area of course content was limited and further work will have to be carried out using other modules as well as using a larger sample size of students. A second concern is that only one structured approach to the oral assessment was tested. While it may be that this structured approach used for further assessment in workshop practice, it may be that it could not be used universally.

It has also been suggested [8] that an investigation of the differential effects of the scoring and the "set-of-pairs' assessment methods to the "positive-grades-only" assessment method and the SOA method, not only the students' test performance, but also to the confidence judgments that they would make on their performance and the accuracy of those judgments. It has also been expressed that the introduction of measurement of meta-cognitive skills to the students, that is, knowledge and regulation of cognition [10] might add valuable information concerning the relative effects and merits of the various assessment methods as related to personal characteristics of the students.

5 CONCLUSIONS

It was found that the scoring method was the most appropriate of the computer-aided assessment methods to replace the oral assessment method. The paired MCQs assessment method outlined also appears to reduce the effects of guessing but with less success. Further work would need to be done to confirm generalization of substituting an SOA with computer-aided assessment.

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11 A STUDENT'S PERCEPTION OF ETHICS DURING HIS FINAL YEAR PROJECT "ETHICS ON A CONSTRUCTION PROJECT" IN THE MIDDLE EAST

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ABSTRACT

The construction industry is known for low ethical performance, and business ethics are rarely taught and emphasised in Middle East academic institutions. The purpose of this study is to show how and why an engineering student's perception of ethics changed during his undergraduate final year project. The study is based on a case study approach and it analyzes the change of the student's perception of ethics, measured by emergence and continuation of ethics concepts. It was found that the student considered the topic unimportant at the beginning, but gradually became aware of its significance without a clear conceptual understanding. His final perceptions were, that personal misbehaviour is the core issue, and that clear expectations, a role model, applying the "Golden Rule" and trust between project participants are the primary solutions for a variety of ethics issues on a construction project. Interaction with an ethically minded project manager and a workshop with high ranking project participants had a greater impact than the student's interviews with the same project participants or literature review. This should be considered when preparing engineering students for ethical dilemmas in the workplace through final year projects and other assignments.

Keywords: Construction project management, Ethics, Case study, Final year project.

1 INTRODUCTION

Following the definition of Robinson et al. [1], ethics is the philosophical study of right and wrong in human conduct and the principles which govern it. Unethical conduct in construction is not limited to a certain region or a certain stakeholder; the whole construction industry is known for its low ethical performance [2]-[3].

Employees show different ethical attitudes and different levels of interest for society [4] and engineering students, the future employees, are no exception. Jonassen et al. [5] reported that workplace problems are complex and ill-structured because they are, among other reasons, composed of conflicting goals. They are usually not sufficiently learned during engineering education. Although understanding ethical responsibility is one of the 11 learning outcomes as defined by the Accreditation Board for Engineering and Technology (ABET) [6] and subjects such as professional ethics, ethics in engineering, or environmental ethics are part of many engineering curricula, graduates are usually left with little understanding of their own ethics perception and how this may influence their decision-making at the workplace.

Ethics is perceived differently in different geographic regions and cultures [7]. Izraeli [8] reported that business ethics is not yet institutionalized in the academia of the Middle East with the consequences that business ethics courses are not taught, little research is carried out and no regular training on business ethics is taking place. Although there have been changes since then and ethics related subjects are part of some curricula in the Middle East, it is important to note that there is no commonly used term for business ethics in the Middle East since speaking about ethics and the meaning of ethics related terms are strongly affected by cultural factors [9].

2 PURPOSE

The purpose of this case study is to show how and why the ethics perception of an engineering student in the Middle East changed while carrying out his final year project "ethics in construction projects". The student interacted with literature and project participants of one of the largest construction projects in the region.

3 METHOD

Case study based research needs to clarify first whether a single case study or multiple case studies are necessary. According to the criteria of Yin [10] a single case study approach is appropriate for the purpose stated here and the data collection process was in line with the following four of the six principles of case study research [11]. The timeline of data collection is shown on Figure 1.

1. Analyze documentation: At various stages of the final year project, the student had to submit documents which were assessed and were also part of the basis for the analysis carried out here: a preliminary plan (submitted day 15), a progress report (submitted day 43) and a final thesis (submitted day 89). In addition, he prepared and submitted a questionnaire (submitted day 41) and meeting minutes for an ethics workshop (submitted day 49).

2. Analyze interviews and discussions: The supervisor conducted three recorded interviews with the student and two recorded discussions with the student and the project manager.

3. Analyze observations of participants: As part of his final year project, the student prepared and carried out an ethics workshop for seven construction project participants, including the client project manager (PM), two further engineers from the client side (client1, client2), two engineers from the consultant side (consultant1, consultant2), and two engineers from the general contractor side (contractor1, contractor2). The student also conducted follow-up interviews with each of the participants after the workshop. The supervisor participated in all of the interviews as a silent observer and in the workshop as an active participant and recorded the communication processes as well as observable behavioural issues.

4. Analyze direct observations: During the supervisor-student interviews, the supervisor observed the student and took notes of his attitude, behaviour, reactions, etc.

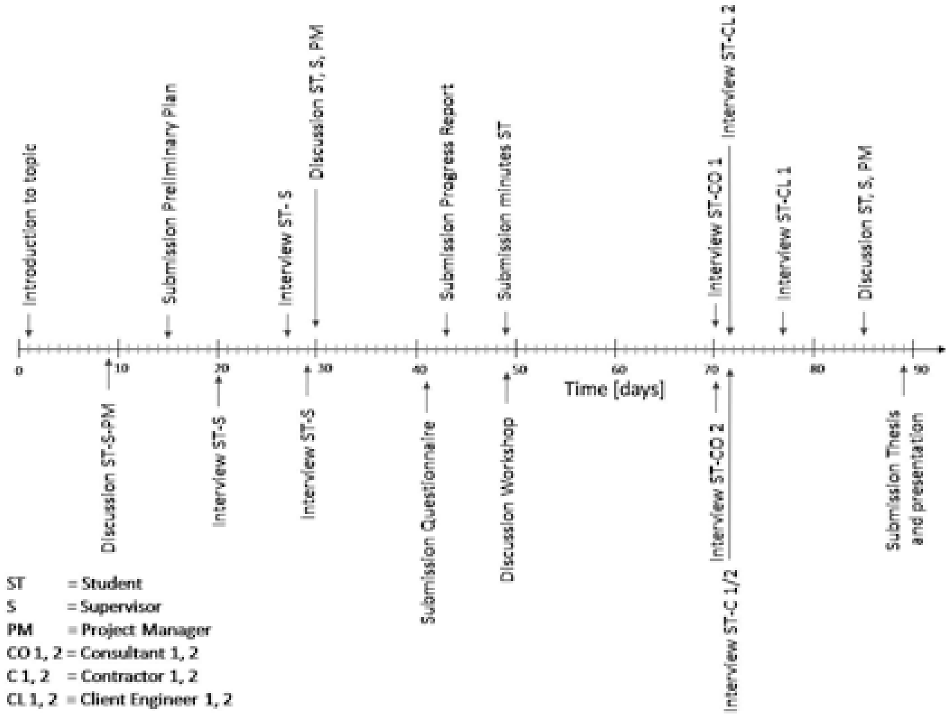

FIGURE 1. *Timeline data collection.*

The recorded data allows chronological measurement of the frequency of used concepts as they relate to ethics principles (taken as unit of analysis [12]), first and last time appearance of concepts, and the tracking of concepts as expressed during the 89 days of the final year project. Based on a logic model [13], a chain of events over time which links cause and effect are stipulated. This means the outcome of an earlier stage becomes the causal event for the next stage. Predicted outcomes are then tested against evidence found in the data. Here, the interviews, discussions and submissions of documents present elements of the logic model (Figure 2).

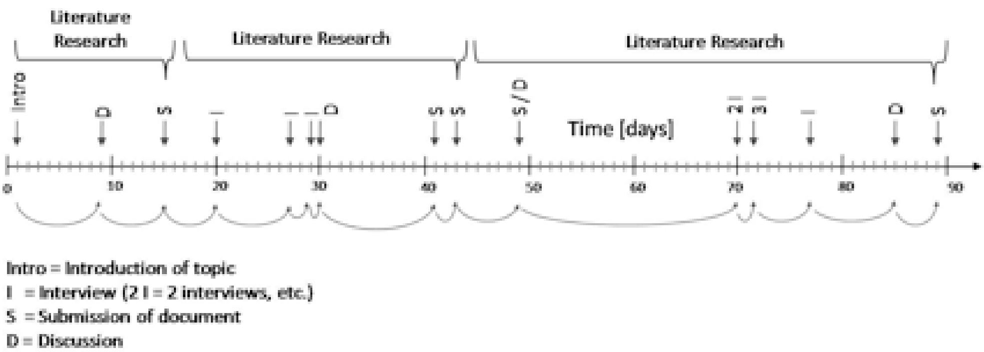

FIGURE 2. *Logic Model.*

4 RESULTS AND DISCUSSION OF QUALITATIVE ANALYSIS

This section covers the results of the qualitative analysis of collected data in chronological order and focuses on identifiable ethics concepts and their discussion.

When the supervisor introduced "ethics on construction projects" as a final year project on day 1 (introduction of topic), the student's first reaction was a smile which seemed to say: "In our region we don't care about ethics". However, when he heard that a project manager of one of the largest construction projects in the region was interested in this topic, he became more serious and listened attentively when the supervisor presented a rough idea about the scope of this final year project.

On day 9 (discussion of student, supervisor and project manager) the student seemed to be impressed by the project manager, although it was unclear if this was because of the project manager's position, appearance, ethics perception, eloquence, or other factors. However, from this discussion onwards the supervisor did not see the student smirking when talking about ethics and he seemed to consider it to be an important topic. One week later (day 15, submission of student's preliminary plan) the student confirmed that he perceived ethics as something important. However, a clear concept of ethics could not be identified.

On day 20 the supervisor interviewed the student in order to see if, and how far, the student's perception of ethics had changed. The degree of answer details and the spontaneity in answering revealed the high impression the project manager must have had on the student. The student confirmed the importance of ethics and the importance of controlling tools to avoid ethics issues, but no emerging new concept could be realized.

A week later (day 27, supervisor's interview of student) the student explained that, based on literature, he found negligence, bribery, fraud, claims and misbehaviour to be the five most critical issues, and he emphasized that claims was also an issue the project manager had mentioned. Interestingly, the student's literature source [14] lists further issues which the student did not perceive as belonging to the five most important ethics issues. The influence of the project manager on the student's ethics perception seemed to be much stronger than the influence of literature. Based on his literature research, the student found that ethics is not only a problem, but constituted also a chance for competitiveness and productivity. Also, the implementation of an ethics office as point of contact for employees with ethics questions and concerns was a strategy he found in literature and he agreed that this might be an important approach.

On day 29 (supervisor's interview of student) potential solutions to the previously identified ethics issues were the focus of the interview. The student explained solutions for the issues of negligence, claims, and misbehaviour which were already mentioned by the project manager on day 9. Regarding fraud he mentioned a solution the project manager explained before (web-cams) and added "additional inspectors". Concerning bribery the student said that he found in literature that payment records can solve the issue. The student's concept concentrated clearly on controlling instruments to combat ethics issues.

The goal of the discussion on day 30 (discussion of project manager, student and supervisor) was the student's presentation of the most significant ethics issues in construction projects as well as potential solution strategies. The project manager interacted with the student positively and critically in that he asked the student to explain statements in more depth. He took an objective stance towards the topic, confirmed the student's findings, recommended caution concerning some examples, encouraged the student to see the "big picture" of construction as a contribution to society, reflected ethnic objectivity and used examples. There was a clear shift in the discussion from the previous focus on controlling tools towards a more proactive focus on honouring team members and being a role model.

The student's submission of a questionnaire (day 41) for an ethics workshop with the above mentioned participants did not reveal a change of his perception of ethics. However, the submission of his progress report (on day 43) revealed for the first time the right of project participants of having a professional conscience and personal ethics. The student began shifting from corporate business ethics towards personal ethics. During the 1.5 hours workshop discussion (day 49a), the student followed the discussion actively, but contributed to the discussion only two times. The first time he referred to a project manager statement from day 30 and the second time he asked a question related to the controlling of rule adherence.

Later on the same day (day 49b), the student submitted his workshop minutes. The following concepts were already raised on previous occasions; however, some of them were discussed during the workshop in more detail which may have caused the student to understand better or even for the first time and, hence, making him to record them. The student recorded that "engineers will find a way to ignore it [ethics]", which was already discussed on day 9. The project manager's statement "We live in a contagious environment" was already made on day 30 and earlier.

On day 70a (student's interview of consultant2) it became apparent that the student considers someone who applies the "Golden Rule" (i.e. do to others as you would have them to do) a role model. Another aspect of the student's ethics perception became clear on day 70b (student's interview of consultant1) when the student expressed less doubts than his interviewee that the "Golden Rule" would be applicable in all cultures and societies.

On day 71a (student's interview of client2), the student was convinced that unethical behaviour must be addressed in some way in order to avoid repetition of the incident, and on day 71b (student's interview of contractor1) he enquired as to why unethical behaviour should not be reported to the direct supervisor of the culprit. The student still considered reporting as a necessity, but did not see the need to involve the PM. On day 77 (student's interview of client1) the student revealed that a role model was not a theoretical construct for the student anymore and the PM came immediately to his mind when client1 used the term "role model".

On day 85 (discussion of project manager, student and supervisor) the student used again the expression "unethical behaviour is contagious" which was used by the project manager previously. Applying the expression in the context of "role model" showed that the student realized again its crucial role. Finally, on day 89, the student submitted a thesis (86 pages) which was coded and analyzed quantitatively using NVivo9 [15].

5 RESULTS AND DISCUSSION OF THE QUANTITATIVE ANALYSIS WITH NVIVO9

After coding the whole thesis regarding different ethics concepts, ethics issues, influences on the student's ethics concepts and the importance of ethics, a cluster analysis of word similarities was performed. The program's analysis of similarity is based on the Pearson correlation coefficient and the cluster analysis generates a diagram which clusters selected nodes consisting of the same concept [15] if they have many words in common. The cluster map (Figure 3) shows the result for the analysis of ethics concepts and influencing factors.

Some of the similarities add to the previous insights and allow the following interpretations. The usage of words to describe the "Golden Rule" and the role model concept show similarities which may be interpreted that, from the student's perception, a role model applies and follows the Golden Rule. This impression was already apparent during the workshop. The word similarities may indicate that the workshop contributed to the understanding that personal misbehaviour is a core issue. Similar, the project manager seemed to have influenced the student's perception of trust as it relates to ethical behaviour. The general importance of ethics seemed to be primarily influenced by the student's literature research. For his thesis he supported the importance of ethics predominantly with literature which may have also been a consequence of a desire to produce many pages. The clusters including one or more cluster-groups have been excluded from further interpretations since they are prone to a higher level of pure chance. Especially the ESL- (English as Second Language) background of student and project participants as well as the strong cultural influence on ethics and its semantics [9] require interpreting the analyzed word similarities with great caution.

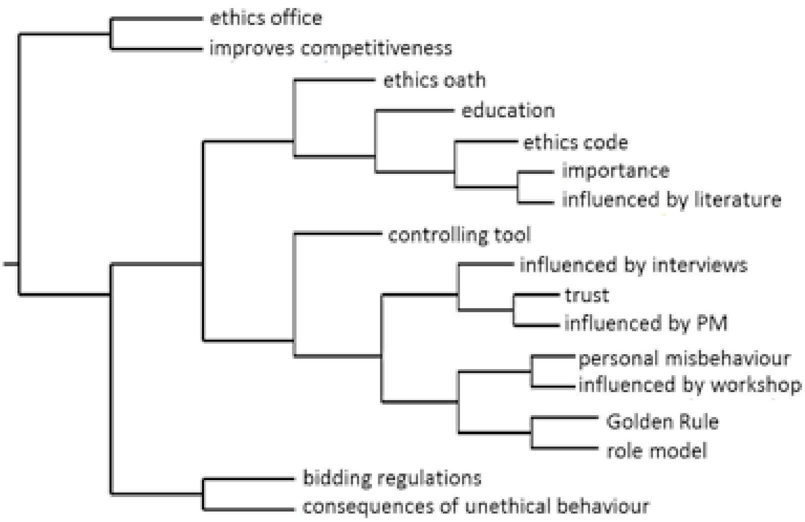

FIGURE 3. *Cluster map of student's ethics concepts and influencing factors.*

Realizing possible limitations of case study research results [10], it can be stated that the student's ethics perception changed throughout his final year project. At the beginning he considered the topic unimportant, but gradually became aware of its significance without a clear conceptual understanding. His final perceptions were, that personal misbehaviour is the core issue, and that clear expectations, a role model, applying the “Golden Rule” and trust between project participants are the primary solutions for a variety of ethics issues on a construction project. Although literature had some influence on shaping the student’s ethics perception, especially regarding the “Golden Rule” and the necessity for clear expectations, the main influence have been the discussions with the project manager and the workshop discussion which influenced his perceptions regarding the core problem (personal misbehaviour), the role model concept and trust.

6 CONCLUSION

Realizing possible limitations of case study research results [10], it can be stated that the student’s ethics perception changed throughout his final year project. At the beginning he considered the topic unimportant, but gradually became aware of its significance without a clear conceptual understanding. His final perceptions were, that personal misbehaviour is the core issue, and that clear expectations, a role model, applying the “Golden Rule” and trust between project participants are the primary solutions for a variety of ethics issues on a construction project. Although literature had some influence on shaping the student’s ethics perception, especially regarding the “Golden Rule” and the necessity for clear expectations, the main influence have been the discussions with the project manager and the workshop discussion which influenced his perceptions regarding the core problem (personal misbehaviour), the role model concept and trust.

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15 INNOVATION PEDAGOGY – A NEW CULTURE FOR EDUCATION

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ABSTRACT

According to Hall [1] "culture is learned and shared behavior". Culture sets the norms which are rules of conduct for particular circumstances and values, which mean sense of what should be maintained or achieved. Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in practice to various innovation processes in working life. Innovation pedagogy introduces how the development of students' innovation skills from the very beginning of their studies can become possible. In this paper we present the concept of innovation pedagogy and show that it can form a new culture for the universities and thus provide a cornerstone for the creation of individuals who are innovative and capable of contributing to the success of future learning organizations of working life.

Keywords: Innovation pedagogy, Culture, Engineering education.

1 INTRODUCTION

According to Hall [1] "culture is learned and shared behaviour", there are great differences among the ways people behave in different cultures and it is essential that we understand how other people read our behaviour. Culture can also be defined as "the entirety of societal knowledge, norms and values". Norms are beliefs how to behave or not to behave; values are stable beliefs regarding desired behaviour or end states. They both create expectations and criteria regarding the conduct of others [2].

Culture controls behaviour in deep and persisting ways, many of which are outside of awareness and therefore beyond conscious control of the individual. Culture sets the norms which are rules of conduct for particular circumstances and values, which mean sense of what should be maintained or achieved. Culture is not a one thing but a complex series of activities interrelated in many ways. There are various approaches for comparing and classifying cultures which usually refer to cultures between nations. However there are different cultures between different occupations, social classes, subcultures etc. Culture is transferred from older to younger generations by different agents in a socialization process. It is obvious that this kind of socialization happens also when a new student arrives into a study program. The norms, values and well-regarded behaviour is different among engineering students and sustainable development students or business students and design students.

Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in practice to various innovation processes in working life. Innovation pedagogy introduces how the development of students' innovation skills from the very beginning of their studies can become possible. [3] Innovation pedagogy contributes to the development of new generation of professionals. [4] [5] It provides a new starting point for all the different study programs. It is a prevailing culture for the new university.

According to Senge [6] a learning organization is "an organization that is continually expanding its capacity to create its future". To remain viable in an environment characterized by uncertainty and change, organizations and individuals alike depend upon an ability to learn. It has been argued that the rate at which organizations learn may become the only sustainable source of competitive advantage for them [7]. Organizations are made up by people so it is essential that the people are capable of being innovative and producing something new, the learning of the organization is directly related to the learning of its employees. [8][9] It has also been presented that organizational learning is a requirement for achieving sustainable competitive advantage. [10][11] So it is vitally important that an organization, when wanting to continuously maintain its competitive advantage, also makes sure that the conditions for organizational learning exist.

In this paper we present the concept of innovation pedagogy and show that it can form a new culture for the universities and thus provide a cornerstone for the creation of individuals who are innovative and capable of contributing to the success of future learning organizations of working life.

2 AN ASPECT ON CULTURE

The three most commonly used cultural classifications are Hofstede's [12], Hall's [13] and Lewis's [14] classifications. These classifications are mainly used to differentiate the cultural characteristics of different nations. When examining them more in detail it can be noticed that people belonging to different cultures behave in a very different manner and not being familiar with the characteristics of different cultures can cause great difficulties in communication. These classifications are handled more in detail in continuation in order to explain the many forms of different behaviour.

First, Hofstede's [12] classification of cultures is one of the most well known approaches to culture in business research. According to him cultures can be classified relative to other cultures based on four basic dimensions of 1) power distance, 2) collectivism versus individualism, 3) femininity versus masculinity and 4) uncertainty avoidance. Together these dimensions form a four-dimensional (4-D) model of differences among national cultures. Each country can be characterized by a score representing each of the four dimensions. According to this classification Finland is a small power distance, reasonably individualistic, very feminine and rather high in uncertainty avoidance country (e.g. Adler [15]). This differs from USA which scores higher in power distance, very high in individualism, high in masculinity and below the average on uncertainty avoidance.

Secondly, Hall [13] noted differences in verbal and non-verbal expression in cultures, and talked about the extent to which communication is carried out by words or is embedded in the context in which people speak the words. He proposed the concept of high versus low context as a way of understanding different cultural orientations. According to him cultures can be placed to a continuum, with high and low context on either extreme. The whole grouping is intuitive and according to his view a high-context culture is one in which people are deeply involved with each other. As a result of intimate relationships among people, a structure of social hierarchy exists, individual inner feelings are kept under strong self-control, and information is widely shared through simple messages with deep meaning. A low context culture is one in which people are highly individualized, somewhat alienated, and fragmented, and there is relatively little involvement with others. Toward the high end in this continuum are countries like China, Korea, Japan, and at the low end of the continuum are Switzerland, Sweden and Norway. Toward the middle are France, Spain, and many African countries.

Third, Lewis [14] defines cultures into three groups: linear-active cultures, multi-active cultures and reactive cultures. In linear-active cultures speech is for information exchange, listening and speaking is done in equal proportions. In multi-active cultures people find it almost impossible to tolerate silence, they think as they speak. Reactive cultures are called “listening cultures”. People in these cultures prefer to listen and establish the other’s position first, only after that they react and formulate their own message. Thinking is done before speaking. Reactive people are introverts; they distrust a surfeit of words and are adept at subtle nonverbal communication. Reactive cultures are to be found in Japan, China, Taiwan, Singapore, Korea, Turkey and Finland. Americans are highly linear-active and thus find reactive tactics hard to fathom. In reactive cultures the preferred mode of communication is monologue – pause – reflection – monologue. In linear active cultures the communication mode is dialogue where one interrupts other’s monologue buy frequent comments, even questions, which signify polite interest in what is being said.

In sum, culture seems to be something which describes the general characteristics and accepted modes of conduct within a certain limited group of people. Taking the Finnish culture as an example we seem to get a culture which can be identified by certain amount of variables. The culture in Finland according to Lewis [14] belongs to the group of reactive cultures. Although most western cultures according to Hall [13] can be defined to belong to low context cultures, there are certain characteristics in the Finnish culture which indicate that it can in Halls classification be placed to the high context end of the cultural continuum. Such characteristics are e.g. the Finnish way of tolerating silence and being extremely concerned about how others perceive themselves. In the same way the different cultures of different professions can be characterized by certain variables which make them different from the other professions.

In the university these differences might demonstrate themselves in many ways. We get the extrovert and active sales students who are very good in delivering presentations and talks and then again the more introvert and task oriented mechanical engineering students who like to concentrate on finding out how something works and what is in the box. What is considered as a respectable and desired mode of conduct is very different in different study programs. Sustainable development students don’t want to be involved in producing profits, they want to concentrate on saving the world. Design students consider all kinds of cheap solutions as unworthy; their emphasis is on design thinking. The more advanced the students are the more they have accepted the desired cultural aspects of their own study program. They are gradually being socialized in the culture of their own future profession.

3 INNOVATION PEDAGOGY IN TURKU UNIVERSITY OF APPLIED SCIENCES

Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in practice to various innovation processes in working life. Innovation pedagogy introduces how the development of students' innovation skills from the very beginning of their studies can become possible. [3] Innovation pedagogy contributes to the development of new generation of professionals whose conceptions of producing, adopting and utilizing knowledge make innovative thinking and creating added value possible. [4][5]

The ultimate aim of innovation pedagogy is to reach the final learning outcomes which are related to the competencies possessed by the students when entering working life once having completed their degrees. The aim of the whole educational process is to equip students with the core competencies of their own subject matter and in addition to that also prepare them to become active contributors in the different innovation processes they are facing when working as entrepreneurs or employees. [16] To reach this goal it becomes essential to define the desired goals, knowledge, skills and attitudes, which refer to the learning outcomes related with the capability of being able to act innovatively. These learning outcomes are called innovation competencies. One of the important tasks of any educational institution is to define, develop and implement the correct methods to be used in education. To succeed in this development work requires joint effort with the faculty members, students and working life.

An innovative individual forms the base for any innovation activities to take place. Innovativeness at individual level usually demonstrates itself as creativeness. But in many cases this is not enough, instead the idea needs to be examined by other creative individuals who get the chance to contribute and develop it further. In this phase the further development of future innovations calls for interpersonal competences in the participating individuals. After interpersonal examination the next level is to connect to the existing networks of the individuals involved. In order to reach successful results a well working network and competencies to operate in the network are needed. Only flowing information and knowledge can create learning in the organization and organizational learning in many cases is an antecedent of innovational behavior.

Learning outcomes are statements which are used to describe specifically what is expected from a learner in form of understanding, knowledge and know-how at the end of a certain period of learning. They are broad statements of what is achieved and assessed at the end of the course of study. [17][18] They represent an approach to education in which decisions about the curriculum are driven by the outcomes the students should display by the end of the course. In outcome-based education, product defines process. The curriculum is being developed from the outcomes the students are wanted to demonstrate rather than writing objectives for the curriculum which already exists. A learning outcome is a written statement of intended and /or desired outcome to be manifested by student performance. [19][20][21] Guidelines for defining learning outcomes recommend that they should be clearly observable and measurable [18].

The outcomes cover both cognitive and practical skills [22]. The learning outcome is divided into components consisting of the cognitive, psychomotor and affective domains of an outcome. They can be called knowledge or understanding, skills and attitudes, feelings and motivation accordingly. As Spitzberg [23] points out the distinction among knowledge, skills and motivation is important because performance can be enhanced or inhibited by any one or all of these components. Learning outcomes are also guaranteed achievements which can be institutionalized and incorporated into practice. The ownership of the outcomes represents a more student-centered approach. Students take responsibility for their own learning. [17] As it is argued that learning outcome might not be suitable for every discipline of education literature also speaks of emerging learning outcomes and thus leaves room for emergent ones which differ from the predetermined intended ones and make unexpected occasionally occurring learning possible. [24][18][25]

Innovation competencies are the learning outcomes which refer to knowledge, skills and attitudes needed for the innovation activities to be successful. The methods applied and the way how teachers and students interact constitute a base for learning and thus enable the forming of innovation competencies. The methods used also facilitate intuitive and unexpected learning during the learning process and make transmitting of tacit knowledge possible when dealing with working life. In innovation pedagogy this kind of learning outcomes can manifest them in the form of intuitive and tacit learning which takes place in the learning situation. They can be f.ex. experiences about cultural differences, about working at customer surface etc. The core idea in innovation pedagogy is to bridge the gap between the educational context and working life. Learning and teaching processes are developed so that they provide improved competences for the students and enable personal and professional growth. Learning is deeper when the previously gained knowledge is continuously applied in practical contexts. [16]

Innovation competencies are learned gradually as new information is added to our knowledge structures. Knowledge acquisition and application are critical components in this process. Thus, creating new services, products and organizational or social innovations – new added value – requires both knowledge and skills, which are applied in an innovation process. [26][4][27][28][29] Innovation pedagogy is defined as “a learning approach that defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations”. [3][4][30]

Innovation can be defined in many ways. For example, Schumpeter [31] speaks about innovative entrepreneurship. It is an Idea, practice or object which is considered new by the people [32] or a solution which brings economic benefits. [33] In Finland’s national innovation strategy (2008), innovation is understood as competitive advantage based on knowledge. Innovations are best born in a special culture which includes freedom to think, equality and brotherhood. In the context of innovation pedagogy innovation is understood as the process of constantly improving knowledge, which leads to new ideas, further knowledge or other practices applicable in working life. [5]

Innovation pedagogy contributes to the development of new generation of professionals whose conceptions of producing; adopting and utilizing knowledge make innovative thinking and creating added value possible. [5][4] This is an important target mentioned in the Finnish National Innovation Strategy [32], which integrates applied research and development, entrepreneurship and flexible curricula to meet the multi-field customer needs in regional and international networks [34]. The core idea in the application of innovation pedagogy is to bridge the gap between the educational context and working life. Learning and teaching processes are developed so that they provide improved competences for the students and enable personal and professional growth. Learning is deeper when the previously gained knowledge is continuously applied in practical contexts. [16]

4 CONCLUSION

Innovation pedagogy can be understood to contain such characteristics which are considered to be describing a culture. The characteristics of culture are being transformed from one individual to another in the socialization process which takes place in the environment the person belongs to. The socialization process in the university means transforming the norms of their study programs as their everyday modes of conduct. As innovation pedagogy is built on the idea of valuing gross-disciplinary actions its aim is to socialize the students to all the fellow students in the university and to modes of conduct which contribute to the development of innovation competencies.

As culture always must be supported by groups of people and it must be remembered that a private belief is not a culture. Instead minority beliefs may form a subculture and when concerning universities the students in different study programs very often seem to belong into a subculture of their own. These subcultures have beliefs and modes of conduct of their own. It can even be possible to distinguish a student's study program from his/her looks as it is known that people display their identity by their dressing style and by the products they use.

However groups of people may change and adapt their culture. The aim of innovation pedagogy is to create a learning environment which is basically gross-disciplinary. The use of new educational research, development and innovation methods makes it possible to reach the desired learning goals concerning both study program specific competences and the three categories of innovation competencies.

One of the aims of this new culture of innovation pedagogy is to form a totally new generation of university graduates who are global citizens, respect other people and have a very broad and gross-disciplinary attitude towards everything. In this way we believe to create innovative actors for the needs of our future society.

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16 PROFILES OF ENGINEERING STUDENTS IN MATHEMATICS

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ABSTRACT

For some time mathematics teachers of Finnish universities of applied sciences in engineering have been talking about students who struggle in passing the courses. It is quite usual that last courses before graduating are the first year mathematics, physics or statics. Amount of these students is growing at the same time when resources are diminishing. It is easy to point the finger at students coming from technical colleges because of their lesser education in mathematics. In this study, freshmen of two academic years were profiled according to their background information, motivation and self-regulation. The profiles of the first year were used to recognize students at risk from freshmen entering next academic year. The recognition was done not only by questionnaires but, also, by students' self-knowledge. Although mathematical background is affecting the grades, there were more common characteristics in students found explaining the grades.

Keywords: Motivation, Self-Regulated Learning, Profiling.

1 INTRODUCTION

Students struggling in their mathematical courses is a growing group in the field of engineering. Because of the demands for graduating in time, this group should be trailed through curriculum as smoothly as possible. In some cases, it may mean not holding out the requirements that is not rational in the sense of the other courses and working in engineering field.

Although students with lesser mathematical education seem to get lower grades, some of them are getting higher grades. On the other hand, some students with extensive mathematics in high school are struggling with engineering mathematics. This can be seen by analyzing grades of the first mathematics course in 2010 at Saimaa UAS. The same kind of diverging can also be found when grades are classified according to the results in the proficiency test, which was hold at the beginning of their studies.

We asked the students to fill in questionnaires about motivation and self-regulation towards mathematical studies. Answers were classified according to the grades with background information like previous education, mathematics studied in a high school and result in the proficiency test. Classification was done with IBM SPSS® Decision Tree. Results show that the same motivational and self-regulating factors are either lowering or raising the grades despite the previous education or results in the proficiency test.

These factors were used to get profiles of different kinds of students. In the autumn 2011, freshmen were asked to select the profile best describing them. The selection was done during the proficiency test. The same students also filled in the motivation and self-regulation questionnaires. In this paper, it is analysed how well students' selection from profiles and their actual mathematical profile according to the questionnaires matched and how, if necessary, the profiles should be improved. When profiles are selected correctly enough by students, their mathematical studies could be supported from the beginning. It would lower frustration felt by students and the diminishing resources could be used efficiently.

2 THEORETICAL FRAMEWORK

Motivation and self-regulated learning are key components in all engineering education. If a student is not interested, i.e. motivated, in engineering, it is almost impossible to drag oneself through studies. On the other hand, motivation is not enough. Diminishing resources requires students to study by themselves. If a student is not self-regulated in learning, studying in a proactive way may be impossible.

Kauppila [1] separates motivation in learning into five groups: avoidance, diverged, escape, achievement and intrinsic motivation. Avoidant motivated students usually are indifferent or reluctant towards subject or they may just find mathematics irrelevant to themselves. Diverged motivated students have much other things, like hobbies or working, in their mind that they do not have time in studying. Escape motivated students try to pass courses with learning by heart. They are just trying to escape failures, and they may be doing everything for external rewards (extra points to pass) or demands (it must be done). Achievement or performance motivated students do everything for good grades. It may help them to get a well-paid job or they avoid shame of not being the best. Intrinsicly motivated students are interested in the subject and are keen to know as much as possible. Grades are not important to them. ([2], [3]).

Self-regulation can be defined as self-generated thoughts, feelings and behavior that are oriented to attaining the goals ([4], [5]). Self-regulation is a skill which matures along the studies ([6]). Self-regulation consists of three phases ([7]) and all phases are equally important. In phase 1, a student activates oneself. A student schedules studies and set goals for achievement. It has to be remembered that self-efficacy beliefs affects in perception of success. Part of this phase is also cognition of prior knowledge. In phase 2, a student is monitoring and controlling e.g. selective strategies for learning and time use and need for help. Decisions made in phase 1 are not beneficial if they are not controlled. Students, for example, have more positive perception of the time used than they actually do if monitored. Although the time used would be the same as scheduled, it is also important to be conscious of focusing. Just sitting beside the books is not an effective way. In phase 3, a student should reflect the learning to the actual studying. One should reflect success to some standards, like success of peers, requirements of the course, etc. A student should "cycle" the phases during the course. If learning is not good enough, a student might schedule studying again or seek for help. On the other hand, if learning has been better than goals, a student could set goals higher.

All these phases should be observed in context of cognition, motivation/affect, behavior and context. Cognition embodies all activities for regulating learning. It is, for example, scheduling, selecting learning strategies and activating prior knowledge. Motivation consists of self-efficacy beliefs, reasons for doing the task, personal interest, etc. Regulation of behavior consists of those actions that a student may change if needed. When controlling the behavior, a student may find out that one is doing other things instead of studying in a scheduled time or a student finds out that one cannot solve the problems alone. Regulating behavior also includes action like seeking for help. Regulating the context is not always in the hands of students. It includes the noise of the dormitory or with whom they are doing the group works.

3 PROFILING STUDENTS

When freshmen start their studies, teachers may only know their background information of previous education and, of course, the result of proficiency test taken in the beginning of their UAS studies. The proficiency test includes some basic problems concerning order of calculations, equation solving, trigonometric questions etc. Because recognizing should be done immediately at the beginning of the studies, profiles must base on previous education and the proficiency test more than mere psychological factors. We have to also remember that freshmen may not even know their studying habits in an academic freedom due to lack of experience.

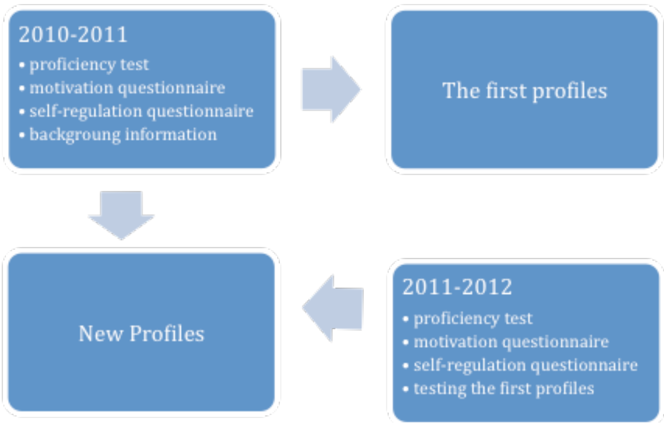

FIGURE 1. *Process of profiling.*

The main steps of the research are shown in Figure 1. The questionnaires filled in 2010 – 2011 were used to get the first profiles. These profiles were tested with freshmen starting at the beginning of the academic year 2011 – 2012. The freshmen of the academic year also filled in the questionnaires. This data is included to the original data to improve profiles (new profiles).

3.1 Results of the academic year 2010 - 2011

The null hypothesis is that all students are average in their mathematical studies. If evidence of something else was found, students would be classified as at risk, weak or excellent. As it is shown in [3] and [8], the easiness of mathematics seems to be the cornerstone in studies. All those students, who at least quite strongly felt that there is no need for guidance in mathematics as they have always learnt mathematics easily, passed the first course in mathematics. For these students, most of the grades were 4 or 5 (20 of 26). If these students were solving all the given problems, they probably got the grade 5 (6 of 7). The grades are usually given from 0 to 5 where

0 refers to failing and 5 is the highest grade. Students also seem to get high grades if they did not feel mathematics as frustrating at all although they were not necessarily solving all the problems. All these students could be marked as excellent students. When factors were analysed according to the results in the proficiency test, it could be seen that freshmen, who got at least average results in the proficiency test and were solving all the given exercises, were getting the grades 4 and 5.

It was also found that students with bad results in the proficiency test were failing the course if they would not even notice the suddenly cancelled lectures as well as did not answer the questionnaires. This refers to the fact that those students are not attending the lectures. When knowledge in mathematics is already weak, attending lectures is very important. It was also found that students with bad results in the proficiency test seem to get lower grades if they felt they have to work to pass the courses.

During the next steps the characteristics of students were further defined. Students with at least average results in the proficiency test could be marked as excellent students if they were not preparing to the examinations too late nor did they mind about applied examples from their professional field. In fact, it was found in many stages that applied examples were important to the weaker students. Applied examples may motivate weaker students to studying the topic as they would know why they need it. Teachers' pre-assumption was that applied problems were important to the better students, as they are not struggling with technical skills anymore.

If students felt that they should do home exercises for learning, they were getting lower grades. If the base was already weak (bad results in the proficiency test), these students could be marked as critical. According to the [9], the word 'should' refer to fear and probably nothing is done: the student knows that they need to do them but for the reason or the other is not able to do them. Of course, all students, who were not sure that they are in the right place, were getting lower grades (no motivation to study) and bad results in the proficiency test referred them to be at risk. On the other hand, if students were hoping to learn as much as possible from mathematics and were also adapting their studying habits to course requirements, they could be marked as excellent students.

3.2 Predicting Success in Mathematics

In the proficiency test, students were asked their previous education, mathematical studies and the grade in matriculation examination with some information of minor importance. When features described in the previous section are combined with the background information and the result in the proficiency test, we can form student types to predict their success in mathematics.

Grades in the first course of mathematics were classified according to the student type for students, who started their studies in the academic year 2010 – 2011. According to the results, about 60% of grades could be explained with the determined student type. All students at risk could be recognized quite well but some average students were also marked to be at risk.

Profiles were given in a written form at the beginning of an academic year 2011 – 2012 as follows.

1. I think mathematics easy to me. I try to do all exercises given and I do not feel studying frustrating at all.
2. I prepare to examinations well in time and I do not necessarily need any applied examples from my professional field during the math lessons.
3. I want to study as much as possible from mathematics. I also try to adapt my studying to the course requirements.
4. I know my knowledge in mathematics is not were strong. I consult my formula book as much as possible, although, understanding the formulas is not easy to me at all.
5. I know that I should do home exercises for to learn.
6. I am not quite sure that this is the right place to me and I am not very interested in mathematics either. I should do lot of work to pass the courses but I am probably not attending the lectures because I just do not feel like attending or I have so much other hurries.
7. None of above describes me at all.

Students were asked to select only one profile describing them the best although it would not be exact.

All students, who chose profile 4 or 6 and got bad results in the proficiency test, were marked as critical (at risk). The profile 6 also refers to a critical student if the student had not studied high school at all or had studied only normal mathematics in the high school. Profile 5 referred to weaker grades. Therefore, they were marked as weak students if they got average results in the proficiency test. All profiles from 1 to 4 refer to the better students. Profile 1 seems to refer to the excellent students despite the background but all profiles 2 – 4 need the results in the proficiency test to be at least average. Furthermore, it was found in the analysis that students studying extensive mathematics in the high school could be marked as excellent, if they got good results in the proficiency test.

3.3 Academic year 2011 – 2012

Previous findings and the results are from the same academic year 2010 – 2011. It is interesting to see how well they portray students entering engineering programs during the academic year 2011 – 2012. When student types and grades were cross-tabulated, it was found that student types did not portray new freshmen well at all. Only 1.5% of the grades could be explained with determined student types. After this, it is not surprising that profiles selected by students combined with background information did not give any better results.

Analysing data of the academic year 2011 – 2012 revealed that the main classifying statement was I need guidance in mathematics as my knowledge is not good enough in the motivation questionnaire. Thirteen of 25 failed students admitted their weak knowledge in mathematics. Twelve of those 13 students did not usually ask clarifications from a teacher. It was also studied how well profiles selected by students reflect grades. Students, who did not find any matching profile, mainly failed the course.

Like mentioned earlier, some students seem to get high grades despite their lesser education in mathematics. According to this data, if students neither needed to work to pass the course nor they mind about grades, they seem to get high grades although not studied the extensive mathematics in high school. Probably, these students were intrinsic motivated. Also, all students feeling that 1) mathematics is easy, 2) studying is helping them to mature, and 3) they would solve extra exercises to learn more, were found to be excellent.

Combining the data of both academic years should reveal some common features of students. It was found that 27 of 38 failed students admitted their weak knowledge in mathematics. Furthermore, 26 of those 27 students felt that they need guidance in mathematics because of their weak knowledge. Eleven failed students did not admit the weak knowledge but ten of them admit that they have to work to pass the courses. The interesting information is that nine of those 10 students were mainly motivated by a well-paid job.

It was found that students with extensive mathematics seem to be at risk if they usually do not mind about the requirements for grades and they just want to pass the course. The risk is also present if students with extensive mathematics admit the need for guidance but they do not revise their knowledge at the beginning of a course. If students with extensive mathematics seem to omit home exercises, they were getting lower grades. Maybe, these students were either not actually interested in studying or they were presuming on their mathematical skills.

The other students seem to be at risk if they admit their weak knowledge and they are working hard to pass the courses. Even the strong motivation for a well-paid job combined with the weak knowledge refers students to be at risk. Also, preparing to tests too late and neglecting lectures were bad signs.

TABLE 1. *Student types vs. grades in mathematics.*

		Course 1 in math						Total
		0	1	2	3	4	5	
student_type	at risk	25	13	5	2	4	0	49
	weak	7	9	11	12	10	7	56
	average	6	4	10	15	19	10	64
	excellent	0	0	0	0	2	8	10
Total		38	26	26	29	35	25	179

Directional Measures

			Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	0,478	0,051	9,189	0,000
		student_type Dependent	0,440	0,048	9,189	0,000
		Course 1 in math Dependent	0,524	0,054	9,189	0,000

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

This new classification explained 52.4% of grades in combined data (see Table 1). The more important information is that 25 failed students out of 38 could be recognised with it. Seven of remaining unrecognized there marked as weak students, so they would not be forgotten. Of course, classification could be more exact but it would make profiles too complicated. If there were many profiles to choose from or profiles were too complicated, freshmen would have difficulties in recognising the best describing profile.

4 CONCLUSION

Some motivational and self-regulating characteristics could be found for profiling the students. Motivation seems to be the key element in predicting the progress. Motivational factors were more clearly perceived among freshmen of the academic year 2010 – 2011 although they did not predict the progress for next year freshmen very well. As mentioned in [8], self-regulating goes hand in hand with motivation. Thus, it is unreasonable to assume high self-regulating for weakly motivated students.

The results of two academic years were different. Freshmen of the academic year 2010 – 2011 answered questionnaires after several months of studies, whereas freshmen of the academic year 2011 – 2012 did it at the beginning of their studies. The lack of experience in academic studies may have affect in answers for the latter group. On the other hand, student types based on the academic year 2010 – 2011 and profile selected by a student matched quite well. Thus, the self-knowledge of learning habits was recognized by freshmen.

The next step will be finding further information about motivational and self-regulating characteristics. It is also important to find methods for motivating and supporting weaker students. As weaker students seem to neglect lectures and they also have some problems in focusing, one solution might be compulsory lectures and exercises. It is also shown in the literature ([10], [11]) that essays in mathematics or writing formulas in written form by students will improve understanding and, in consequence, may motivate students more.

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19 IMPROVING HANDS-ON EDUCATION BY INTRODUCING A MECHANICAL COMPONENTS MODEL SUITCASE

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ABSTRACT

Engineering students start their bachelor degree course with little or none understanding of mechanical components. As part of the education program the Institute of Product Engineering developed a mechanical design course to improve the students understanding [1]. In addition to the theoretical lectures the students are participating in hands-on workshops starting from the first through to the fourth semester. The objective of the workshops is to close the gap between theory and praxis. The student teams are working on engineering problems with increasing complexity [2]. It has been shown in the past that students understand a mechanical system faster when presented a working model. [3]

This paper presents an education approach using a "mechanical components model suitcase" to improve the students understanding of mechanical components and their functions. The content of this suitcase ranges from bearings to a gear box. By using real objects it becomes much easier to point out complex relationships such as working surfaces (WS), the relevance of surface roughness and tolerances.

Keywords: Mechanical Components Model Suitcase, Hands-On Education.

1 INTRODUCTION

Today's engineers are expected to handle products and the corresponding product engineering processes with increasing complexness. Due to globalization of the economy, increasing competitive constraints the graduate's competence has become increasingly important. Mechanical design courses are the engineers key qualification foundation.

The Karlsruhe Education Model for Product Engineering (KaLeP) – introduced in 1999 – describes very successful approach for academic education in product engineering [4, 5]. Different types of course settings are combined consecutively on increasing levels, focusing on certain fields of product engineering-specific knowledge (Figure 1): Mechanical Design I – IV (concerning systems), Methods of Product Development (concerning tools and methods) and Integrated Product Development (concerning processes).

Karlsruhe Education Model for Product Development
KaLeP Elements

	Systems	Methods	Processes
Degree program	Bachelor of Science	Master of Science	Master of Science
Course title	Mechanical Design I – IV *mandatory for all students*	Methods of Product Development - Design Process *mandatory for all students*	Integrated Product Development
Setting	• lecture • tutorials • project work	• lecture • tutorials	• lecture • tutorials • project work
Key competencies: Level of acquisition	high	medium	very high
Course contents	• design engineering • team work • self organization • communication • idea transfer	• methodological skills • creativity techniques • processes in product development • problem solving methods	• team leading • team development • project management • presentation • moderation
Number of students per year	~750	~400	~40

FIGURE 1. *Elements of the "Karlsruhe Education Model for Product Engineering".*

The mechanical design course as described by the KaLeP [2] includes lectures as well as hands-on project work. This paper focuses on improving the education by implementing real models to the rather theoretical lectures.

2 MECHANICAL DESIGN I – IV

The course Mechanical Design I – IV is part of the first two years of every mechanical engineering student at the KIT. It contains the elements lecture, tutorials and project work. The lectures focus on theoretical contents of design engineering which will be implemented in the tutorials in example cases. During the project work the teams are coached continuously by faculty staff and experienced and trained student tutors. During these team meetings all students receive individual feedback regarding the individual performance and the team performance. The performance is assessed according to five fields of competence: professional, methodological and social competencies as well as potential of creativity and the ability of transferring ideas. These five fields of competence are shown in Figure 2.

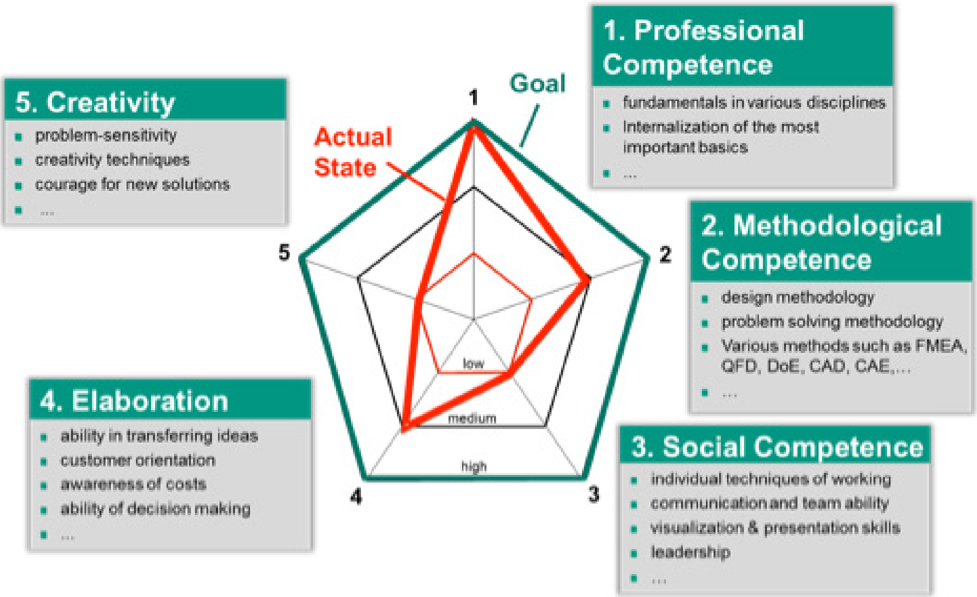

FIGURE 2. *Fields of competence as described by KaLeP [2].*

Mechanical Design I

Mechanical design I focus on the analysis of technical systems. Student teams consisting of five are disassembling a gearbox. Function relevant working surfaces are analysed and described. Technical drawings and free hand drafts are drawn by the students.

Mechanical Design II

Students receive lectures on the synthesis of technical systems. The topics include the design of technical elements like bearings and complex angular gears.

Mechanical Design III and IV

A complex design task is given to the teams; a student's favourite is e.g. a racing scooter. The design task is divided into small parts, according to the current student's state of knowledge following the lectures. The students are expected to conduct a thorough research on the state-of-the-art, followed by solving the given problem(s) and creating hand drawings as well as CAD models.

Figure 3 summarises the mechanical design course as well as the activities.

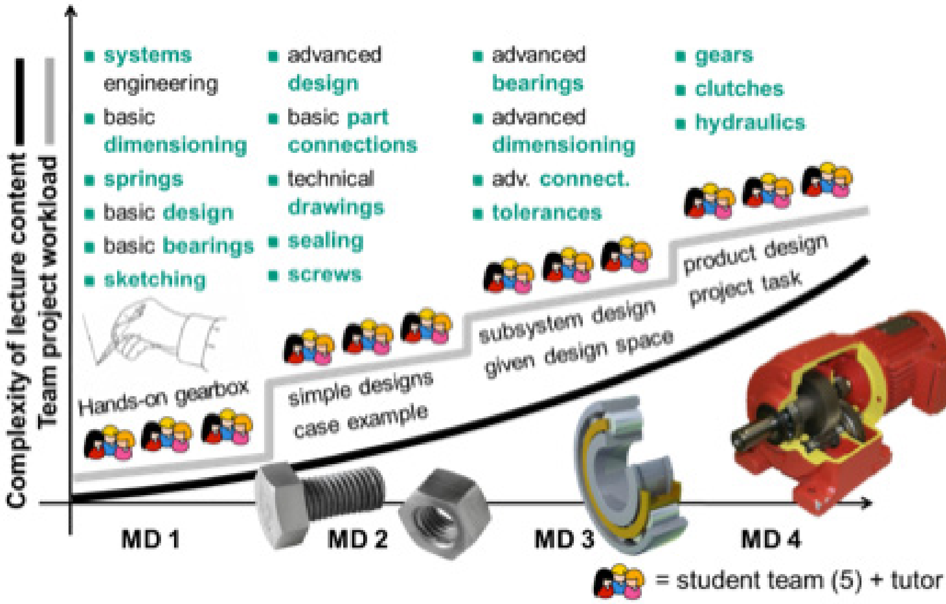

FIGURE 3. *Curriculum of mechanical design according to KaLeP [2].*

With the continuously rising numbers of freshmen it has become increasingly challenging to make complex mechanical systems accessible to students. In order to meet this challenge a mechanical components model suitcase was designed which is described in the following chapter.

3 MECHANICAL COMPONENTS MODEL SUITCASE

The content of this suitcase was carefully chosen by cross referencing the content of the lectures and the needs of the students. It was assumed that the average freshman knows only little of mechanical systems. Only few have e.g. laid hands on a synchronised transmission.

Therefore the objective clearly was to develop a suitcase that shows a wide variety of components on different complexity levels. Additionally most of the components are cutaway models to point out functionalities which are otherwise hidden.

The models were designed using CAD and then manufactured using norm parts wherever applicable. As an example Figure 4 (left) shows a 3D CAD image of a bearing including sealing ring and circlip, Figure 4 (right) shows the real model, using mostly norm parts, such as FAG bearings.

FIGURE 4. *Bearing including sealing rings and circlip, 3D CAD and real model.*

Each model was design to demonstrate different typical principles of functions. In case of the bearing model for example the function of the sealing rings and their working surface pairs with the shaft and bearing were focused.

Figure 5 gives an overview over the components of the suitcase. Some tools were also included to e.g. mount circlips. Models worth mentioning are:

- Different gear models
- Bearing model including sealing rings
- Bellow coupling
- Thread models
- Synchronized transmission
- Surface roughness model
- Model shaft
- And many more.

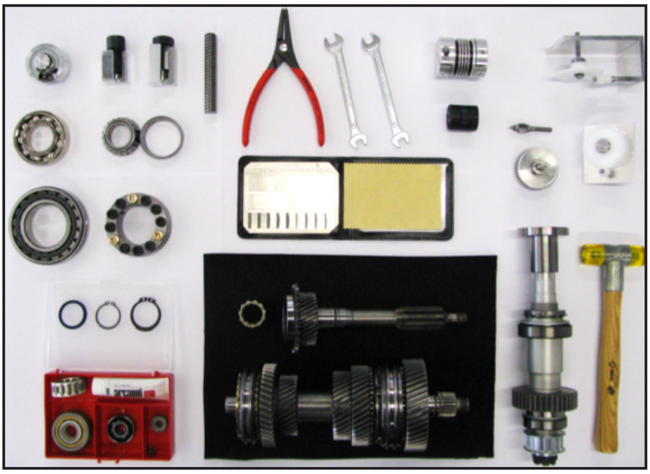

FIGURE 5. *Suitcase content.*

A unique “model shaft” was designed to point out as many different characteristics as possible. The idea of the “model shaft” was to create a handy tool, which can be easily carried from one lecture to another. Therefore the shaft (Figure 6) displays features, such as different threads, conical interference fit, lock nut, feather key groove, spline shaft, circlip grooves and different fits. Each of these features corresponds to a norm part (see Figure 7), e.g. bearing, circlip, etc. which can be mounted using the provided tools.

When working with this shaft students are able to mount and disassemble the norm parts, which support the understanding for these components. 2D sketches e.g. of lock nuts or spline shafts have dramatically improved leading to the conclusion, that the students has learned and understood the principle of function.

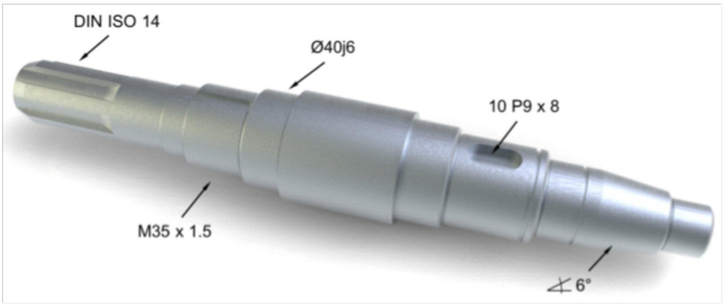

FIGURE 6. *3D CAD model and characteristic features of “model shaft”.*

FIGURE 7. *Model shaft and norm components.*

In total ten suitcases were assembled. Each suitcase has a value of round about 2.000 € not including donated models and CAD costs.

4 WORKSHOP APPLICATION

The model suitcase has been implemented into the workshops from MD I through MD IV. It has proven to be beneficial for both tutors and students. In the past students often had trouble understanding complex systems. The theoretical knowledge taught in the lectures could not be transferred to a practical application. For example only few were able to sketch simple systems such as bearing arrangements for bevel gears. The students also lacked understanding for working surface pairs, i.e. which surface is working in which way with its counterpart.

The tutors underwent training in the usage of all the models. Each tutor has access to at least one suitcase during the workshops. Depending on the students' knowledge level each workgroup is using the suitcase for around one hour. For the first time they have real models to work with; they are no longer solely dependent on sketches and handbooks. Even complex mechanical systems such as gear shifts can be broken down into simple components. The specific working surface pairs, bearing arrangements and their impact on the accessibility and mounting sequence can be easily explained, thus making it more accessible to students.

Some parts, e.g. the synchronized transmission are from used vehicles. The working surface pairs of gears or bearings are therefore clearly recognizable. The students are able to identify those on their own and thus getting a deeper understanding for the general working principle.

5 CONCLUSION

With a steady increasing numbers of students, currently 700, but constant numbers of tutors, it has become a challenge to suit an individual student's need for sufficiently understanding complex mechanical systems. Students understand mechanical systems faster when presented a working model, which has been shown in the past. A novel approach is to implement real models in mechanical design (MD) education. For this purpose a suitcase with suitable and representative models of mechanical systems on different complexity levels was developed. With this handy tool the gap between the theoretical lectures and practical application could be closed.

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21 RESIDENCY PROGRAMS FOR ENTREPRENEURIAL UNDERGRADUATE ENGINEERING STUDENTS

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ABSTRACT

This paper discusses the twelve-year experience of the first undergraduate entrepreneurship program in which a diverse group of third and fourth year students with strong entrepreneurial spirits live together. In a special residence hall they eat, sleep and breathe together as they learn entrepreneurial processes, start and operate their companies. Also discussed is a similar and newer program for first and second year students.

Keywords: Experiential learning, Diversity, Student Ventures.

1 INTRODUCTION

The University of Maryland is a recognized leader in entrepreneurship and innovation education through its award-winning faculty, staff and programs [1]-[7] with a primary goal being to infuse students with practical entrepreneurial knowledge and experience. Understanding that an important component of any entrepreneurial endeavor is diversity of the founders, leads to a practice of incorporating engineering students with those majoring in business and all other fields. A second important aspect of entrepreneurship education is experiential learning [8]-[9]; i.e., facilitating student entrepreneurial endeavors in a supportive and nurturing environment. A third important element involves students being closely associated with other students with strong entrepreneurial spirits.

In 2000, the Clark School of Engineering started a program for entrepreneurial junior and senior students which incorporated these three elements into a unique program called the Hinman CEOs Program. Each year about 45 entrepreneurial junior students are selected to join with about 45 senior students to live together in a residence hall where they form teams, start and operate companies while pursuing their chosen fields of study. While the Hinman CEOs Program had been serving juniors and seniors for over a decade, there were no living-learning opportunities for University freshmen and sophomores with interests in entrepreneurship and innovation. Students desiring this experience would either wait two years at the University or enroll in other universities with underclassman opportunities to study entrepreneurship and innovation.

In order to accommodate this demand, a program for first and second year students was launched in fall semester of 2010. This program, the Entrepreneurship and Innovation Program (EIP), is one of six living-learning programs within the Honors College. The very top applicants to the University of Maryland are invited into the Honors College and they select one of the six programs. Courses are taught by exceptional faculty with the wide range of additional education opportunities that are available at the University of Maryland which is a large research institution. For the living component of the Program, all students reside in an exclusive Program residence hall for both years. Through company creation, courses, seminars, workshops, competitions, and volunteerism, students are part of a special experiential learning model. Demand for this program is very high with 150 or more students selecting the EIP Program, and this program is drawing entrepreneurial students to the University of Maryland who in some cases would otherwise have selected other, more prestigious, universities. Details are discussed below.

2 THE HINMAN CEOS AND EIP PROGRAMS

2.1 Selection Processes

Students apply to the Hinman CEOs Program in their second year for admission into the program in the beginning of their third year. There are two basic criteria: good academic record indicating that the student can handle substantial extra activities without diminishing their academics and a strong entrepreneurial spirit. Their academic ability is largely determined by their grade point average which is usually above 3.5/4.0. Their entrepreneurial spirit is evaluated by interviews conducted by the director of the Program along with senior Hinman CEOs students. Usually, students accepted into the program have a history of entrepreneurial endeavors. Once accepted, the students spend their third and fourth years living in the residence hall with other entrepreneurial students where they take entrepreneurship course, form teams, start and operate companies from the residence hall.

The selection process for the EIP Program is different from that of the Hinman CEOs Program. Once students are invited into the Honors College, they select rank their first and second preferences, and in most cases their first preference is honored.

2.2 Diversity

It is highly desirable to have as much diversity in the entrepreneurship student body as possible including ethnicity, gender and major fields of study. This is because success in an entrepreneurial endeavor is enhanced by having founders who see things from different points of view. Diversity figures for a typical Hinman CEOs and EIP cohorts are:

45% ethnically diverse
40% female, 60% male

Majors:
35% business majors – know finances, marketing
35% engineering majors – know how to design and make things
30% liberal arts & sciences majors – creative thinkers (not that business and engineering majors aren't creative).

2.3 Living Space

With the mission of the Hinman CEOs Program being to foster an entrepreneurial spirit, create a sense of community and cooperation and impact the way that they think about their careers, a vital item in creating a sense of community is a physical environment where the students can eat, sleep, breathe and practice entrepreneurship in a safe and supportive setting. Also, students are helped to discover and act upon their creativity and innovativeness, celebrate successes and learn from failures. Included in the residence hall are:

- Student residences
- Advisor offices located in student residences
- Board room and meeting rooms for team meetings
- Business center with computers and software, copier and FAX
- Classrooms for courses
- Social space and group meeting space.

Figure 1 provides photographs of the Hinman CEOs residence hall.

FIGURE 1. *Photographs of the residence hall, meeting room and board room.*

Figure 2 provides a layout of the apartment-style residences for Hinman CEOs. The apartment style facilitates close interactions among the students.

Because of campus residence hall constraints, living space for the students in the EIP Program is more typically of residence halls with hallways, although apartment-style space would be more desirable. This residential experience has proved invaluable to community building of young entrepreneurs in the Hinman CEOs Program, and as with the Hinman CEOs Program, all EIP students must reside in the exclusive program residence hall for both years. Offices of the program director and staff are located within the residences to encourage frequent mentoring and interactions. A rich set of community building activities is provided in the residence hall for EIP students.

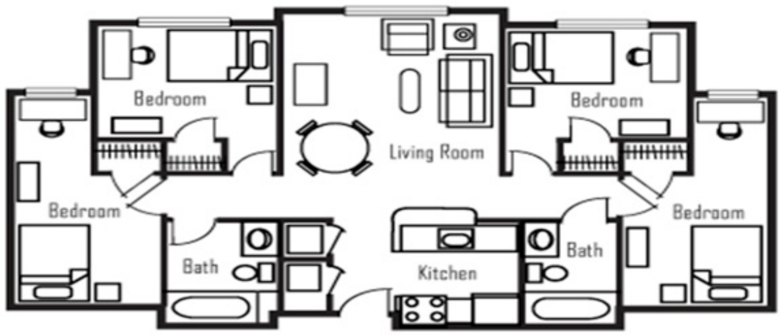

FIGURE 2. *Apartment-style layout of the Hinman CEOs student living space.*

2.4 Supportive Development Environment

All student companies are 100% student-owned, no equity is taken by the University, and no fee is charged for participation in these programs which helps to motivate and inspire the students to launch their ventures as undergraduates (and possibly give back as alumni).

It is important to have a supportive environment to help the students from many different perspectives, and common elements of the Hinman CEOs Program and the Entrepreneurship and Innovation Programs include:

• Coaching and mentoring
• Internships including with international companies
• Seed funding for start-up ventures
• Facilities and equipment
• Events and competitions
• Entrepreneur office hours
• Intellectual property assistance.

2.5 Entrepreneurship Academics

Each of the four semesters that students are in the Hinman CEOs Program, they take four or more of the following special three-credit entrepreneurship courses:

• Advanced Entrepreneurial Opportunity Analysis in Technology Ventures: Using a cognitive theoretical framework, the course examines the integration of motivation, emotions and information processing modes to identify and examine entrepreneurial opportunities in technology areas.

• Marketing High-Technology Products & Innovations: Marketing of high-technology products occurs in turbulent environments, and requires rapid decision making with incomplete information. Innovations are introduced at frequent intervals, research-and-development spending is vital, and there are high mortality rates for both products and businesses. The course provides a balance between conceptual discussions and applied/hands-on analysis.

• Strategies for Managing Innovation: Emphasizes how the technology entrepreneur can use strategic management of innovation and technology to enhance firm performance. It helps students to understand the process of technological change; the ways that firms come up with innovations; the strategies that firms use to benefit from innovation; and the process of formulating strategy.

• International Entrepreneurship & Innovation: Focuses on the need for every entrepreneur and innovator to understand the global market in today's hypercompetitive world, and to appreciate how to compete effectively in domestic markets by managing international competitors, suppliers, and influencers. Students develop skills to identify and manage opportunities on a global basis.

• Entrepreneurial Design Thinking: Explores the use of design thinking as an approach to developing customer-centered solutions to problems and fostering sustained innovation within an organization. Through interactive lectures, discussions, and hands-on, team-based activities, students learn design thinking strategies and apply them to finding innovative product- or service-based solutions to contemporary issues.

Over their four semesters in the EIP Program, students take the following course sequence:

• Foundations of Entrepreneurship & Innovation (1 credit): Building the entrepreneurial mind-set and introducing basic entrepreneurship principles and terminology

• Contemporary Issues in Entrepreneurship & Innovation (3 credits): Inspiring innovation and creativity through interactive lectures, workshops, and case studies in contemporary issues to include energy, life sciences, healthcare, etc.

• Exploring International Entrepreneurship & Innovation (3 credits): Introducing the opportunities and challenges of entrepreneurship and innovation from an international perspective through lectures and speakers

• Capstone - Social Entrepreneurship Practicum (2 credits): Enhancing strategic capabilities and leadership skills through the development of an innovative for-profit product or service concept with social benefits (Top ventures compete for the $50,000 Seed Fund).

3 HINMAN CEOS PROGRAM RESULTS

In fulfilling the mission, four factors are most important while the students are in the program and long afterward:

• Entrepreneurial Mind-set: Entrepreneurial attitudes, communications, and interpersonal skills

• Functional Skill Sets: Teamwork, strategic thinking, and management of risk, marketing, finances and operations

• Launching and Career Activities: Long-term outcomes associated with new venture creation as well as innovation and entrepreneurship in graduate school and normal employment

• Student satisfaction: Short-term and long-term feedback regarding the impact of the program(s) on their careers.

3.1 Student Satisfaction

In order to examine student satisfaction, they are surveyed at program entry, at the completion of the first year (as a midpoint measure), and upon graduation. A 100-question written survey was administered. The survey is based on the Entrepreneurial Attitude Orientation scale of Robinson [10] plus further questions developed to examine areas to include opportunity discovery and interpersonal skills.

Table 1 provides survey results for the satisfaction rating for Hinman CEOs students for fall 2010 and spring 2011 based on the 9-point Likert survey, with “1” = strongly agree and “9” = strongly disagree.

TABLE 1. *Student Satisfaction Survey Results.*

Question	*Mean*	*Median*	*Mode*
Overall Experience	**1.95**	**1.5**	**1.0**
I would recommend Hinman CEOs to other students interested in an entrepreneurial experience on campus.	1.7	1.0	1.0
The Hinman CEOs Program helped me to achieve my personal goals.	2.2	2.0	1.0
Coaching/Mentoring Experience	**2.8**	**2.0**	**1.0**
The quality of new venture coaching that I receive from the Program Director meets my expectations.	2.8	2.0	2.0
The quality of personal and career mentoring that I receive from the Program Director meets my expectations.	2.8	2.0	1.0
Living Experience	**3.3**	**3.2**	**1.0**
Living alongside fellow Hinman CEOs is a critical element of the program.	2.7	2.0	1.0
I expect lifelong friendships with fellow Hinman CEOs.	3.2	3.0	1.0
I discuss entrepreneurial topics including new venture ideas with my roommates.	3.9	4.0	1.0
I discuss entrepreneurial topics including new venture ideas with other Hinman CEOs beyond my roommates.	3.0	4.0	1.0
There is a high level of interaction across ethnically and religiously diverse students in the Hinman CEOs Program.	3.2	3.0	1.0
My social activities outside of the Hinman CEOs Program, such as movies and sports, include other CEOs.	3.9	3.0	1.0

3.2 Quality and Effectiveness Information

Beyond students self-reporting and related observable impacts, measureable quality and effectiveness are further evident in:

• Research-based Surveys – Based on the performance measurement system, the entrepreneurial mindsets of Hinman CEOs are improving during their time in the program. The opportunity recognition skills of students are also improving during the experience. The entrepreneurial mindset is often quoted as students see the world as subject to change with their leadership and contribution.

• Founding Companies – At any one time, 25% of the Hinman CEOs students are operating companies that are generating revenues from their residence hall. Upon graduation, 10% of the students work full-time in their own companies. Hinman CEOs student companies operating in their residence hall were generating annual revenues of over $1.5M, with top sectors being: $1,000,000 in web-based services; $450,000 in landscaping; $60,000 in software, and IT; and $40,000 in retail.

• Securing Grants and Awards – Hinman CEOs alumni company Squarespace raised $38.5 million in venture capital in 2010 with a company valuation of approximately $100 million. Hinman CEOs students have won grants and awards exceeding $500,000 from notable organizations. One 2005 Hinman CEO graduate was named #2 in Business Week's Best Young Entrepreneurs, and the companies of two 2005 graduates were ranked in the 2010 Inc. 500.

• Corporate Success – Hinman CEOs are thriving in corporations, typically in entrepreneurial roles including product management, new venture financing, and intellectual property law, to include Booz Allen, Deloitte, Facebook, GE, Google, Goldman Sachs, Microsoft, Peace Corps, and Teach for America.

• Graduate Schools – Alumni also pursue graduate studies in engineering, business, law, medicine, and other disciplines at leading universities including Berkeley, Columbia, Duke, Georgia Tech, Harvard, Maryland, Michigan, MIT, Penn, Princeton, Stanford, UCSF, and Yale.

4 CONCLUSION

Based on the satisfaction of the students and their entrepreneurial success, it can be concluded that the Hinman CEOs Program is fulfilling its mission to foster an entrepreneurial spirit, create a sense of community and cooperation and impact the way that the students think about their careers. The fact that the living-leaning model provided by the Hinman CEOs Program has been replicated at 24 other universities provides evidence that the living-learning model is effective for experiential entrepreneurship education.

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25 OUTSTANDING FEMALE HIGH SCHOOL PUPILS' PERCEPTION OF ELECTRICAL ENGINEERING – WHAT HAS CHANGED?

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ABSTRACT

This paper describes an annual one-day conference for outstanding female high school pupils held by the Technion's Department of Electrical Engineering in 2011. Analysis of data collected before and after the day reveals a notable increase in pupils' willingness to consider studying electrical engineering, accompanied by a substantial increase in intrinsic motivation factors (e.g. interest and enjoyment) at the expense of extrinsic factors (e.g. high salary, fringe benefits, and status). Moreover, this one-day conference sharpens the vague picture the pupils have of electrical engineering and creates the impression that electrical engineering is an appropriate field of occupation for both genders. A comparison with findings from the 2005 conference indicates that initial awareness to electrical engineering and initial willingness to consider studying electrical engineering have increased considerably over the past six years. This finding is in accordance with the increase in the representation of women among the undergraduate population of the Department, from 13% in 2005 to 17% in 2011.

Keywords: Engineering perception, Gender issues, Electrical engineering education.

1 INTRODUCTION

The underrepresentation of women studying engineering is a well-known phenomenon in many countries, including Israel [1-3]. Since 2005, the Department of Electrical Engineering (EE) at the Technion – Israel Institute of Technology has established a tradition of inviting female high school pupils who excel in mathematics to an annual one-day conference in order to increase the representation of women in the Department's undergraduate population, which currently (2011) stands at 17%.

This paper describes main findings of the 2011 one-day conference, compares them with the 2005 observations [4], and analyzes the differences.

2 THEORETICAL BACKGROUND

As mentioned earlier, the underrepresentation of women studying EE is a well-documented phenomenon in many countries [1-2]. It is referred to as part of the pipeline shrinkage problem for women in computer science and engineering [5-6], where the ratio of women to men shrinks substantially from early student years to working years. The phenomenon focuses on several junctions: from high school to undergraduate studies, at graduate school, and at seniority levels [7].

Attracting young women to this field is a challenge since females have a less positive attitude towards engineering than do males [8-9]. According to Muller [10], “women, to a somewhat greater extent than men, are apt to choose fields of study they believe will contribute to the social good, and engineering and related sciences are not widely perceived as professions making such contributions”. A recent study [11] confirmed that women are significantly less likely to choose engineering as a major than men.

Thus, universities throughout the world hold exposure days for female high school pupils aimed at encouraging them to consider taking up engineering studies [1-4]. These days are based on the assumption that early positive experiences have the potential to influence career decisions [12].

3 ONE-DAY CONFERENCE AGENDA

The Department of EE at the Technion – Israel Institute of Technology is the largest of the Technion’s departments, with 1800 undergraduate students and 400 graduate students. It is ranked among the top EE departments in the world [13]. The research activity covers, among other topics, the following areas of electrical and computer engineering: electro-optics and opto-electronic systems, VLSI and nanoelectronics, communication and information theory, image processing and computer vision, computer networks, and automatic control.

As mentioned above, since 2005, the Department has established a tradition of inviting female high school pupils who excel in mathematics to a one-day conference. These annual conferences are led by a female faculty member and have the following agenda. After the dean’s greeting, a female undergraduate student describes her academic and social life in the department. The pupils then listen to a plenary talk on the relationship between science, engineering and society, which focuses on products developed by electrical engineers that affect everyday life. Next, groups of twenty pupils, each accompanied by an undergraduate student from the department, visit several of the department’s laboratories and see demonstrations presented by faculty members. Over lunch, the pupils meet female alumni of the department, who relate their personal stories, describe their current positions, and answer the pupils’ questions.

The major concepts emphasized throughout the one-day conference are: the interdisciplinary nature of the profession of EE, its role as a lever for economic and social development, and, finally, the potential success of women as electrical engineers.

4 GOALS & METHODOLOGY

The goals of the study are to track changes that took place in outstanding female high school pupils’ perception of EE over the course of the 2011 one-day conference and compare them with the 2005 observations, given in [4]. As the constructivist-qualitative approach was found to be suitable for studying the process undergone by the pupils, we used open questionnaires in order to accomplish the objectives mentioned above.

In the morning, the pupils were requested to complete an open questionnaire that focuses on their perception of EE and on the possibility of their studying EE in the future. The day ended with another open questionnaire that examines the same issues as those addressed in the morning questionnaire. In 2005, the morning questionnaire was completed by 86 pupils, while the end-of-the-day questionnaire was completed by 57 pupils (the other pupils were too tired by the end of the day to fill it out). In 2011, the same morning questionnaire (as in 2005) was completed by 61 pupils, while the same end-of-the-day questionnaire was completed by 47 pupils, who were not too tired to fill it out. It should be noted that no data was collected between these two years.

5 FINDINGS

Following are several observations based on the analysis of the two questionnaires distributed during the 2011 one-day conference.

5.1 Studying at the Technion, Department of EE

Both morning and end-of-the-day questionnaires asked pupils whether they would consider studying at the Technion's Department of EE. Pupils' willingness in the morning was 41%, while at the end of day it increased notably to 79%. During the 2005 conference, interest in the department increased from 26% to 82% (See Table 1). A comparison shows that in both years, final interest was approximately the same but initial interest was considerably higher in 2011. One possible explanation for this is that pupils' awareness of EE has increased over the past six years; this argument will be discussed later on.

TABLE 1. *Possible Future Studies at the Technion's Department of EE.*

Would you consider studying at the Technion's Department of EE?	2005		2011	
	Morning (N=86)	End of the day (N=57)	Morning (N=61)	End of the day (N=47)
Yes	26%	82%	41%	79%
No	33%	13%	33%	13%
Maybe / NA	41%	5%	26%	8%

5.2 Pros of Studying EE

The two questionnaires asked the pupils why they would consider studying EE. In the morning, pupils mentioned interest (57%) and high salary (43%), while at the end of day their answers were interest (86%), high salary (7%) and high status (7%). It is seen that the relative proportion of both intrinsic (interest) and extrinsic (high salary and status) motivation factors is comparable at the beginning of the day but that by the end of the day, the relative proportion of the intrinsic factors is notably higher, at the expense of the extrinsic factors. This finding is important in light of Herzberg's two-factor theory [14], which distinguishes between intrinsic (e.g. interest and enjoyment) and extrinsic factors (e.g. high salary, fringe benefits and status) and claims that only intrinsic factors can motivate the individual towards higher performance. Current leading motivation theories, such as self-determination theory [15-16], also emphasize the crucial role of intrinsic factors in improving motivation. The considerable increase in the relative proportion of intrinsic factors observed suggests that pupils' motivation is higher by the end of the conference than at its beginning. A similar observation was made in 2005.

5.3 Cons of Studying EE

Both questionnaires asked pupils why they would not consider studying EE. In the morning, the pupils mentioned lack of interest (75%) and stated that EE is a masculine profession that is not suitable for women (25%). At the end of day, pupils stated that they would not consider studying EE as it is too demanding and difficult (80%). They also mentioned lack of interest (20%) as a con. It is clear to see that the gender argument is absent from the end-of-the-day questionnaire responses. It is also interesting to see that the conference created the impression that EE is a very difficult discipline. A similar observation was made in 2005, and so, we recommend EE not be presented as a field that is exceedingly challenging.

5.4 Areas in which EE Graduates Work

The questionnaires asked pupils to specify what EE graduates do when they graduate. In the morning, the pupils wrote that graduates "work in hi-tech" (48%), "work in the industry" (18%), "work in research and development" (8%) and "I do not know" (11%). At the end of the day, pupils gave concrete answers, as opposed to the more vague answers given in the morning: "work in computers" (49%) and "work in communications" (49%). Answers to the same question on the morning questionnaire at the 2005 conference were: "EE graduates make electricity" (29%), "EE graduates work in high-tech" (22%), and "I do not know" (17%). At the end of that day, the vague answers were replaced by more specific ones: "work in computers" (46%) and "work in communications" (32%). A comparison between the findings of the two years reveals that pupils' awareness of EE has increased over the past six years and that the most frequent answer given in 2005 (morning) – "EE graduates make electricity" – was totally absent in 2011.

5.5 Gender Issues

In answer to the question "Do you know any female electrical engineers?", presented in the morning, 30% answered positively and 67% negatively. At the end of the day, 89% agreed with the statement "EE is equally suitable for men and women" while 9% disagreed. It can be seen that by the end of the conference, pupils perceived the profession to be suitable for both genders, although most of them did not know any female electrical engineers prior to the conference. In the morning of the 2005 conference, 9% stated that they knew a female electrical engineer, while 79% declared that they did not. At the end of the day, 96% agreed with the aforementioned statement regarding the suitability of EE for both genders, while the rest disagreed. A comparison between the answers to the question "Do you know any female electrical engineers?" in 2005 and in 2011 indicates that pupils' awareness of EE has increased over the past six years, as claimed previously.

5.6 Conference Evaluation

Every single one of the pupils (100%) who completed the end-of-the-day questionnaire stated that they would recommend attending a similar conference next year to their friends. The arguments for such a recommendation were: interest (42%), exposure to EE (42%), changing attitudes towards EE (8%), and successful organization of the conference (8%). These results show the positive impact of the conference as perceived by the pupils. The 2005 conference was evaluated similarly.

6 DISCUSSION

The 2011 conference, like the one held in 2005, improved the image of EE as a profession as perceived by female high school pupils who excel in mathematics. Main findings indicate a notable increase in pupils' willingness to consider studying EE, accompanied by a substantial increase in intrinsic motivation factors (e.g. interest and enjoyment) at the expense of extrinsic factors (e.g. high salary, fringe benefits and status). Moreover, this one-day conference sharpens the vague picture the pupils have of EE and creates the impression that EE is an appropriate field of occupation for both genders. The conference, however, also creates the impression that EE is an exceedingly challenging discipline.

One of the differences between the 2011 and 2005 observations pertains to the pupils' initial awareness of EE. In 2011, the proportion of pupils who were aware of the areas in which EE graduates work and who were acquainted with a female electrical engineer was much higher compared with 2005. In addition, the pupils' initial willingness (i.e., prior to the conference) to consider studying EE was found to have increased substantially over the past six years. This finding is in accordance with the increase in the representation of women among the undergraduate population of the Technion's Department of EE, from 13% in 2005 to 15% in 2009 and to 17% in 2011.

The author suggests that his colleagues adapt the idea of a one-day conference, described above. It should, however, be taken into account that female high school pupils today have a greater awareness of EE compared with previous years. It is also recommended that EE not be presented as a field that is exceedingly challenging.

7 ACKNOWLEDGEMENTS

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33 DIGITAL TANGIBLES INTERFACES AS AN ALTERNATIVE OF TANGIBLE MODELS FOR ITS USE IN A VIRTUAL LEARNING ENVIRONMENT IN ENGINEERING

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ABSTRACT

A 3D modelling workshop has been developed at the University of La Laguna in order to improve the spatial skills of engineering students. The first exercise of this workshop used tangible painted aluminium models. Students should manipulate them with their own hands for creating normalized representation drawings in paper. In order to implement the workshop in a Virtual Learning Environment, the problem arises when these pieces (aluminium models) are only available to students in the classroom. The aim of the Virtual Learning Environment is allowing students to make the workshop both at the University and at home. Because of this, we intend to replace aluminium models by digital files that are still necessary for their handling or manipulation. Having this aim in mind, we propose two different solutions: the use of augmented reality files and 3D virtual models manipulated through digital tablets.

Keywords: Virtual Learning Environment, Augmented Reality, Digital Tablet.

1 INTRODUCTION

Virtual Learning Environments are becoming more popular in education every day. The use of a Virtual Learning environment is a good complement for interacting face to face. At the University of La Laguna we have been teaching drawing to future engineers for the last few years with a workshop especially design to improve spatial abilities. The first exercise of this workshop used painted aluminum models. Students should manipulate them with their own hands and, afterwards, create a normalized 2D representation drawing in a paper.

In education, for understanding the links between the 3D world and its 2D orthogonal views, the physical corporeal models are frequently used so students can handle them for its sketching. The appearance of advanced graphic technologies is having an influence so users interact and manipulate reality, offering the chance to replace those corporeal models by virtual models which can be interact with the hands' movement. Among these advanced technologies, augmented reality and multi-tactile digital tablets stand out. In both of them, the interface is based on gestures and comes closer to the relation established with the physical model [1] [2].

Since 2004, the La Laguna University Research Group of Development of Spatial Abilities (Dehaes) investigates about the influence of different strategies and technologies focusing on the learning of contents related to the 3D perception and new technologies. In 2006, a remedial course was taught using physical aluminum models. In this remedial course a 3D model is drawn in the computer with a specific software (Google SketchUp) starting from aluminum pieces. This remedial course uses a set of six mechanized pieces which are part of the M14 briefcase (lot 14A) by the Maditeg Corporation (Figure 1). Handling physical models has been demonstrated as quite useful for the student's development aiming the transfer ability from 3D reality to 2D orthogonal views [3].

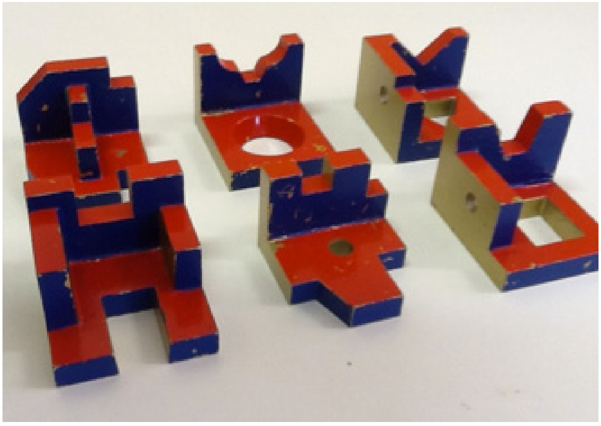

FIGURE 1. *Maditeg Briefcase M14. Physical Models.*

Because the Virtual Learning Environment (VLA) use is becoming widespread, it's necessary analyzing the possibilities of digital tools aiming for development of teaching innovation strategies [4]. Through the last few years, research about advanced man-machine interfaces has been an intensely developed field. Among the latest developed technologies we should point out, among others, the virtual reality and gesture-based interfaces. A relevant aspect outstanding in these interfaces is that they allow the user to interact with graphic information through direct manipulation. This is the reason leading to the choice of augmented reality and 3D models over the digital multi-tactile tablets as the replacement of physical models as they offer the chance to manipulate a digital 3D model in a similar way to a physical model [5]. Augmented reality allows the manipulation of digital objects through a printed mark using gestures. In the same way, digital tablets allow 3D models manipulation with fingers. Although these interfaces don't replace the real pieces, at least their manipulation through the hands is quite similar to the experience of manipulating reality.

Besides, it's worth pointing out that according to the New Media Consortium's 2011 Horizon Report [6] augmented reality and digital tablets are becoming technical trends in higher education and are expected to reach mainstream use in education in two or three years. Considering what have been exposed, in 2010 it was decided the redesign of the workshop for its possible implementation inside a Virtual Learning Environment changing the physical aluminum models by digital models [5].

2 RELATED THEORY

2.1 Augmented Reality

Augmented reality (AR) is a technology that combines three-dimensional (3D) computer generated objects and text superimposed onto real images and video, all in real time. AR allows the user to see the real world, with virtual objects superimposed or mixed with the real world [7]. The virtual objects may be manipulated by the individual who must coordinate his hands movements for obtaining the desired point of view in his mind. This technology is not the same that virtual reality (VR) as it already exists as a part of physical reality which is added to the synthetic virtual part.

The AR technology appears in 1968: Ian Sutherland creates the first system of augmented reality. Due to limited strength of the computer technology at the time, only very simple models could be visualized in real time [8]. First publication belongs to 1992 [9], where AR advantages are studied against virtual reality (VR). In 1966 a system of plain 2D marks is introduced [10] which allowed following the camera with six degrees of freedom. In 1997 it's published the first study about AR [7] and applications are developed through AR [11]. In 1999, AR Toolkit is introduced as a fiducial square marks library for obtaining the marks' orientation. AR toolkit is available as an open code and it's a quite used tool for easy development of easy AR applications.

The applications that are incorporating augmented reality technology are divided into two groups: first, there are those applications that use markers or trackers opposite to those who do not use them, called marker-less or tracker-less. A marker (tracker) is defined as a symbolic figure that the computer can recognize through a camera from different points of view and transform into the desired virtual information. If this information is a digital three-dimensional model, the display of that marker will create the model on the screen where the augmented reality application is running. In this case the relative movements of the camera and the marker generate the impression that reality and virtual objects interact on the same stage.

There are several applications of RA in various fields: aerospace, manufacturing and maintenance of aircraft [12] or medicine, where we can find applications that allow the possibility of assistance during surgery [13]. In education, the application of RA is beginning to develop [14]. One of the first application of RA in education is Construct 3D [15], developed for the Interactive Media Systems Group from Viena University of Technology. Construct 3D allows the generation of geometric scenarios where students and teacher can interact during the explanation of contents related to spatial geometry.

In 2008 the DEHAES research group of the University of La Laguna, together with the Interuniversity Institute for Bioengineering Research and Oriented Technology from the Polytechnical University of Valencia (LabHuman) developed an augmented book called AR-Dehaes for improving spatial abilities of engineering students [16]. AR-DEHAES is a toolkit that provides the students a set of different kinds of performing graphic engineering exercises using augmented reality for training spatial abilities through an augmented book. It contains three-dimensional virtual models, and the students will be able to see different perspectives of the virtual model and complementary information for solving problems. In 2011, the commercial version of AR-Dehaes was developed comprising a unique augmented book containing 100 exercises (www.ar-books.com).

2.2 Digital tablets

The concept of mobile learning is completely accepted today [17], [18], [19]. In this field, the breakthrough of digital tablets may be a breakpoint for educational models. These tablets have a screen size similar to a computer's and they also have all the advantages of mobility and use of a touchscreen interface.

The digital tablets represent a new way of interaction with graphics software. The drawing applications for digital tablets offer mobility, gestures and tridimensional interaction as a new set of possibilities [20]. The characteristics of these new devices, weight, size, battery life, fast start-up, network access through either Wi-Fi or 3G, gesture interaction on the touch screen and the great amount of specific applications can turn them into a paradigm shift for teaching.

The tablet's is not new. In 1968 Alan Kay (Xerox-PARC) designed one of them, known Dyanabook, which was never manufactured despite reaching the prototype stage. This initial tablet was designed for educational use in children. In 1993, the first model of digital tablet hit the market. It was the Message Pad made by Apple, better known as Newton. For nearly a decade, the world of portable touch screen devices was dominated by the PDA's where the company Palm was the market leader. In 2001, Microsoft presented in Comdex the prototype of Tablet PC, using the new Windows XP-Tablet PC Edition.

In 2010, Apple presented a digital tablet, the iPad, which used the company's experience with mobile touch screen devices that already had in the market (iPhone and iPod Touch). The success of these devices is not just due to the combination of hardware and software: the creation of a virtual store application (Apple Store) proved a clear success by offering the user a large number of applications for the iPad, iPhone and iPod Touch at reasonable prices (many of them are even free) which can be downloaded from the internet. Since 2011 there are several other models and brands of digital tablets, many of which use the Android operating system and also have an online store application. Digital tablets and smartphones are currently the fastest growing sectors in the computer industry.

Due to its recent emerging, there are few documented experiences of digital tablets in education. Some researchers have determined which factors have an influence on student´s acceptance of digital tablet in an educational setting [21]. In 2010 an iPad Study was performed at the University of San Francisco. This study is a six-month research project that will review, experiment and share potential use of the iPad in higher education. It was analyzed (among other questions) if iPad´s apps could be used to support teaching and learning in courses as well as the usability of iPad for reading, writing, communicating and creating contents [22].

3 PROPOSAL FOR DIGITAL ALTERNATIVES TO PHYSICAL MODELS

As we have seen, the AR and digital tablets can be an alternative to tangible physical models. We have to manipulate the virtual models with ours hands instead of the mouse. So in this part, we describe how we have made these digital models.

3.1 Digital Models in Augmented Reality

The six aluminum models of Maditeg were prepared for being used with augmented reality. These models were set to be viewed in a PC using a webcam. First, they were modeled in Google SketchUp 8 free version and then, the files were generated in Augmented Reality with AR-media plugin for Google SketchUp of Inglobe Technologies. For viewing augmented reality files a free viewer called ARPlayer is needed. As we can see in Figure 2, students have to manipulate a printed marker with their hands. However, in the computer they can see just the virtual models. They must move the printed marker and solve the first exercise of the workshop with this information.

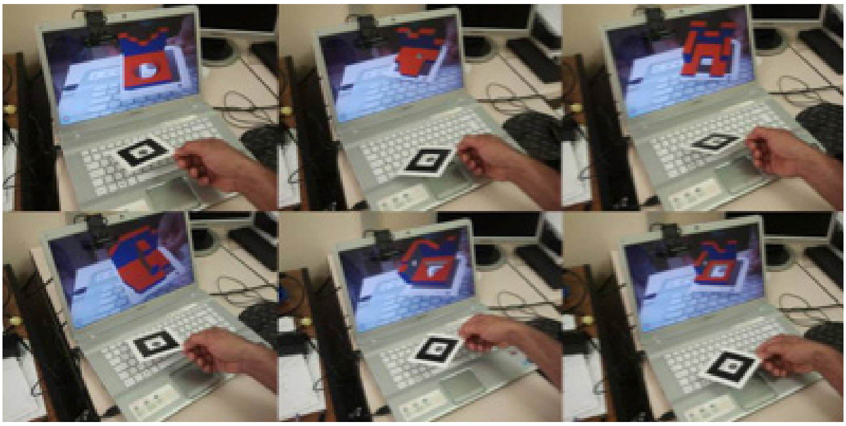

FIGURE 2. *Manipulation of an augmented reality model.*

3.2 Digital models in digital tablets

These models were prepared for being viewed in an iPad 2. The six Maditeg aluminum models were created having this in mind. First the pieces were made in Google Sketch Up 8 (free version) and afterwards there were exported to a mobile device using Autodesk© Inventor Publisher 2012. For viewing and manipulating the tridimensional models onto any digital tablet the free app called Inventor© Publisher Mobile Viewer (available for IOs and Android) was used. As we can see in Figure 3, students have to manipulate a touchscreen with their fingers. They can use different gestures to rotate, zoom or translate the models.

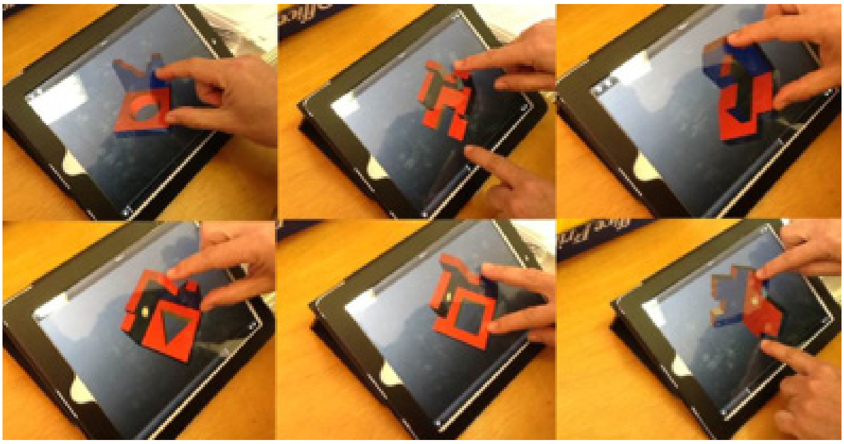

FIGURE 3. *Manipulation of iPad models.*

4 CONCLUSIONS AND FUTURE WORKS

The digital alternative to physical models is feasible. Both augmented reality models and digital tablet models must be manipulate by students with their hands or fingers instead of a mouse. These two alternatives can be used in a Virtual Learning Environment (VLA) allowing students to self-study and attend online workshops including manipulation of models.

As a future work, we intend to compare these two alternatives in a pilot study with students of different levels. We wish to find out their opinion about the two technologies proposed as alternatives to physical models. We also intend to create digital models in Augmented Reality running over digital tablets.

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34 ASSESSMENT OF SHORT-TERM POST-IMPACT OF STUDENTS' LEARNING EXPERIENCE IN AN ORAL COMMUNICATION COURSE AT MIT FOR EECS MAJORS

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ABSTRACT

Electrical Engineering and Computer Science majors at MIT are required to take a communication-intensive course called "6.UAT". An assessment of the oral presentation skills component of this course was performed during the Spring 2009 and Fall 2009 semesters. This paper describes a follow-up study in which a retrospective survey was designed and administered to assess the impact of the course on these same cohorts, eight months after their completion of the course. The response rates were 56% and 52% respectively, and the findings were consistent and positive: students clearly feel they now give more effective presentations and do so with more confidence. They also understand that their presentation skills are a "work in progress" and 90% say they continue to strengthen their oral presentation skills.

Keywords: Assessment, Retrospective survey, Oral presentations, Technical communication skills, Professional skills development.

1 INTRODUCTION

"6.UAT" is the name of a communication-intensive course that is required for all MIT undergraduates majoring in Electrical Engineering and Computer Science (EECS). It is a course consisting of lectures and recitations that encourages students to think about effective oral technical communication and equips them with communication skills necessary to succeed in a professional technical academic/industry setting.

The course is usually taken in the junior or senior year. It is offered every semester, and consists of a series of approximately 15 lectures and 17 recitations that take place over a 14-week period. Lectures are large group (70-200 students in attendance, depending on the semester). Students also meet separately in smaller groups of 8-9 individuals called "recitations". Each recitation is led by a recitation instructor (an EECS Faculty member) and a teaching assistant (an EECS graduate student). While lectures are suitable for disseminating information and demonstrating material, the recitation is an intimate, interactive and supportive setting that is more conducive to small-group activities. In recitation, students are given the opportunity to participate in in-class exercises that complement/reinforce lecture material, give oral presentations (as part of the course assignments), receive feedback on their performance, and provide feedback to other students. (A more detailed overview of the course is given in [1].)

At the end of the course, students should have gained experience on how to:

- Critically evaluate technical presentations,
- Architect technical presentations,
- Present technical material to different audiences at different levels of detail,
- Give and receive feedback and
- Communicate more effectively in a professional setting.

In 2009, an assessment of students' learning experience in 6.UAT was performed by MIT's Teaching and Learning Laboratory (TLL). Four overarching questions served as the focus of the assessment:

1. How much experience and confidence did students possess at the start of 6.UAT?
2. How did students find the 6.UAT learning experience?
3. What impact did 6.UAT make?
4. Would students take 6.UAT if it were not mandatory?

The assessment consisted of two methodologies: surveys and interviews. Both were administered to students who took the course either in Spring '09 or in Fall '09 at the end of the semester. The evaluation of the Spring '09 cohort included the development of several scales that could provide measures of 6.UAT's impact. The evaluation of the Fall '09 class focused on replicating the positive findings of the spring evaluation as well as validating and expanding the impact measures of the earlier study. The results of both assessments (reported in [2] and [3] respectively) were positive and consistent – students were glad they took the course, perceived an impact both for themselves and in their peers, and found 6.UAT effective in helping them develop their oral presentation ability.

It is the goal of any sound educational program to make a difference in the lives of students but it is uncommon that outcomes are documented 8 months after the conclusion of a program. In this paper, we describe and summarize the findings of a follow-up study conducted to investigate the short-term impact of 6.UAT on the same student cohorts 8 months after their completion of 6.UAT.

2 METHODS

To examine the short-term impact of 6.UAT, we designed a survey that was administered to students eight months after their completion of the course. The survey probed the following three questions:

1. What presentation experiences did students have since completing the course?
2. How did 6.UAT specifically affect the effectiveness of their presentations?
3. With the benefit of hindsight, what is their perspective on the value of 6.UAT?

The survey was developed by the second author, in consultation with the first. It was administered to the same cohorts from the earlier studies [2]-[3], but eight months after the course ended – i.e., in February '10 for the Spring '09 cohort and September '10 for the Fall '09 cohort.

The administration of the survey to both cohorts was overseen by the second author who is not a member of the 6.UAT teaching staff and is affiliated with MIT's Teaching and Learning Laboratory (TLL), an entity that is separate from and independent of the EECS Department. The subsequent analysis of the results from both surveys was performed by the third author, a long time consultant with the TLL, and the transformation of the study report into this paper was performed by the first author.

2.1 Recruitment

Students previously enrolled in 6.UAT in Spring '09 and Fall '09 received an email inviting them to complete the survey, described as the second of a two-part survey. The invitation reminded them that they had completed the first part of the survey at the end of 6.UAT, and that this second part was designed to assess the impact of 6.UAT on their oral presentation skills eight months later. The email invitation stated that in order for the data to be of value to the department, a high response rate was needed but also advised students that participation was entirely voluntary. Three brief follow-up reminders were sent to encourage responses: each included the original email from EECS. No incentives were provided to complete the survey.

2.2 Survey

The retrospective survey consisted of 51 items that addressed class profile, presentation experiences, strategies and skills, assessment of the course, and impact. Question formats included multiple-choice questions and Likert scale items (for which students rated their degree of agreement with each statement by using a seven-point rating scale where "1" represented "strongly disagree," "4" represented "neutral," and "7" represented "strongly agree." In this paper, the mean response is sometimes reported - this is the average of all responses given by a cohort to a particular question.)

2.3 Statistical Analysis

The analyses included the following procedures: descriptive statistics (means, standard deviations, frequencies), factor analysis (varimax rotation), coefficient alpha, paired t-test, and MANOVA.

A scale is a group of survey items that collectively represent an attitude, and for this study, we used two scales that were developed in the earlier assessments of [2] and [3] – namely, one scale on explaining ideas ("explaining") and another on impromptu speaking ("thinking on feet"). These scales measured students' perception of how well they thought they could express their ideas and think on their feet while making an oral presentation.

A re-examination of these scales showed they were still relevant in this retrospective study, but because the impact of 6.UAT at the end of the course might be different from the impact eight months later, another factor analysis with varimax rotation was performed. This yielded two additional scales that provided a different though consistent perspective on the course. These two additional scales were "effectiveness of presentations" and "confidence in ability to give good presentations."

For each scale, we computed its coefficient alpha - a measure of the scale's reliability.

3 RESULTS AND DISCUSSION

The analysis begins with response rates and class profiles and then summarizes the strategies and skills used, the learning experiences, and impact on students' oral presentations since the course. This report also discusses similarities and differences between the two cohorts and highlights major themes.

3.1 Response Rate and Participant Profile

For Spring '09, 68 invitations to complete the survey were sent and 38 surveys were completed, a response rate of 56%. For the Fall '09, 107 students were asked to participate in the study and 56 filled out surveys, a response rate of 52%. All but two of the students completing the survey were in their senior year. Respondents from Spring '09 included 60% male and 40% female: Fall '09 included 68% male and 32% female. Just under one-fourth (23%) of students in both groups reported English was not their first language. Independent t-tests revealed no significant differences in the responses by gender or English as a second language.

In terms of presentations given since 6.UAT (a presentation was defined as speaking five minutes or longer before five or more people), the Spring '09 cohort indicated that during Summer '09: 29% of them had given no presentations; 37% had given 1-2 presentations; 26% had given 3-6, and 8% had given more than six.

And the Spring '09 cohort indicated that three months after that, during Fall '09: 24% of them had given no presentations; 45% had given 1-2 presentations; 26% had given 3-6, and 5% had given more than six.

A similar question was posed to the Fall '09 cohort, but this survey inadvertently used the exact same wording as the Spring '09 survey, which asked for the number of presentations given during Summer '09 and Fall '09 – i.e. students in the Fall '09 cohort could have reported the number of presentations they gave during the summer before taking 6.UAT and during the semester they took 6.UAT. Keeping this in mind, the Fall '09 reported that during Summer '09: 20% of them had given no presentations; 53% had given 1-2 presentations; 24% had given 3-6, and 4% had given more than six.

And during Fall '09: 6% of them had given no presentations; 15% had given 1-2 presentations; 43% had given 3-6, and 36% giving more than six.

So while we cannot compare the answers for both cohorts nor can we reliably interpret the data's implications we can safely assume that a student is likely to give one or more presentations during a semester and during the summer session, so that it is highly likely that most students have given at least one presentation in the eight month period after taking 6.UAT, and thus had the opportunity to use some of the skills taught in 6.UAT.

Just over 40% of students in both cohorts said they sought one or more opportunities to further develop their presentation skills since taking 6.UAT such as taking a class or lessons, seeking expert advice or pursuing an activity that would help improve a particular aspect of presentation skills.

3.2 Strategies and Skills

The strategies and skills covered in 6.UAT were clearly applied by the Spring '09 cohort in the subsequent semester's classes, projects, and/or activities. Again, due to inadvertent wording, the Fall '09 cohort was asked to think about presentations they gave in Summer '09, (before 6.UAT), and in Fall '09 (during 6.UAT). Thus, while the Spring '09 cohort addressed a period after 6.UAT, the Fall '09 cohort's responses likely included their presentations from 6.UAT. As a result, the results for both cohorts on this item are not directly comparable. Nevertheless, the overall finding is that both cohorts had experience applying the strategies and skills taught in 6.UAT.

Eighty five percent of the Spring cohort and 98% of the Fall students said they applied strategies that made their presentations more coherent and most students in both cohorts made their presentation more interesting [Spring: 82%, Fall: 88%] (henceforth denoted [82%, 88%]), explained concepts well [76%, 85%], and sought to make the presentation persuasive [75%, 77%]. Other responses suggest how their presentations were made more coherent and interesting: they created more effective slides [79%, 90%], gave their presentation a focus [79%, 85%], and practiced the presentation beforehand [65%, 87%]. Storyboarding the presentation, even though possibly viewed as a time-consuming step, was done by over 60% of students in both cohorts. While giving presentations, students monitored audience understanding [75%, 70%]. Thus, students envisioned and planned their presentations beforehand, employed strategies and skills to more clearly and convincingly deliver their presentations, and continued to monitor the impact on audiences while giving the presentation.

3.3 Learning experience

Students were asked to indicate their level of agreement with statements about the 6.UAT learning experience. Even though it had been eight months since 6.UAT, students continued to express strong support for the course and appreciation for what they learned. For example, students realized that the oral presentation skills learned in 6.UAT will be of value to them in their future academic and professional life[85%, 94%], are glad they took the course [81%, 86%], and found it an effective learning experience [82%, 90%].

The course gave students a greater awareness for what makes speakers (at lectures, meetings, talks, etc) effective or ineffective [78%, 80%]. Students were more aware of how well they communicate with others [81%, 82%]. Looking back, they appreciated even more the presentations skills they learned in 6.UAT [76%, 78%].

When asked to reflect on what they now do to prepare for oral presentations, students reported important changes. They were more likely to: think about how to make their presentation interesting [75%, 82%]; consider how to make a talk clear to the audience [75%, 82%]; provide the concept [84%, 86%] and supply context and overview before jumping into technical data/details [81%, 84%].

In preparing for the future, students intended to continue to strengthen their oral presentation skills [91%, 82%] and felt more confident in their ability to present in real world professional situations [81%, 82%]. In future academic or professional settings, they felt they would more likely remain calm and think clearly when asked tough questions during presentations [75%, 80%].

3.4 Short-Term Impact

Twenty-two survey questions asked students about the short-term impact of 6.UAT on their oral presentation skills eight months after taking 6.UAT. These were a subset of the very same questions asked in the earlier assessments (performed 8 months prior). Since the earlier assessment included additional questions that asked about students' observations of peer improvement and were omitted from this study, factor analysis was performed and coefficient alphas were recalculated. The Explaining and the Thinking-on-Feet scales from the earlier assessment proved reliable in this retrospective study, and two additional scales were found to be relevant: Effectiveness and Confidence scales. All four are discussed in greater detail in this section.

The Explaining scale measured students' perception of how much they improved in the ability to explain concepts/ideas clearly, effectively, confidently and concisely. There were six questions making up this scale, each based on a 7-point scale with the top scale point indicating strong agreement that improvement occurred. The overall scale mean was [5.20, 5.49] (i.e. the average mean over all questions in the scale) with a 0.928 coefficient alpha. Over 75% of students in both cohorts agreed that they had improved in each of the six scale items. Respondents indicated they present more clearly [mean for Spring '09: 5.28, mean for Fall '09: 5.69], are more effective explaining their ideas [5.03, 5.42], and are more confident explaining complex concepts to non-experts [4.91, 5.35] and peers [5.06, 5.40]. They felt they could give concise focused presentations [5.41, 5.51], and could do so confidently [5.50, 5.59]. Particularly noteworthy is the fact that over 87% of both cohorts were more confident they could give an effective presentation, and that they present more clearly than before 6.UAT [81%, 90%].

The majority agreed that they were better able to "think on their feet" when giving a presentation (mean: [4.87, 5.07] with coefficient alpha 0.903). Students were equally likely to be better able to read how well an audience understands their presentations [63%, 61%]. However, students in the Fall cohort were clearly more comfortable about their ability to think on their feet [63%, 78%] and less likely to become flustered by tough questions during Q&A [53%, 69%]. The Fall cohort (67%) was somewhat more likely to feel aware of when they are not connecting with an audience than students in the Spring course (59%).

The Effectiveness scale had 7 items, a mean of [5.27, 5.49], and a coefficient alpha of 0.925. The Confidence scale had 11 items, mean [4.5, 5.26], and a coefficient alpha of 0.962. Note that items in these two scales overlap with those of the previous two scales.

In terms of effective presentations, 53% of Spring and 48% of Fall cohorts agreed with the statement, Before I began 6.UAT, I gave effective presentations. The mean scores of [4.50, 4.35] indicate that even those who agreed with this statement did not do so strongly. However, when students reflect on the various aspects of giving oral presentations eight months after taking 6.UAT, the mean scores for all 22 questions are each higher, indicating that students believe they are doing much better now than before the course.

Students in both cohorts overwhelmingly agreed they were more effective in preparing for and delivering oral presentations since they took 6.UAT. Over 90% in both cohorts could identify at least one aspect of their delivery that has improved, and 88% in both cohorts felt more confident in their ability to make an effective presentation.

Analyses showed there were no significant differences in response patterns for males and females, nor for students for whom English is a second language. The only meaningful difference was the Fall '09 cohort rated most items more highly. In our search for an explanation for the differences, we considered any relevant changes that had been made to the course in the Fall '09 semester. There were two:

1. An advanced recitation section was created for students with more presentation experience. There were eight students in this section; they were chosen by audition.
2. Some changes were made (specifically, removal of an assignment involving an ethics debate, and a lecture on literature searching) to allow time for mandatory dry runs of their final presentation.

Of the eight students in the advanced recitation, three answered the survey, and where was no common pattern of responses. Given the number and variety in responses, the advanced recitation was unlikely to have influenced the direction of the findings.

Although not directly explored, it is possible that the mandatory dry run could have bolstered the course's impact on students, since this occurred at the end of the term, and revision and reinforcement are beneficial in the learning process.

4 CONCLUSION

The retrospective study of students who took 6.UAT in Spring '09 and in Fall '09 provided strong evidence that the oral presentation strategies and skills taught in 6.UAT have been retained and applied successfully over the eight month period since taking the course.

Students had very positive views of their 6.UAT learning experience. Not only were they glad they had taken the course and felt they strengthened their presentation skills, they clearly agreed that the oral presentation skills they learned will be of value in their future academic/professional life. Furthermore, they now have an increased awareness of their own communication skills; are now more critical observers of other speakers' presentations; are better able to read an audience and “think on their feet” when giving a presentation; and are more confident about their ability to make an effective presentation.

Prior to 6.UAT, about half the students said they felt that they could make effective presentations (with one half of these students agreeing only slightly that they could). The proportion who felt confident after 6.UAT was much greater, as high as 87% for items within the Confidence scale. Students also learned that presentation skills can continue to be improved, and 90% say they continue to strengthen their oral presentation skills.

The retrospective survey provided strong support for the efficacy of the 6.UAT course. The findings that such a high proportion of students are so positive that 6.UAT has had a lasting short-term impact were surprising and encouraging. What would be even more impressive is if 6.UAT’s impact continued well beyond the short-term, into students’ careers and professional development post-MIT.

5 ACKNOWLEDGEMENTS

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35 LECTURERS' PERSPECTIVES ON THE EDUCATIONAL BACKGROUND OF ENGINEERING STUDENTS

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ABSTRACT

One of the rich flavors but also central challenges present in engineering education deals with the high level of heterogeneity among the incoming engineering students. Students enter Bachelor's level engineering education with many different educational backgrounds. However, there are rather limited possibilities to tailor the teaching and learning processes so that they fit the different needs of individual students or even the different student categories. There are different opinions between the lecturers whether the educational background affects students' risk of dropping out, or their possibilities to reach the learning objectives in the first place. In this paper, the results of a small-scale survey on the lecturers of the B.Eng. Degree Program in Information Technology at Turku University of Applied Sciences (TUAS) are presented and discussed. The goal of the survey was to study how the lecturers consider the possible differences between the students with different educational backgrounds.

Keywords: Student Attrition, Ability Groups, Mathematics

1 INTRODUCTION

Topics dealing with delayed graduation and discontinuation of studies in higher education have frequently been in the headlines during the past few years. The global recession has meant challenging times even in the public economy and, accordingly, issues like extending the average length of working life have been widely discussed by political decision makers (see e.g. [1]).

Similar reasons seem to lead to student drop outs in the different branches of higher education all over the world. According to Liimatainen et al. [2], the most important reasons behind delayed graduation both in scientific universities and universities of applied sciences in Finland deal with working during the studies, lack of study motivation, psychological problems, and family-related issues. On the other hand, also variables like the student's age at the beginning of the studies, parents' educational background, and academic performance and success during the studies often appear to correlate with student drop outs [3]. Thoughts hindering the reaching of educational and career-related goals have also been shown to correlate with the drop out risk [4].

Although similar problems are present in all fields of education, engineering is one of the main areas of concern dealing with student attrition. Shuman et al. [5] reported that approximately only a half of the students entering engineering education ever graduate, and roughly a half of drop outs take place during the first academic year. These types of figures are the reality in many Finnish engineering degree programs as well.

One of the challenges present in engineering education deals with the high level of heterogeneity among the incoming engineering students. Students enter Bachelor-level engineering education in Finnish universities of applied sciences with many different educational backgrounds. For example, the new students entering the Degree Program in Information Technology at TUAS typically represent three main categories. Usually approximately 1/3 of them have a vocational degree, 1/3 have completed the upper secondary school with the so called "short" course in Mathematics, and the remaining 1/3 enter the program with upper secondary school certificate with a "long" course in Mathematics. In addition, the students with vocational degrees often represent many different fields; usually technical, but also others. Although this study focuses on the Finnish context, this challenge is also present elsewhere (see e.g. Reed [6]).

The goal is to provide such a learning environment that all the admitted students have equal possibilities to learn and, finally, reach the same core learning objectives regardless of their educational background. However, there are rather limited possibilities to tailor the teaching and learning processes so that they fit the different needs of individual students or even the different student categories. Furthermore, there are different opinions between the lecturers whether the educational background affects students' risk of dropping out, or their possibilities to reach the learning objectives. In this paper, the results of a small-scale survey on the lecturers of the B.Eng. Degree Program in Information Technology at TUAS are presented and discussed. The goal of the survey was to study how the lecturers consider the possible differences between the students with different educational backgrounds.

2 RESEARCH QUESTIONS AND METHODS

The central research goal is to complement the results presented in [7] and to study how the lecturers of the degree program consider the possible differences between the students with different educational backgrounds. How do the lecturers describe the differences (if any)? Do the lecturers consider the different students in their teaching? How could the learning of different students be supported better than it currently is?

The research instrument was a survey implemented as a questionnaire, distributed in late April 2011. The questionnaire, its goals and contents were first presented at the degree program's development event and then the participants were asked to answer the questionnaire anonymously using a web-based form. 16 lecturers and other full-time teaching staff members of the degree program answered the questionnaire during the event. The survey covered nearly all permanent teachers of the program. A request to answer the questionnaire was also sent to 16 other lecturers regularly teaching in the program but only two of them answered, resulting in 18 answers.

The questionnaire included three main questions to find out how the lecturers describe the differences (if any) between the students with different educational backgrounds, how they consider the needs of different students in their own teaching, and how the different students could be better supported. In addition, a set of background variables were asked to map the profiles of the teachers who answered the questionnaire. The questionnaire was implemented in Finnish.

3 RESULTS

As the main goal of the survey was to find out the qualitative aspects in the teachers' ways to describe the potential differences they experience, the background data was not used to analyze, for example, the possible differences between the different lecturer categories. Moreover, the sample was limited, and it would also have been very difficult not to reveal individual answers. However, it is of interest to study the overall profile of the lecturers that participated in the survey. This information is presented in Table 1.

TABLE 1. *The profile of the respondents of the Lecturer Survey implemented in April – May 2011.*

Primary teaching discipline (#)	
Mathematics or Physics	2
Languages and Communication	1
ICT Subjects	13
Others	2
Experience as full-time teacher (years)	
Average / Median	13.8 / 12.5
Min / Max	2 / 34
Working experience other than teaching (years)	
Average / Median	6.1 / 5.0
Min / Max	0 / 20
Level of education (#)	
Bachelor's Degree	4
Master's Degree	9
Postgraduate Degree	5

As the data in Table 1 illustrates, the respondents represent a wide selection of teaching professionals on different disciplines, with different educational backgrounds, and in different phases of their careers. Even though it is not possible to make any further generalizations considering the potential differences between the different disciplines based on this sample and the obtained answers, the results nicely cover the lecturers' perspectives in the context of this study.

The answers were studied using thematic content analysis, focusing separately on each of the three main questions. The answers are illustrated by presenting a set of direct quotations (translated from Finnish to English by the author). Similar or nearly similar answers are grouped by displaying only one quotation that captures the topic clearly.

3.1 Describing the Students' Differences

All respondents discussed the differences between individual students. 14 respondents (78%) had experienced differences, major or minor, based on the educational background of the students. These differences can be divided into three categories:

Differences in Disciplinary Knowledge and Skills

- The upper secondary school graduates have better theoretical competences and they can write better reports.
- The students with vocational background have better knowledge on Electronics. The upper secondary school graduates may have better foundation in Mathematics, Physics and languages.
- One problem with the upper secondary school graduates with "long Math." is that the courses contain same topics than they have already studied but not really l earned yet. Realizing this seems to frustrate some students.
- The knowledge base of the students with vocational background is really weak. The vocational institutes should use separate groups for the students that will continue t heir studies.
- The mathematical knowledge and skills of the upper secondary school graduates with "short Math." are as weak as those of the students with vocational background.
- The results of the upper secondary school graduates with "short Math." form typically two clusters on both ends of the scale.
- The students with vocational background know things from before. This is clearly visible in my courses. The upper secondary school graduates have better mathematical skills.

Differences in Study Skills

- The upper secondary school graduates are used to "school-like" exercises. The students with vocational background complain more often about writing reports and ask for practical tasks. They [vocational students] are bolder and more self-confident in projects.
- The students' educational background is mainly visible in the study skills and habits and typically during the first academic year. Later there are no differences, I think.
- Most of the students have difficulties in following intensive lecture-type teaching.
- The students with vocational background are more practical; they have been interested in doing things hands-on from the beginning.
- The students with vocational background start solving laboratory exercises (with openly defined questions) more quickly. The upper secondary students often just "freeze" and do nothing.
- The upper secondary school graduates are more self-regulated and able to understand abstractions. However, they have difficulties in acting as a group.

Differences in Motivation

- I think that the students with vocational background are more eager to learn new things. That is the case also if the student already has another degree; they are somehow more motivated to study. But there are always exceptions, too.

- The students with vocational background are more motivated and, thus, they manage better in the studies. Some of the upper secondary school graduates are more lost.
- The educational background doesn't really matter. However, the students' own interest or proper workplace experience creates differences in the students' subject knowledge.

- The motivation level of the students with vocational background is mainly ok; the team spirit is best compared with the other groups. The motivation level of the upper secondary school graduates with "short Math." is modest, and the group doesn't really support individual students. The "long Math." students are a fuzzy group with great differences in talent; they think that they know more than they actually do.
- Learning occurs probably always according to the same rules. The most important thing is one's own intrinsic motivation. I cannot see any differences between these students, at least not when considering those coming from Finnish secondary education institutes.

3.2 Practical Actions in one's own Teaching

12 (67%) respondents answered that they try to consider the differences between the students in different ways whereas 6 respondents (33%) stated that they do not tailor their courses based on the students' backgrounds. The lecturers' answers can be divided into four categories:

Tailoring Tutoring Activities

- I try to focus on motivating the students: I tell and repeat continuously why the subject is important and where one can bump into it in working life.
- I consider the students with continuous tutoring and development discussions.

Tailoring Learning and Teaching Methods

- I have tried to decrease the number of exercises that contain lots of writing, and use different types of assignments instead. In addition, I'll keep my info sessions shorter and arrange something to do in between. In group exercises, I mix the students with different backgrounds.
- The students can complete a part of the course as their own project, if they are no longer interested in lecture- and exercise-based activities during the last academic year.
- I offer different options to complete the course. I'll try to make the courses more interesting and practically oriented. I seek good learning environments, too.
- During the laboratory classes, it is possible to give individual guidance in Finnish. Occasionally, it is rather frustrating to explain the same thing to five students again that was just explained (in English) jointly to all and that in visible in the slides, too.
- The teacher must always repeat topics over and over again. These and these results are needed in the exercise… This is pretty frustrating.

Tailoring Course Contents

- Especially in the specialization courses one must focus on teaching basic topics during the common sessions, which may frustrate the more advanced students.
  We try to give them project assignments that are challenging enough for their skills.
- I use a couple of hours more repeating the basic things with the students from the

vocational institutes. I give them extra exercises, too, if they ask for them.

- The examples, especially, must be selected based on the level of the group. I have not been able to use challenging exercises during the lectures for a long time. The teacher's pain level would increase too much otherwise.
- The teaching material has not been sufficiently updated according to the "current requirements". The exercises in the old books are often far too difficult.
- In the current laboratory exercises, the student does not need to master Mathematics or Physics especially well. We try to teach general understanding of the phenomena, measuring technology and critical thinking using practical tasks.

No Tailoring

- I do not consider the students' background in my teaching.
- In my subjects, it is not really possible to tailor the teaching in other ways than giving extra exercises to the fast ones.
- In the basic subjects it is difficult to do any tailoring.

3.3 Improvement Initiatives

All but one (94%) respondents discussed the potential ways to develop the current situation and proposed actions for better considering the different needs of the students. The lecturers' answers and initiatives can be divided into four categories:

Supporting Team Spirit and Group Dynamics

- Team spirit is important; supporting its development has succeeded better due to Problem-Based Learning. Pair work could be facilitated more.
- The most important factor supporting learning results is motivation. Here, small groups and group tutors have great importance.
- In general, the group should have a good spirit; the teacher must gain the group's "trust".
- A couple of good and active students can facilitate the team spirit to a high level. Active attitude spreads. One must encourage those who manage well to support the others.

Improving Tutoring and Supporting Development of Study Skills

- Girls should be supported especially in Mathematics, Physics and Programming.
- The students' intrinsic motivation should be activated using all possible means; reasoning, feelings, "bribes and threats" etc. Each student should realize that there is a conflict between the current knowledge and skills and the motivating goals.
- Individual guidance helps for sure but it is not always possible due to lack of resources. The more advanced students should go through detailed personal study planning so that they would get more challenges and optional courses.
- It would be easier to support [the students] if one got out from them what they really want. So far, the best piece of information was a brief message on a post-it-note: "Please try to get us to do more exercises in groups."
- The students seem to need more of "a supporting shoulder" nowadays. The teacher must

have good “situational eye”. The students need personal guidance and they have very “odd” problems.

Improving Curriculum, Course Structures and Instructions

- The number of optional courses should be increased.
- Clearer task definitions that clearly state what should be done and what is expected.
- There could be short intensive courses in certain specific topics (no credits) before the courses that require this content.

- The requirements should always be the same. There cannot be courses that are possible to pass with knowledge from vocational schools. The skills exams must be demanding enough!
- It would be beneficial to complete a questionnaire concerning the students' background in the beginning of the course. The teacher would get informed on who may need extra guidance. The practicality of the laboratory exams could be developed further.

Other Topics

- State-of-the-art software applications and equipment.
- Older students that have passed the course with moderate grades could be used as course assistants. This could increase the resources to support and guide the students.

4 DISCUSSION

Many lecturers have experienced differences between the students with different educational backgrounds. These differences depend on the subject and both vocational and upper secondary school graduates seem to have specific strengths and challenges. The differences are mainly visible during the first academic year, and do not play any significant role towards the end of the studies.

Students with vocational backgrounds are experienced as more practically-oriented and more motivated learn. Upper secondary school students have better theoretical competences and are perhaps better equipped for tasks that require independent work and self-regulation. The importance of intrinsic motivation is stressed by many respondents. Upper secondary school graduates, especially those with “short Math.”, seem to have more motivational challenges than the others. On the other hand, there are exceptions in all categories.

Most respondents indicated that they consider the different needs of the students by providing alternative ways to complete the courses, optional exercises, as well as by focusing additional guidance to those individuals that seem to need it. Different tutoring activities and ways to reinforce motivation are also deemed important. Certain answers reflect change in the incoming students' knowledge and skills on a longer perspective. These respondents have experienced that the competences of the current students are weaker than before which creates feelings of frustration. Furthermore, some lecturers seem not to invest in any significant efforts in tailoring their teaching based on the different needs of the students. One reason behind this is the lack of resources but it might also reflect their professional orientation and learning concept.

Team dynamics in its different forms as well as reinforcement of motivational factors are considered as the most important topics when aiming at improving the overall results. Individual and personal guidance and trustworthy mutual relations between the students and faculty members play an important role, too. On the other hand, some of the answers indicate a certain level of frustration. The lecturers are not always so sure what should be done in order to develop the situation in a positive direction; some try to externalize the challenges and use defensive expressions.

5 CONCLUSIONS

In this paper, the results of a small-scale survey to the lecturers of the B.Eng. Degree Program in Information Technology at TUAS were presented. It was discussed how the lecturers describe the possible differences between the students with different educational backgrounds, how they consider these differences in their teaching, and how could the learning of different students be better supported.

The experiences of the respondents vary. Most of them had experienced significant differences between the students, partly based on their educational background. Many lecturers consider these differences by, for example, providing alternative ways to complete the courses. However, some colleagues experience working with the heterogeneous student base very challenging or even frustrating.

Topics in motivation and general study skills are seen as the main areas for improvement. Motivation and the different factors behind it are the key elements of an efficient learning process. When both students and teachers can consider themselves as respected members of the learning community and feel home both in the physical and mental environment, the results and a positive, even curious, spirit will speak for itself.

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37 A MODERN COURSE IN VIBRATION OF RODS AND BEAMS

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ABSTRACT

This work shows how dynamics of rods and beams can be taught in a modern way. The authors develop the theory based on variational principles and set the focus on linear rods and Euler-Bernoulli beams. From their teaching experience the authors know that certain mathematical problems for the students appear in this topic especially during the solution procedure of the partial differential equations of motion. This work shows how these challenging problems can be mastered with the help two different solution techniques. The first one is the classical separation of variables method in conjunction with Fourier series. The second one is the Green's function method. Further on, as it is necessary for engineering students to be familiar with modern computational tools, this work gives several examples how a computer algebra system (CAS), in this case MAPLE, can be used by instructors and students to shorten lengthy calculations during lessons or self-studies. Additionally the visualisation capabilities of the CAS are used extensively. For example, the motion of a beam or time-dependent variables can be animated in an easy manner. On this basis, it is an easy task to study the influence of different boundary conditions or change material properties to make case studies. All underlying worksheets can be obtained from the authors.

Keywords: computer algebra, Green's function method, elastic wave equation.

1 GOVERNING EQUATIONS

In the following two sections the derivation of the governing equations for longitudinal vibration of rods and transversal vibration of beams is outlined [4,6]. A comprehensive discussion and further details on this topic are given in [3].

1.1 Vibration of rods

The task is to find the equation of motion for a straight bar of cross-sectional area A, length a and is made of linear elastic material with density ρ and Young's modulus E. Additionally, it is assumed that the geometric linear theory is valid. The displacement u and the linear longitudinal strain are given by

$$u = u(x,t), \qquad \varepsilon = \partial_x u(x,t) \tag{1}$$

The equation of motion is derived in the Lagrangian framework of continuum mechanics [6,9]. This offers several advantages in generalising of the theory to more space dimensions (vibration of curved rods or beams, membranes, plates, etc.) and in considering complex material behaviour. The Lagrangian L is given by

$$\mathcal{L} = A \cdot \int_0^a dx \, \xi \tag{2}$$

with the Lagrangian density ξ

$$\xi = \xi\left(u, \partial_x u, \partial_t u, x, t\right) \tag{3}$$

In Eq.3 ∂x and ∂t mean the derivation with respect to space and time, respectively. In classical mechanics the Lagrangian L is given by

$$\mathcal{L} = T - U, \tag{4}$$

which represents the difference of kinetic and potential energy. For a one-dimensional linear elastic continuum the Lagrangian density ξ is

$$\xi = \frac{\rho}{2}\left(\partial_t u\right)^2 - \frac{E}{2}\left(\partial_x u\right)^2. \tag{5}$$

In Eq.5 the first term is the specific kinetic energy and the second term is the specific elastic energy due to linear elastic deformation. The first principle in Lagrangian mechanics is that the first variation of the Action

$$\hat{\mathrm{A}} = \int_{t_1}^{t_2} dt \, \mathcal{L}, \tag{6}$$

must vanish (Hamilton's principle), which means that

$$\delta \hat{\mathrm{A}} = 0 \tag{7}$$

With the principle, it can be shown that a variational problem corresponds to a partial differential equation called Euler or Euler-Lagrange equation [11]. The corresponding Euler equation for the stationary condition, Eq.7, is

$$\partial_u \xi - \left(\partial_t \partial_{u_t} \xi + \partial_x \partial_{u_x} \xi\right) = 0. \tag{8}$$

Computation of the derivatives of Lagrangian density L and insertion in Eq.8 delivers the equation of motion for the bar

$$u_{tt} = c^2 u_{xx}, \quad \text{with} \quad c^2 := \frac{E}{\rho}. \tag{9}$$

An extension of the foregoing considerations and introduction of the concept of generalised forces allows deriving the one dimensional wave equation with a source term

$$\partial_{tt} u(x,t) = c^2 \partial_{xx} u(x,t) + h(x,t) \tag{10}$$

As the source term an external applied force is understood.

In the following part the solution procedure for the wave equation is sketched. In general the boundary conditions are given by

$$\kappa_1 u(0,t) + \kappa_2 \partial_x u(0,t) = A(t) \tag{11}$$

$$\kappa_3 u(a,t) + \kappa_4 \partial_x u(a,t) = B(t) \tag{12}$$

The complete or general solution is divided into two parts by

$$u(x,t) = v(x,t) + s(x,t). \tag{13}$$

The second term is called linear part of the solution. It is obtained with the Ansatz

$$s(x,t) = m(t)x + b(t) \tag{14}$$

Insertion of Eq.13 into the wave equation (Eq.9) delivers a PDE (partial differential eq.) for v(x, t). By the method of separation of variables

$$v(x,t) = X(x)T(t) \tag{15}$$

the PDE is split up into two ODE's (ordinary differential eq.'s), one Eigenvalue problem in the space for X(x) and a second order time-dependent equation for T(t). The equation for T(t) is solved by the Green's function [1,2] which is obtained by the classical approach via the basis vectors and the Wronskian of the ODE [1]. In detail the Green's function is given by

$$G_2(t,\tau) = \frac{\sin\left(c \cdot \sqrt{\lambda_n}(t-\tau)\right)}{c \cdot \sqrt{\lambda_n}}. \tag{16}$$

The particular solution becomes

$$v(x,t) = \sum_{n=1}^{\infty} X_n(x)\left(C(n)\cos\left(c \cdot \sqrt{\lambda_n}\, t\right) + D(n)\sin\left(c \cdot \sqrt{\lambda_n}\, t\right) + \int_0^t d\tau\, G_2(t,\tau) Q_n(\tau)\right) \tag{17}$$

With

$$Q_n(t) = \int dx\, q(x,t) X_n(x) \qquad and \qquad q(x,t) = h(x,t) - \partial_{tt} s(x,t) \tag{18}$$

Addition of particular and linear solution gives the complete solution of the non-homogeneous wave equation as

$$u(x,t) = (m(t)x + b(t)) \cdot \sum_{n=1}^{\infty} X_n(x)\left(C(n)\cos\left(c \cdot \sqrt{\lambda_n}\, t\right) + D(n)\sin\left(c \cdot \sqrt{\lambda_n}\, t\right) + \int_0^t d\tau G_2(t,\tau) Q_n(\tau)\right) \tag{19}$$

1.2 Vibration of beams

The free transversal vibrations of a uniform Euler-Bernoulli beam are described by the partial differential equation

$$\rho A \partial_{t^2} w(x,t) + EI \partial_{x^4} w(x,t) = 0. \tag{20}$$

In Eq.20 ρ is the mass density, A is the cross-sectional area, E is the modulus of elasticity and I the cross-sectional moment of inertia. The effects of axial loads are not included in this equation. Additionally it should be mentioned that the effects of rotary inertia are also neglected. These effects are considered in the extended Timoshenko beam theory [5]. The normal mode solution of Eq.20 is given by

$$w(x,t) = X(x) e^{i\omega t} \tag{21}$$

Inserting the Ansatz (Eq.21) into the equation of motion leads to

$$\partial_{x^4} X - \frac{\rho A}{EI}\omega^2 X = 0. \tag{22}$$

The general solution of this 4th-order ODE is given by

$$X(x) = C_1 \cos \lambda x + C_2 \sin \lambda x + C_3 \cosh \lambda x + C_4 \sinh \lambda x, \text{ with } \lambda = \left(\frac{\rho A \omega}{EI}\right)^{\frac{1}{4}} \tag{23}$$

The constants of integration Ci are specified by boundary conditions. Introduction of the BC's in Eq.23 leads to the characteristic equation, which is satisfied by the natural or eigenfrequencies ωi. A continuum has an infinite, but countable number of eigenfrequencies and every one of them corresponds to an eigenmode Xi(x), which fulfil the orthogonality and normalisation relations

$$\int_0^L dx X_i(x) Y_j(x) = 0, \qquad \int_0^L dx\, X_i^{\,2}(x) = 0. \tag{24}$$

2 EXAMPLES

2.1 Rod vibration

In the following example the longitudinal wave motion is investigated. The displacement u(x, t) for longitudinal wave motion in a bar over the interval I = {x|0 < x < 1}. The left end of the bar is fixed, whereas the right end experiences an oscillatory compression. There is no external applied force acting on the system. At t = 0 the bar has an initial displacement distribution u(x, 0) = f(x) and the initial speed distribution ∂tu(x, 0) = g(x). The wave speed is c = 1/5 and the Young's modulus E = 1. To find the solution means to solve the non-homogeneous wave equation

$$\partial_{tt} u(x,t) = c^2 \partial_{xx} u(x,t) + h(x,t). \tag{25}$$

Boundary condition at the left end of the beam is homogeneous and at the right end non-homogeneous. Mathematically they are given by

$$u(0,t) = 0, \qquad \partial_x u(1,t) = \sin(t). \tag{26}$$

The initial displacement distribution is given by the second order function

$$u(x,0) = x\left(1 - \frac{x}{2}\right), \tag{27}$$

and the vanishing initial speed distribution is

$$\partial_t u(x,0) = 0. \tag{28}$$

There is no external applied force on the bar, i.e.,

$$h(x,t) = 0. \tag{29}$$

The solution is given by u(x, t) = v(x, t) + s(x, t). As already mentioned before, the solution is split into a linear part s(x, t) and a variable part v(x, t). The function v(x, t) satisfies the partial differential equation

$$\partial_{tt} v(x,t) = c^2 \partial_{xx} v(x,t) + q(x,t), \tag{30}$$

with the abbreviation

$$q(x,t) = h(x,t) - \partial_{tt} s(x,t) \tag{31}$$

Insertion of the system parameters delivers

$$b(t) = 0, \qquad m(t) = \sin(t) \tag{32}$$

With this the linear portion of the solution is calculated as

$$s(x,t) = x \sin(t). \tag{33}$$

The variable solution is obtained by the method of separation of variables, i.e.,

$$v(x,t) = \sum_{n=1}^{\infty} X_n(x)\, T_n(t), \tag{34}$$

where Tn(t) is the solution to the time-dependent differential equation

$$\partial_{t^2} T_n(t) + c^2 \lambda^2 T_n(t) = Q_n(t), \tag{35}$$

and Xn(x) is the solution to the spatial-dependent eigenvalue equation

$$\partial_{x^2} X_n(x) + \lambda^2 X_n(x) = 0\,. \tag{36}$$

The boundary conditions for the last ODE are

$$X(0) = 0, \qquad \partial_x X(1) = 0\,. \tag{37}$$

The solutions of the spatial-dependent eigenvalue problem are the eigenvalues and corresponding orthonormal eigenfunctions given by

$$\lambda_n = \frac{1}{4}(2n-1)^2 \pi^2, \qquad X_n(x) = \sqrt{2}\sin\left(\frac{1}{2}(2n-1)\pi x\right), \qquad n = 1,2,3\ldots \tag{38}$$

The time-dependent ODE is

$$\partial_{tt} T_n(t) + \frac{1}{100}\pi^2 (2n-1)^2 T_n(t) = Q_n(t) \text{ with } Q_n(t) = \frac{4(-1)^{1+n}\sqrt{2}\sin t}{\pi^2 (2n-1)^2}. \tag{39}$$

The corresponding basis vectors for this ODE are

$$T_1(t) = \cos\left(\frac{1}{10}(2n-1)\pi\, t\right), \qquad T_2(t) = \sin\left(\frac{1}{10}(2n-1)\pi\, t\right). \tag{40}$$

With the basis it is possible to construct the Green's function as

$$G_2(t,\tau) = \frac{10\sin\left(\frac{1}{10}(2n-1)\pi(t-\tau)\right)}{(2n-1)\pi}, \tag{41}$$

and the variable part of the solution v(x, t) can be computed. From the initial conditions on v(x, t) it is possible to determine the Fourier coefficients C(n) and D(n). Substitution of the initial conditions and evaluation of the integrals for C(n) and D(n) delivers

$$v(x,0) = f(x) - s(x,0) \qquad and \qquad \partial_t v(x,0) = g(x) - \partial_t s(x,0) \tag{42}$$

And evaluation of the integrals for C(n) and D(n) delivers

$$C(n) = \frac{8\sqrt{2}}{\pi^3\left(8n^3 - 12n^2 + 6n - 1\right)}, \; D(n) = \frac{(-1)^n 40\sqrt{2}}{\pi^3\left(8n^3 - 12n^2 + 6n - 1\right)}, \qquad n = 1,2,3... \tag{43}$$

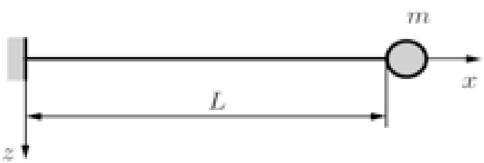
Finally the complete solution for the time-dependent displacement u(x, t) becomes

$$\begin{aligned} u(x,t) = \sum_{n=1}^{\infty} & \frac{8\sqrt{2}\cos\left(\frac{1}{10}(2n-1)\pi t\right)}{\pi^3\left(8n^3 - 12n^2 + 6n - 1\right)} + \frac{(-1)^n 40\sqrt{2}\sin\left(\frac{1}{10}(2n-1)\pi t\right)}{\pi^3\left(8n^3 - 12n^2 + 6n - 1\right)} \\ & + \frac{\sqrt{2}\sin\left(\frac{1}{2}(2n-1)\pi x\right)\cdot\left(400(-1)^{1+n}\left(2\sin t - 10\sin\left(\frac{1}{5}\pi nt\right)\cos\left(\frac{1}{10}\pi t\right)\right)\sqrt{2}\right)}{\left(16n^4\pi^2 - 32n^3\pi^2 + 2416n^2\pi^2 - 816n\pi^2 + \pi^2 - 400n^2 + 400n - 100\right)(2n-1)\pi^3} \\ & + x\sin t \end{aligned} \tag{44}$$

The solution of this problem is performed in detail with a MAPLE [7]. Further examples can be found in the textbook [8].

2.2 Beam vibration

For the beam in Figure 1 the four lowest eigenfrequencies ωi and the corresponding eigenmodes Xi(x) should be determined. The example is taken from the textbook [8] where several other illustrative examples are given.



$\rho = 7800\ \mathrm{kg/m^3}$
$A = 2.6 \times 10^{-3}\ \mathrm{m^2}$
$E = 200\ \mathrm{GPa}$
$I = 4.7 \times 10^{-6}\ \mathrm{m^4}$
$L = 1\ \mathrm{m}$
$m = 10\ \mathrm{kg}$

FIGURE 1. *Cantilever beam with mass on the free end, geometry, material properties.*

The beam is clamped at x = 0, hence the boundary conditions are

$$w(0,t) = 0 \qquad \partial_x w(0,t) = 0. \tag{45}$$

The boundary conditions at the right end are determined by writing the equation of motion for the mass. From the free body diagram in Figure 2 it follows that

$$m\partial_{t^2} w(L,t) = EI\partial_{x^3} w(L,t). \tag{46}$$

Additionally the bending moment at the free end is zero. This statement is given by

$$EI\partial_{x^2} w(L,t) = 0. \tag{47}$$

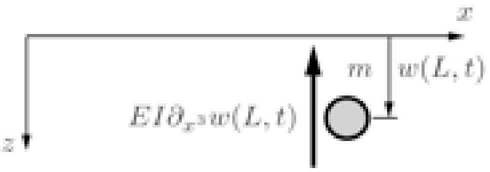


FIGURE 2. *Free body diagram for the mass m.*

The boundary conditions are

$$X(0) = 0, \qquad \partial_x X(0) = 0, \tag{48}$$

$$\partial_{x^2} X(L) = 0, \qquad EI\partial_{x^3} X(L) = -m\omega^2 X(L) \tag{49}$$

Insertion of these equations in the general solution, Eq.23, delivers the following system of four homogeneous equations

$$C_1 + C_3 = 0, \tag{50}$$

$$\lambda C_2 + \lambda C_4 = 0, \tag{51}$$

$$-\lambda^2\cos(\lambda L)C_1 - \lambda^2\sin(\lambda L)C_2 + \lambda^2\cosh(\lambda L)C_3 + \lambda^2\sinh(\lambda L)C_4 = 0, \tag{52}$$

$$\left[\frac{\rho A}{m}\sin(\lambda L) + \lambda\cos(\lambda L)\right]C_1 + \left[-\frac{\rho A}{m}\cos(\lambda L) + \lambda\sin(\lambda L)\right]C_2 +$$
$$\left[\frac{\rho A}{m}\sinh(\lambda L) + \lambda\cosh(\lambda L)\right]C_3 + \left[\frac{\rho A}{m}\cosh(\lambda L) + \lambda\sinh(\lambda L)\right]C_4 = 0 \tag{53}$$

A nontrivial solution exists only for a vanishing determinant of the coefficients. This leads to the following characteristic equation

$$(1 + \cos\psi\cosh\psi) + \frac{m\psi}{\rho AL}(\cos\psi\sinh\psi - \cosh\psi\sin\psi) = 0, \qquad \psi = L\cdot\left(\frac{\rho A\omega^2}{EI}\right)^{1/4}. \tag{54}$$

This transcendental equation is solved numerically by MAPLE [9]. With the data from Figure 1 the four lowest eigenfrequencies become

$$\omega_1 = 486.1\,{}^{rad}/_{s}, \qquad \omega_2 = 3642\,{}^{rad}/_{s}, \qquad \omega_3 = 11135\,{}^{rad}/_{s}, \qquad \omega_4 = 22838\,{}^{rad}/_{s}. \tag{55}$$

From the homogeneous system Eq. 50–53 the constants C1 . . .C3 can be determined by setting C4 = 1. In detail the constants C1 . . .C4 are

$$C_1 = \frac{\sin\lambda + \sinh\lambda}{\cos\lambda + \cosh\lambda}, \qquad C_2 = -1, \qquad C_3 = -\frac{\sin\lambda + \sinh\lambda}{\cos\lambda + \cosh\lambda}, \qquad C_4 = 1. \tag{56}$$

With the eigenfrequencies, Eq.55, and the relation shown in Eq.23 it is possible to write the i-th eigenmode as

$$X_i(x) = \frac{\sin\lambda_i + \sinh\lambda_i}{\cos\lambda_i + \cosh\lambda_i}\cos\lambda_i x - \sin\lambda_i x - \frac{\sin\lambda_i + \sinh\lambda_i}{\cos\lambda_i + \cosh\lambda_i}\cosh\lambda_i x + \cosh\lambda_i x. \tag{57}$$

A graphical representation of the first four modes is given in Figure 3.

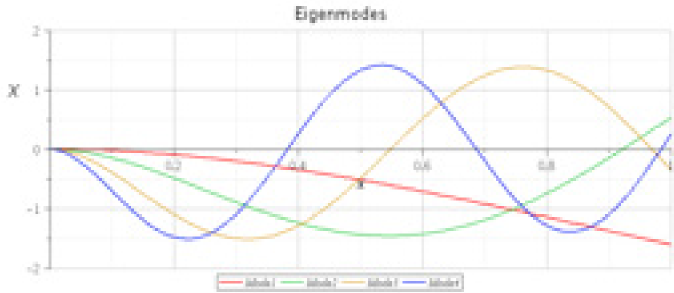


FIGURE 3. *The four lowest mode shapes for the beam with increasing eigenfrequencies from red to blue.*

The solution of this problem, the graphical representation of the eigenmodes and an animation of the mode shapes is done with MAPLE.

3 CONCLUSION

In this work it is shown how dynamics of rods and beams can be taught with the help of a computer algebra system. Based on variational principles the governing equations for linear rods and beams are developed. For both topics an example is given and solved with the help of a computer algebra system. The use of such a system provides many advantages, for example, it is easy to calculate different mode shapes and animate them. Additionally, it is a simple task to observe the influence of different boundary conditions and initial conditions or to study the impact of variant material properties. Due to the fact that there is not enough space to show the computations in detail, all of the worksheets can be obtained from the authors.

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39 NEW CHALLENGES FOR ENGINEERS: DESIGN AND IMPLEMENTATION OF A MOBILE SYSTEM DEDICATED TO IMPROVE ORAL HEALTH CONDITIONS

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ABSTRACT

The aim of this paper is to address how engineering students can face real problems through interdisciplinary approach in social relevant problems. Quite often, engineering and computer science students just deal in their academic processes with toy problems, simulations and black "box models". It is well known that there is a shortage of engineering students in many countries, which it is the actual case in Brazil. Some of the attractiveness for the engineering careers is strongly related to the vision perception that society has about the importance and role of engineers professional. In this sense, through a research and extension project of the UFRGS, undergraduate students of Computer Engineering course are facing real and relevant problems through their understand of health situation in the south of Brazil. This is done through the entire development of an ICT, which aims to provide integrated electronic medical records to a robust information system. The data collection and large parts of processing are done through the utilization of mobile devices. In this paper, it is shown how the enrolled interdisciplinary team of engineering students received strong benefits in their formation processes through their contribution to solve real problems which benefits a lot of people.

Keywords: Information and Communication Technology (ICT), Android, Problem Based Learning

1 INTRODUCTION

It is well known, that engineers are very important to the social and economic conditions since they play a very important role in the technological development. These professionals are in general associated to continuous process enhancements, aiming to ameliorate products, fabrication procedures , management of productive flows and they are also responsible for the activities of research and innovation in companies, industries and public sectors.

Brazil ´s National Industry Confederation (CNI) poses that there is a shortage of 120 thousand in the market in 2012.

Brazil belongs to the acronym known as BRICS, which are countries of emergent economies. Quite probably they will take a prominent role in many predictions for the future years in different serious analysis. BRICS corresponds to Brazil, Russia, India, China and South Africa. In the real world, there are indicators that place Brazil below the fast growing economies of Russia, India and China. China graduates annualy 350 thousand engineers or even 650 thousand if the three years courses are taken into account. Russia forms 190 thousand engineers and India, 120 thousand professionals. Even more than 220 thousand if three years courses are also considered.

Among the countries of high or medium revenues, Brazil has one of the lowest levels of high education around the world. This seems to be a consequence of all educational system , where the low quality of basic education creates difficulties to access high education as well as to follow undergraduate studies at normal steps. One major characteristic that show different levels and importance of higher education is the amount of young people in the ages between 18 and 24 years old, that are enrolled in universities. Brazil has 12. 4 % , whereas just to give some comparative examples, United Kingdom has 20 %, Italy has 31.1%, United States has 34 %, Finland 39.6 % and South Korea which is in the top of the OECD countries has 48.9 %.

In Brazil just 5.1 % of the annually graduated students belong to Engineering careers and only 9.7 % graduate in the careers of Sciences, Mathematics, Computer Science and Agrarian Sciences.

There are some consensus about the causes of this dramatic situation, but very often students can´t arrive at the end of their courses due to the lack of good basic knowledges in Mathematics and Sciences Many students think also that the first two years of the engineering courses are very theoretical and far from real problems creating major problems specially to students not so well motivated to follow courses considered difficult as Engineering and Computer Science courses.

In this work, we assume an additional hypothesis to this scenario: we think that students could be much more stimulated to accomplish successfully their careers if in their formation process real problems, but not only in specific engineering tasks. They must be challenged by complex and real problems which once solved could change the quality of life standards of countless people, trying to ameliorate health conditions and health public indicators. Deal with so complex systems can be handled only through the efforts and skills of interdisciplinary teams working with Problem Based Learning (PBL) methodology .We have established an interdisciplinary team formed by two university professors, one from Computer Science and other from Odontology and three undergraduate students, one student from Computer Science, other from Computer Engineering and other from Odontology. Their task is to develop a state of the art ICT mobile system to register and process data of some citizens of a deprived city in the south of Brazil. The city is called Viamão in the state of Rio Grande do Sul, Brazil.

2 RELATED WORKS REGARDING THE APPLICATION OF ICT SYSTEMS TO THE HEALTH AREA

In this work a management system dedicated to health centers integrated to a mobile system which takes care of data collection at attended homes is developed. This system has some characteristics which makes it to be original. In the literature we didn't see any work which deals also with oral health conditions. Nevertheless, we would like to point out some other related works that have shown some characteristics in common with the present work [1,2]

The research conducted by Miller with 1200 American physicians showed that only 13 % of them use electronic medical records but 32 % of them showed to be interested in their utilization. This indicates the potential of growing acceptance and adoption of electronic medical records. [3]

Fiales work has presented the development of a system to identify patients, trying to deal with the problem of identifying a single patient through his/hers data collected in different information systems, each one of them linked to a specific health institution. This situation is quite common also in health centers, where some patient´s data must be integrated to other instances from the same person, since people can move from one city to another city and normally the health information systems don´t take into account the possibility to incorporate data from the same patient collected through another system. State of the art electronic medical records must take this in consideration. [4]

Another project that deserves to be mentioned is the Butterfly Project which goal is to develop a home assistance system to deprived communities through the utilization of mobile devices. This system was developed by the Computer Science Department of the Mathematics and Statistics Institute of the São Paulo University, which is the largest Brazilian university. [5]

Some related works begin to present the possibilities of utilization of mobile devices related to enhance some health systems characteristics as well as how to use them related to electronic medical records.

3 BRIEF DESCRIPTION OF THE DEVELOPED SYSTEM

In Brazil, there is a special program from the Health Ministry known as Family Health Program, where health agents visit citizens homes in order to acquire some specific data as social indicators, health indicators, blood pressure, weight and many other ones. More recently, a new and very important service to this population was added through the analysis of oral health conditions.

In the undergraduate Computer Science course of the Federal University of Rio Grande do Sul (UFRGS), which is considered through official standards the best Brazil´s course in this area, there is a discipline called Computers and Society which can be attended also by Computer Engineering students. In the second semester of 2011 when this discipline was taught by the first author of the present work many discussions were pointed out about the role of ICT professionals in the near future and the importance of interdisciplinary disciplines.

One other characteristic of both courses is that the students at the end of their studies must do a kind of final research work, which can take one to two academic semesters. One of the Computer and Society´s student felt stimulated to put into action some theoretical discussions about the role of professionals in the perspective that they can develop systems that can improve definitely some society´s conditions as health conditions in deprived populations through the development of an ICT system incorporating mobility to collect patients data.

The challenge was to allow the students to develop a new entire system through the complete understanding of a social reality, which of course isn´t taught at the university during the curricular activities.

With this purpose, a research team of students from both courses was created for this project in order to develop a computer system that can collect data through mobile phones (smart phones), including the treatment of complex data, as mouth images.

This project is then a common initiative from two areas: Engineering and Computer Science combined with Health. Evidently, synergy can be created through this association presenting good potential outcomes to society, especially for poor and deprived citizens. In this case, just one common objective appears to be relevant to this interdisciplinary team: how to contribute to ameliorate health conditions of poor families.

Although there are still many inequalities in Brazil regarding economic incomes to its 190 million habitants, there are 250 million mobile active lines which a fifth part has also 3G broad band interconnection to Internet. In this sense, the mobile phone becomes therefore a very powerful tool to help to assist patients, since if electronic medical records are developed for this kind of device, it becomes possible to keep health data of the patients improving the reliability of systems and reducing operational costs.

Health professionals visiting poor villages face difficulties finding houses that have no numbers or no exact address, and they must also consider the lack of documentation of patients who do not know their national register number. Therefore, care of these individuals must be very well done, since in many practical situations it is hard to find the right people, besides the fact that it becomes difficult to carry and to process manually the records of huge number of patients.

This reality can be changed due to efforts from engineers and computer scientists to develop a mobile system that could efficiently deal with electronic medical records integrated to a data base system which can deal efficiently with the problems previously mentioned when compared to manual treatment of information and patient´s data. In some sense, it is quite difficult for engineering students to face real bad social conditions from citizens that belong to the same cities where they live, but this characteristic must be considered as a challenge for the formation of engineers in the dawn of the XXI century.

Taking into consideration the characteristics and necessities just described. The proposed system presents a functional and simple interface trying to facilitate the registering and insertion of patients ‘data.

The proposed structure is quite simple: the person to be interviewed by the health agents through the mobile system is the caregiver as also called the householder, who represents a family and a house. So, when a caregiver is registered, associated house´s data are added to this caregiver. Once a caregiver is registered, it becomes possible to add other dwellers, which are automatically linked to the caregiver(Figure 1, Figure 2 and Figure 3).

One special feature of the developed system consists in the utilisation of geo -localizations through GPS. Mainly used to localize dwellings, which don´t possess official addresses. [6,7,8]

The system has also been designed in foreign languages as Spanish and English. Translations are automatically generated due to some device configurations.

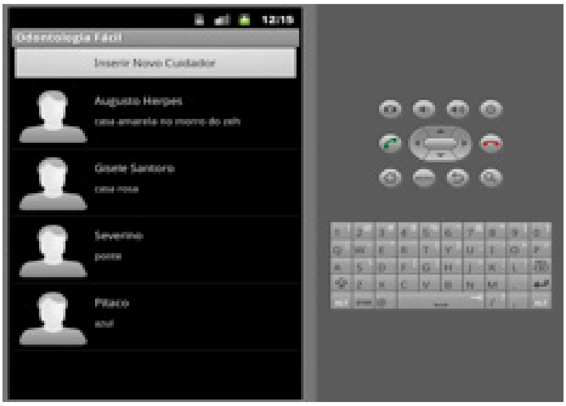

FIGURE 1. *Shows a program´s printscreen where the houses are represented by their caregivers.*

FIGURE 2. *Shows a program´s printscreen where the insertion of a new caregiver is done.*

FIGURE 3. *Shows the program´s printscreen of the house which corresponds to a specific caregiver. Data of other dwellers of this house can be added.*

4 BENEFITS TO THE STUDENTS FORMATION THROUGH THE DEVELOPMENT OF THE PRESENT WORK

This project has encouraged the involved students to seek knowledge within their own courses, creating motivation to learn what was intended as soon as the students begin their Computer Science and Computer Engineering courses. It turns out, that as it occurs with many engineering students they face a variety of curricular disciplines which are far from practical reality and even more distant if one curricular discipline considers the understanding of complex social problems and social and economic realities.

Many times in Brazil computer and engineering students are pejoratively considered to be nerds or geeks and since many of them have difficulties to make friendships. Another big problem regarding engineering education in Brazil deals with high evasion rates. Only 35 percent of engineering students enrolled in public universities finish their courses whereas only 25 percent of engineering students enrolled in private universities follow their courses until completion.

Working in interdisciplinary teams showed also to be very stimulating to the team´s students, since they could share knowledge and they felt that they can have " valuable " expertises and skills which can be offered to a wider public: the society.

5 CONCLUSIONS

The main benefits to enrolled students in this project were related to their understanding of the reality from brazilian society, composed in its majority by people of low incomes, which live in very difficult conditions. Once the students have participated in this project, they could realize that many people can be helped through the utilization of simple technologies which can be applied to their daily problems.

The activity of dental assistance in a deprived community presents many and complex problems to the dental professionals as well as to the dwellers. In this sense , it was clearly perceived as an advantage to these communities that they can profit from innovation brought by the interdisciplinary team formed at the University.The reached goal was to provide robust solutions in the development of an integrated mobile system dedicated to ameliorate control and health conditions of the enrolled persons through the system and through the facilitated work of health agents in these communities.

6 ACKNOWLEDGEMENTS

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40 TEACHING STRATEGY AS A MODULAR SERVICE PRODUCT IN COMPREHENSIVE COURSE DEVELOPMENT

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ABSTRACT

The teachers in the engineering education continuously develop the courses to reach the better learning outcomes which also fit with the competence needs of the industry. This work is in nature similar to the important product development work in the companies. The comparison suggests the use of the product development methodologies also in this course development work in the universities. This paper proposes the use of the modular product concept in a comprehensive course development. The service product under development is the teaching strategy of a course. It includes several modules from the targets for learning outcomes to the learning and teaching assessment. The modularization of the teaching strategy product offers many benefits for its development. For example the product development work of a modular product can also be split into the module level. Also the use of the well-proven industrial product development tools and methods can be efficiently applied on a course development. In this paper these benefits, tools and methods are introduced for a teaching strategy product in the environment of the engineering education.

Keywords: Modular service product, teaching strategy, engineering education, course development.

1 INTRODUCTION

The product architecture plays an important role in the product management and development. The architecture can be either integral or modular or a combination of these both. Even though the integral architecture has some benefits, the modularization of the product offers many important and useful features, mainly because each of the modules represents some specific function of the product. For example a refrigerator and a freezer may create one integral cold storage unit or the two units may be separate modules having only the compatible interfaces to make one unit. A thorough analysis about the two main types of the architectures of the physical products, integral or modular, has been made in [1]. The paper articulates the linkages between the architecture of the product and the five areas of managerial importance: product change, product variety, component standardization, product performance and product development management.

The service products have become recently very important for the success of many companies. Typically these service products are connected with the physical products of the company, like the regular maintenance services of the elevators. It is unusual to split the service products into the modules as in the cases of the physical products. However, a modular concept application in the domain of the IT services has been presented in [2].

The courses in the universities are typically developed by changing the contents or methods used for learning. However, it is important to note that these two course elements are to some extent linked together. The assessment is also one element of the course implementation. It includes both the learning assessment and the teaching assessment. The starting point of the course development is to define the targets for the learning outcomes. This paper introduces the teaching strategy of a course as a modular service product, which has these five elements or rather called modules. The use of the modularization in this service product case is illustrated and analysed. Even though the methodology used can be applied in principle to any educational field, the engineering education is the most potential one.

2 MODULAR TEACHING STRATEGY PRODUCT

The most essential elements of the technical specification of a physical product are the bill of materials (BOM) and the drawings. The BOM describes the architecture of the product and the drawings give the detailed information, like dimensions, of the individual components and assemblies. In the case of the modular service product the BOM lists the modules and the components of each module. The detailed information of the components is given by the verbal description rather than by the drawings.

In this study the teaching strategy of a course has the following five modules:

1. Targets for learning outcomes
2. Contents of teaching
3. Methods used for learning
4. Learning assessment
5. Teaching assessment

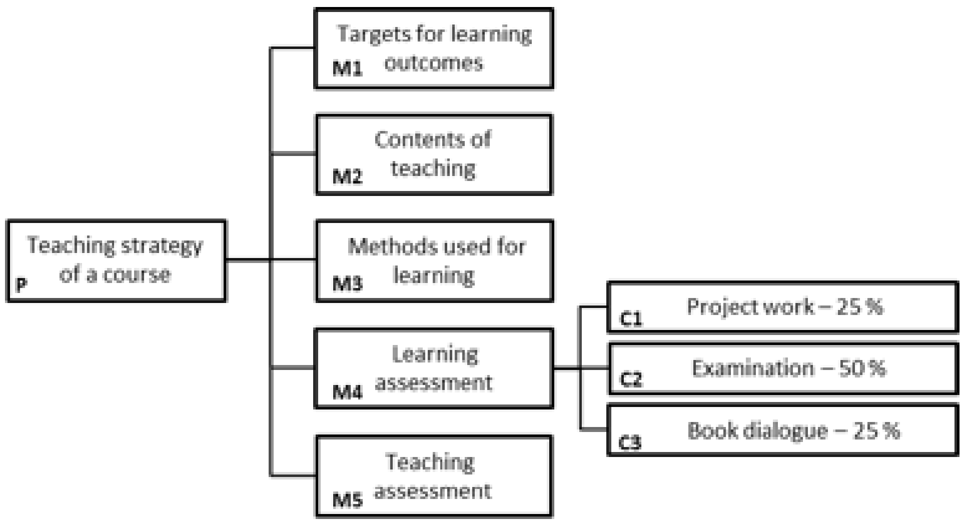

FIGURE 1. *The illustrative architecture (BOM) of the teaching strategy product, only the components of M4 are shown.*

As already stated above, the specification of the product still needs a detailed description of each component (compare with the drawings of a physical product). Figure 2 shows the descriptions of the three components of the module M4 as an example. Also these descriptions are illustrative.

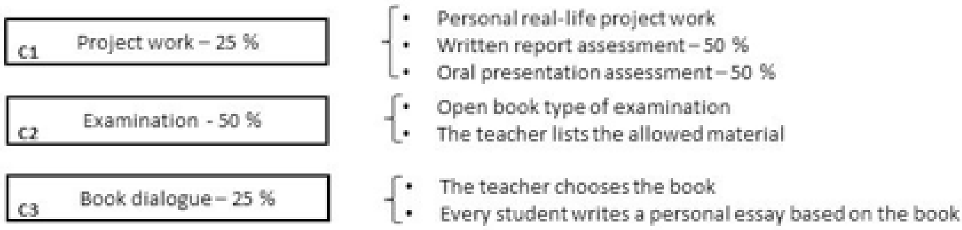

FIGURE 2. *The descriptions of the three components of M4 (illustrative).*

After the complete BOM with all the components of every module M1…M5 and the descriptions of the components have been defined the technical specification of the teaching strategy product is ready to be used in the course implementation.

3 BENEFITS OF THE MODULAR TEACHING STRATEGY PRODUCT

The use of the modular architecture of our service product described in the previous chapter has many benefits compared with the traditional way of thinking to handle some of the components or some of the modules of the product separately in different times. The next sections introduce the most important reasons for the use of the modular product architecture in the case of the course teaching strategy.

3.1 Product development

As the modular product architecture, the stage-gate type product development process [3] is widely used in industry. Also in the case of our modular service product this process is recommended to be used. The modularization of the teaching strategy product means a significantly shorter lead-time of the project, because the modules can be to a certain extent developed separately from each other. This is the general benefit of the concurrent engineering. Another important benefit of the modular structure is that the next generation product has typically the development focus in one or two modules only and the other modules may remain essentially the same as in the current product. However, also in this case the module links must be considered.

At the beginning of the product development process the product cost and the project time schedule estimates are needed in order to decide if the project is to be started or not. The modular architecture of the teaching strategy makes these estimates much more reliable, because the estimates can be made module by module. Also one project can utilize the development results of the other project in the module level. The manager of the product development project has generally better control of the project.

3.2 Product variations

Several teaching strategy variations can be created or configured using optional modules. The different degree programs usually have slight differences for example in the targets and the contents of the same course. This means that the modules of one course can be efficiently utilized in another course. Also, if the courses are similar type in nature, the development results of one course can be used in other courses as well. For example the courses like statics, dynamics and strength of materials may have exactly the same modules M3…M5 and only the first two modules are different. All the three courses are analytical and so the learning methods as well as assessment methods can be the same.

The course teaching strategy needs to be formulated by the teacher separately for each course and learning environment. There are and there should be differences in the teaching strategies of the different teachers in the same university. For example selecting the most suitable learning methods depends among other things also on the teacher. One teacher may be a specialist in the traditional lectures and the other one in the learning by doing based methods. And finally, it is very important that the teaching is made skilfully whatever methods are selected. All these needed implementation variations of the same course can be made in an easier way, if the teaching strategy has the modular architecture.

Sometimes the course implementation may be different for the two student groups, because the learning styles of the students in the groups are different [4]. Then the first two modules can be exactly the same for the two course implementations and on the other hand the last three are different. This is the case for example if the students have an academic orientation in one group and a non-academic in another, see Figure 3.

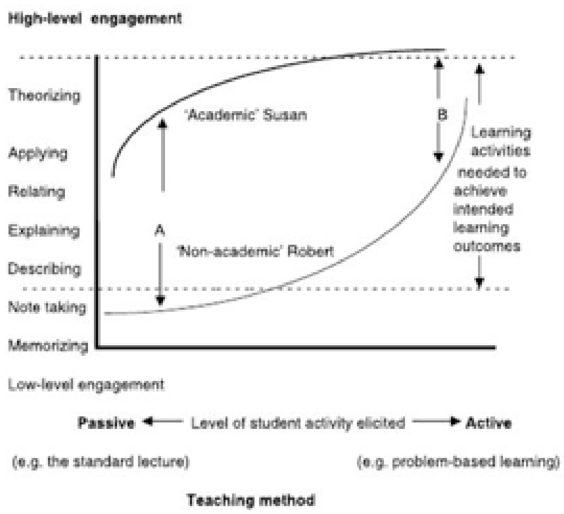

FIGURE 3. *Student orientation, teaching method and level of engagement [5].*

The methods used for learning (M3) of the non-academic student group need to be more practical (as problem-based learning) than the methods of the academic group. This way the good learning outcomes can be reached by using the two variations of the module M3.

4 APPLICATION TO A COURSE OF MACHINE ELEMENTS

This course includes material about several types of machine elements like housings, shafts, gears, bearings, springs, clutches and brakes. It also includes different types of fasteners and welded joints. After the course the students need to understand how the different machine elements are used in the products and also they need to be able to make the basic technical calculations of these elements.

The assessment results of teaching after the course implementation were positive except for the following notes:

- Operating principles of some machine elements were difficult to understand
- As a whole the course consisted of tough theory parts

Both the notes have a significant connection to the module M3 (see Figure 1). So, the teacher needs to make some modifications of this module. The other modules (targets, contents, assessments) are not to be modified. The original components of the module M3 were:

- Interactive lectures
- Technical calculations of the machine elements by the teacher and the students

Both the components are also in the modified module and the next two components are to be added:

- Hands-on models of the different machine elements to be used in the classroom
- Company visits

The descriptions of the added components still need to be done in order to have a complete specification of the modified module M3. The hands-on models include individual machine elements and one gearbox, which has a removable cover plate. The idea is to help the students understand the structures and the operating principles of the machine elements by touching and studying them. They can also disassemble and assemble the gearbox understanding thus in a deeper way the function of each machine element inside the box. The student group will visit together with the teacher a vehicle manufacturing company which uses many kinds of machine elements in their products. Before the visit the students become acquainted with the Internet pages of the company and prepare some questions to be made during the visit.

The next implementation of the course using this new module M3 with the four components is supposed to give better assessment results of teaching. The use of the hands-on models probably gives the students high learning motivation and good understanding of the course contents. The company visit shows how the machine elements are designed in the engineering department of the company.

5 CONCLUSION

The modular architecture is successfully used in the industrial products due to the important benefits it offers. The industrial companies also develop the service products which are usually connected with their physical products. Even though the modular service product architecture as a concept is uncommon, there are similar types of benefits as in the cases of physical products.

The management systems of the universities and the industrial companies are nowadays very similar. For example they both have products, customers and markets as well as the processes to manage these. The quality of teaching is one of the key success factors of the universities. It means the continuous and comprehensive development of the course offering and implementation. The idea of the paper is to use the modular product architecture for the teaching strategy of a course. This service product has been split into the five modules: Targets for learning outcomes, Contents of teaching, Methods used for learning, Learning assessment, Teaching assessment. Each module has a specific function in the product.

In addition to these five modules the complete bill of materials (BOM) includes the individual components of each module. The full specification of the teaching strategy product consists of the BOM and the detailed description of all the components.

The use of the modular architecture of the teaching strategy offers many important benefits for the product development management and makes the product variations easier and more flexible. In principle this modular product concept can be utilized in any field of sciences. However, it is most suitable to be used in the engineering education, because the teachers in the field are aware of the idea of the product modularization.

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43 ANALYSIS OF THE IMPACT OF PLACING ENGINEERING, MATHEMATICS, AND COMPUTER SCIENCE GRADUATE STUDENTS IN THE K-12 CLASSROOM

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ABSTRACT

As we approach the end of a nine-year project, K-12 Learning Partnerships: Creating Problem-Centered, Interdisciplinary Learning Environments, we reflect on the impact on the stakeholders. This paper examines the impact of the program on the graduate student fellows, specifically. Participating graduate fellows attended a two-week summer workshop with middle school (grades 6 – 8) mathematics and science teachers. In the academic year, the graduate fellows visited the middle school classrooms for 10 to 15 hours per week. These graduate fellows were also participating in either a Masters or Doctoral program in their technical departments. Forty-six graduate students have participated in the program. A survey of these students has investigated the impact of the program on these graduate students. The results show that 24% of the students are still presently in graduate school, 48% are working in their technical professions in either industry or government employment, and 28 % have entered educational careers. Those who have chosen a teaching career credit the Learning Partnership with guiding them towards that profession. These former graduate fellows teach at both the high school and college levels. Others credit the project with encouraging them to participate in educational outreach even though they have pursued technical careers.

Keywords: Graduate Students, Outreach, K-12.

1 INTRODUCTION

The National Science Foundation (NSF) in the United States has funded the GK-12 program since 1999. In this program (1), through the Directorate for Education and Human Resources, 200 projects have been funded in 140 Universities in the United States and Puerto Rico. The purpose of this NSF program is to provide fellowships and training for graduate students in science, technology, engineering, and mathematics (STEM) fields. The funding for these projects includes university faculty partial salaries, K-12 teacher stipends and graduate student fellowships plus educational expenses (fees, health insurance, books, etc). A GK-12 funded project has a budget of about $600,000 per year.

The Colorado School of Mines (CSM) has been a participant in the GK-12 NSF program from 2003 through May, 2012 (NSF – DGE-0638719 and 0231611) with a project titled: K-12 Learning Partnerships: Creating Problem-Centered, Interdisciplinary Learning Environments. CSM is a small technical university with approximately 5000 students at both the undergraduate and graduate levels. Degrees are offered from the Bachelors to Doctoral level in Engineering and Applied Sciences solely. As we approach the completion of this nine-year grant, it is important to reflect of the impact that the program has had on the various stakeholders: the university, the university faculty, the university graduate students, the K-12 school district, the K-12 teachers, and the K-12 students. A variety of papers have addressed the impact on some of the participants [2] - [6]. This paper specifically targets the impact of our GK-12 program on the graduate student fellows, especially in the long term.

2 THE CSM GK-12 PROGRAM

Our program, *K-12 Learning Partnerships: Creating Problem-Centered, Interdisciplinary Learning Environments*, targeted mathematics and science classrooms at the middle school (grades 6 – 8) level. The principle objective was to increase student knowledge of mathematics and science through hands-on experiences in earth science and engineering.

The specific goals of this initiative were:

1. To foster the cooperative efforts of a practicing teacher, university faculty, a graduate student and undergraduate student in the implementation of problem centered, interdisciplinary learning environments that focus on the application of mathematics to earth science and engineering for middle school students;
2. To enrich the teacher preparation experiences of undergraduate and graduate students who are interested in pursuing pre-college or college education as a potential career;
3. To enrich the content, application and interdisciplinary knowledge of practicing science and mathematics teachers with respect to the application of mathematics to earth science and engineering, and;
4. To enrich the learning experience of middle school students by creating problem centered, interdisciplinary learning environments that focus on the application of mathematics to earth science and engineering.

The methodology used to accomplish these goals included two major components: a summer workshop and academic year follow-up. During the summer, graduate fellows, middle school teachers, and university faculty met for a two-week period. These workshops were held to increase K-12 mathematics/science teacher knowledge and to provide training in the K-12 classroom environment for graduate students. Presentations were given by university faculty and by graduate student fellows on earth science or engineering topics that incorporated both mathematics and science information. Hands-on activities were emphasized. One example was a study of heating and cooling curves. This information was then applied to solar energy. Also, during the workshops, graduate students were paired with one or two teachers that they would continue to work with throughout the academic year. The graduate students were also presented with training in work in the middle school arena. Behavior and knowledge base of middle school students was discussed. Expectations and restrictions for the graduate students as they worked in the middle school were also presented. The second component consisted of the graduate student fellows working with teachers in the middle school classroom regularly throughout the academic year.

3 GRADUATE STUDENT FELLOW PARTICIPATION

Graduate students from the departments of Geophysical Engineering, Mathematical and Computer Sciences, and Engineering Physics as well as the Division of Engineering (Civil, Mechanical, Electrical, and Systems Engineering) at our university were eligible to apply for a GK-12 Fellowship. The application process included an essay on why the applicant wanted to be part of the program. Letters of recommendation were also required. From the pool of applicants, 5 – 10 fellows were chosen annually. The fellows began the program by participation in the two-week summer workshop. They then were supported by the program for the next two years – for both the academic semesters as well as the summer. At the end of the two-year period, fellows either graduated or returned to their technical research programs.

The actual fellowship began during the academic year. The graduate students received a fellowship to pay for their tuition, fees, and a monthly stipend. The expectation was that the graduate fellow would spend 10 – 15 hours per week in the middle school classroom during the academic. An additional 5 – 10 hours per week were spent in lesson planning and regular meetings with the cadre of GK-12 fellows and faculty. During the summer, experienced fellows were responsible for lesson planning and presentation of hands-on activities as well as mentoring new fellows. Opportunities for attending local and national conventions were given to all fellows. Preparation of presentations or professional papers was also included in summer activities. A select group of fellows were also given the opportunity for international educational experiences. Many fellows worked with their teachers in writing proposals for classroom supplies or field experiences, as well.

In the middle school classroom during the academic year, graduate fellows were technical experts for the teachers to use in a variety of ways. Often the graduate students would prepare a hands-on activity, help students who had fallen behind, or challenge the students who were ahead in the classroom. They might research a lesson topic for the teacher or help to bring in a guest speaker. They often arranged field trips to the CSM campus or other technical sights such as the National Renewable Energy Laboratory. They also served as mentors for the middle school students and as "near peers" served as role models. The graduate students were NOT student teachers, substitute teachers, or graders.

The advantages for graduate student participation included financial support of graduate studies and a gain of a classroom experience. Graduate fellows also had the opportunity to improve communication skills and team skills. They gained grant writing experience, enhanced thesis opportunities, and increased their publication and presentation experience.

4 GRADUATE STUDENT IMPACT ASSESSMENT SURVEY

In order to assess the impact of the CSM GK-12 program on the graduate student fellows, a survey was designed. Institutional Review Board (IRB) approval was also gained for Human Subjects Studies as we developed the survey. Forty-six fellows have participated in the program over nine years beginning in 2003. We were able to obtain information on present employment through the CSM Alumni Office, Department Offices, and social media such as Facebook and LinkedIn. Contact information for 40 of the 46 former fellows was obtained through the same sources. For those 40 former fellows, a survey was e-mailed through SurveyMonkey [7]. SurveyMonkey is a free on-line survey software and questionnaire tool. Figure 1 lists the opened-ended questions that were posed to them.

What was the impact of GK12 on your CSM experience?

What was the impact of GK12 on your present employment?

Has GK12 had an effect in other areas of your life?

Do you presently participate in any educational activities or educational outreach activities? Did the GK12 program have an influence on these?

FIGURE 1. *Open-ended questions to former GK-12 Graduate Fellows.*

5 SURVEY RESPONSES AND ANALYSIS

As stated earlier, 46 fellows have participated in the GK-12 program at CSM over the last nine years. Thirty of them (66 %) were male and sixteen (34%) were female. Although the percentages have varied over the nine years, the present CSM student percentages are 75% male and 25% female. Analysis of these numbers indicates that a higher percentage of females (34% compared to 25%) are drawn toward the GK-12 program. This follows national trends that females are more likely than males to participate in programs and careers seen as "care giving" [8].

Of the 46 graduate fellows, 11 (24%) are still pursuing graduate studies. Twenty-two (48%) have employment in industry or in government. The remaining 13 (28%) have employment in education either as teachers or in educational curriculum development firms. Although we do not have baseline or control information for comparison, 28% seems quite high for those with Masters or Doctoral degrees in Applied Science or in Engineering to enter the field of education.

The remainder of the data has been collected from the on-line survey. Responses, although anonymous, indicate that information was received from fellows throughout the course of the project including all nine years. Of the forty-six former fellows, direct contact information was available for forty. These forty former fellows received an e-mail inviting them to participate in the SuveryMonkey questions. Responses were received from 23 fellows. This is 50% of the total participation or 58% of those who received an e-mail. Below, the responses to each question will be discussed.

5.1 What was the impact of GK12 on your CSM experience?

The 23 responses to this question were all positive. There were some recurring topics:

Paid for graduate school – 7 responses
Helped in communication skills – 4 responses
Provided an avenue for service – 5 responses
Influenced a choice in an educational career – 7 responses
Provided a sense of community – 5 responses

To quote some of the answers:

"The GK12 program gave me a summer job and experience teaching. It helped me decide what I wanted to do and the GK12 program is why I decided to teach instead of looking for a job in industry."

"First and foremost GK12 helped me practice explaining rather complicated subjects to a broad range of audiences with drastically different understanding levels. The program also reinforced pros and cons of management styles and helped me decide how I approach managing people. The last major lesson that I learned from GK12 was the importance of clear communication and planning when working with other people."

Overall, the GK-12 experience was a positive one for all of those who responded to the survey.

5.2 What was the impact of GK12 on your present employment?

Four responded that GK-12 had no impact on current employment. Of the others the responses can be grouped into topics:

Improved communication skills – 6 responses
Improved organizational skills – 2 responses
Influenced a decision to enter teaching – 7 responses
Influenced participation in volunteer opportunities – 2 responses

Quotes include:

"The GK12 program was my foot in the door. This program is what made me decide that I wanted to teach and also what gave me the basic tools to be a good teacher. I learned classroom management, how to plan lessons, how to plan a year of curriculum. Without this program, I am sure I wouldn't be where I am today."

"One of the skills I learned during GK12 outreach was to take an abstract or advanced technical concept and develop different methods to explain it and allow a wide range of age groups to understand it. For my job, I commonly interact on projects with civil engineers, environmental engineers, structural engineers, chemists, risk assessors, regulators, managers, laypeople with no technical background, and so on. Sadly, geophysics is just a black magic to them so I have found that my GK12 experience has allowed me to communicate what we (as geophysicists) do and further their understanding and comfort level. People appear to appreciate this skill and I honestly believe it will advance my career further than any technical abilities I can bring to the organization."

Analysis shows that there was a positive influence of the GK-12 program on 83% of those who responded to the survey.

5.3 Has GK12 had an effect in other areas of your life?

Eight of the respondents (35%) said that GK-12 had not had an influence on other parts of their life. The remaining responses can again be grouped:

Non-specific but positive effect –7 responses
Influence on decision to become more involved in education – 10 responses

Quoting some of the responses:

"I do believe that the GK12 program helped positively shape my outlook regarding both math and science, as well as education. Because of this, I am strongly considering returning to school so that I may then become an educator."

"GK12 continues to help me in my current position because of the things I learned about myself and just having the experience. It has helped me with creating great communication skills both written and verbal."

The conclusion can be drawn that for a large number of participants, GK-12 influenced other parts of their life.

5.4 Do you presently participate in any educational activities or educational outreach activities? Did the GK12 program have an influence on these?

Four responses (17%) said no to the first question while 17 (74%) responded with yes. Two did not answer this part of the survey. Of those who responded with yes, all credited the GK-12 program with having an influence.

Some of these quotes were among the most interesting to the author:

"I have started to Volunteer for Big Brothers Big Sisters of Colorado and I do not believe I would have taken that on without this program. First, the program helped to give me a personal connection to under privileged neighbourhoods, schools and families who need help in many different ways. Second, it was nice to see that I could make an impact on the lives of the kids I worked with, which gave me the confidence necessary to assert my teaching style into other parts of my life, such as the BBBS program."

"Yes, I am a part of the Interactive Game Developers Special Interest Group on Games and Learning. I also am an advisor to a group at PBS Kids Interactive. GK12 had a profound influence on my current ventures as it exposed me to using technology in education and educational outreach activities."

Analysis shows that a majority of the respondents do participate in outreach activities.

6 CONCLUSION AND FUTURE OUTLOOK

In reviewing the goals of the GK-12 program at CSM, there were two goals directly relating to graduate students. One was to enrich the educational preparation experiences and other was to foster cooperative efforts. From the survey information, we can conclude that, even though these goals were written for the short term of the grant itself, that a longer-term effect has been made. With 28% of Engineering and Applied Science graduate students choosing a career in education, GK-12 has had a great influence. Perhaps the greatest influence has been the participation in outreach activities with 74% of the respondents indicating involvement. Unfortunately, baseline or comparison data are not available for either of these areas. However, the U.S. Bureau of Labor Statistics [9] shows an overall U.S. volunteer rate at 26.8 %. Our rate of 74% is almost three times that number.

Although the GK-12 NSF program has reached its conclusion, we continue similar projects. We have extended the program to include lower grade levels (K- 5) and high schools and continue to place graduate students in classrooms. We have been fortunate to receive significant funding through the Colorado Department of Education (DOE MSP program) as well as the Bechtel Foundation and Exxon Mobil Corporation for continuation. Matching funding has also been received from numerous foundations and corporations including ECA Foundation, the Denver Foundation, JP Morgan Chase Foundation, Shell Oil, Boeing Corporation, and Northrop Grumman.

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47 ISSUES OF INFRASTRUCTURE AND CAPACITY BUILDING FOR ENHANCING ENGINEERING EDUCATION IN DEVELOPING NATIONS: A FOCUS ON AFRICA

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ABSTRACT

Education in Africa suffers from issues related to the availability of infrastructure including the availability of suitable equipment. In many cases, open source tools exist that provide highly realistic computer based simulations of the experiments or equipment including network and computer devices. Computer based simulations involving multiple devices or objects may be enhanced to cover a larger domain (that is more devices) or higher resolution by running them on High Performance Computing (HPC) clusters. This paper presents a project of the International Centre for Theoretical Physics (ICTP) which was funded by the Italian Government (through UNESCO) to implement computational physics centers in sub-Saharan Africa using low cost Linux based commodity High Performance Computing (HPC) clusters.

The project was concerned with matching the right infrastructure to solving immediate scientific needs and also building local (in Africa) capacity for deploying, maintaining and using HPC clusters in a sustainable manner. The paper stresses the importance of investment in development of infrastructure which must be backed with appropriate policy and strategy for both implementation and capacity building in order to achieve enhanced engineering education.

Keywords: Simulation, HPC, Africa, sustainability.

1 INTRODUCTION

A key problem with education in emerging economies such as in Africa is the lack of adequate infrastructure. It appears that a common trend is that the policy makers and funders of institutions are more concerned with capital projects mainly building of classrooms and computer laboratories. This is probably due to a rather limited interpretation of the word ``infrastructure''. Infrastructure in education should correctly take on different (expanded) meaning, usually related to the subject matter. While for some disciplines, a simple classroom and computer laboratory is sufficient; in others it is simply not enough. For example, in electronic engineering, infrastructure would include the tools needed to create a printed circuit board (pcb), similarly infrastructure for a course on computer networking would be different from that needed for wireless networking, even though wireless networking could be viewed as a subset of computer networking. In some disciplines such as computer science, the use of structured practical hands-on experience is sometimes ignored in favour of a main theoretical (sometimes mathematical) approach.

For some of the institutions, the rather fast growth in student population led to a situation whereby the existing facilities are stretched far beyond the intended capacity. That is even if an institution started out with adequate infrastructure; poor capacity (both initial and growth) planning ensures that what is adequate today becomes in-adequate in a matter of months.

Currently there are a category of tools that could be used to reduce the impact of the lack of adequate infrastructure; these software are collectively known as simulators. For example applications such as Lab View and PSpice are capable of simulating electronic circuits. Generally simulations also exist for other physical and scientific problems in diverse disciplines such as material sciences and economics. These simulators tend to be more numeric in nature and for numerical computer based simulations; increasing the parameters can quickly lead to a situation where a single cpu is not able to handle all the required numerical computations in a timely manner. A classical example is high fidelity computer aided engineering (CAE) design, where timely results are only possible if they are run on High Performance Computing (HPC) clusters. Generally it may be said that HPC clusters are useful for resolving many variable or complex numerical problems as may be found in transportation engineering, material engineering (stress analysis and complex fluid dynamics). HPC technology is a vital enabling tool that will permit Africans to tackle African issues through simulation and modelling including local economic growth, weather and climate change, productivity, water & resource management, design and manufacturing.

2 PROJECT INTRODUCTION

The Abdus Salam International Centre for Theoretical Physics (ICTP) is located in the city of Trieste, Italy. It operates under the auspices of the UNESCO, IAEA and the Italian Government. The ICTP was founded in 1964 and works to foster the growth of advanced studies and research in physical and mathematical sciences, especially in support of excellence in developing countries. From the early 1990s, the centre identified ICT as a key tool for to end the isolated nature of scientists in developing countries. The ICT related programmes and missions are focused on supporting scientific development.

In 2009, with special funding from the Italian Government via UNESCO, the ICTP started a project focused on sub-Saharan Africa. The main areas of the project were building environmental networks and the monitoring of the environment in Africa; conducting practical training and research in basic and applied sciences including education, energy, environment and health education for Africa and developing research infrastructure for Africa, including computational physics centres. The computational physics centres will be based around the implementation of low cost Linux based commodity HPC clusters with generally less than 100 cores and a complimentary capacity building program as a way of ensuring long-term sustainability and self-reliance.

The Linux based HPC clusters are typically just a bunch of computers (even desktops) interconnected together using some fast communication device such as gigabit Ethernet or infiniband switches. Building a HPC cluster from old computers is an activity that should be part of training of engineers as it gives valuable know-how and insight into the concept of horizontal scalability for tackling large problems.

3 SUSTAINABILITY AND RESULTS

The project ran between 2009 and 2012, selection of the African partner was based on several criteria including an assurance that the HPC cluster would immediately solve a local scientific need, The first site installed was a single 80 core HPC cluster at the Addis Ababa University, Ethiopia. The cluster was immediately used for climate and weather simulation activities over the Eastern Africa region. Subsequently the cluster has been used in the training of students in building, running and maintaining HPC clusters and in 2012/2013 academic session will be used by science and engineering students of the University for numerical analysis and modelling. In 2010, a team from Addis Ababa University was instrumental in the installation of a HPC cluster for atomistic science in University of Douala, Cameroon.

4 CONCLUSION

High Performance Computing (HPC) clusters are an enabling tool that cuts across many different scientific disciplines including engineering thanks to modelling and simulation. The knowledge of building and using HPC clusters is valuable for engineering education in Africa as a way of tackling the challenges of in-adequate infrastructure and enhance the employability skills of engineering students.

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48 ENGINEERING STUDENTS' DILEMMA – WORK VS. LOAN

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ABSTRACT

The research seeks to understand why Israeli engineering students choose to finance their education by working rather than applying for readily available loans. Research results indicate several prevalent student attitudes: (1) Working during studies is detrimental to academic achievements; (2) Investment in studies and academic achievements leads to clear dividends expressed by finding rewarding employment; (3) Taking a loan is a responsible and rational step that helps students succeed in their studies, and engineering students will be able to repay the loan upon graduation when employed as engineers. Nevertheless, despite professing these attitudes, in practice only very few students in the sample (15%) actually took loans. How can this disparity between students' declared attitudes and their actual behavior be explained? Prospect Theory and Norm Theory may help to answer these questions.

Keywords: Engineering students, Loan, Financial plan, Norm Theory, Prospect Theory.

1 INTRODUCTION

In contrast to students in the UK, Continental Europe and the USA, who generally begin higher education immediately after their high school studies and usually have little to no experience living anywhere but their parents' home, most Israeli students embark on their academic studies after completing mandatory military or civil service. During this period of their life they receive a regular income, which means that they have a modicum of financial understanding [1]. Israeli students start their academic life much later than their Western counterparts. This difference in age and life experience may explain the significant difference in Israeli vs. non-Israeli students' approaches to financing their studies. Most Israeli students avoid taking loans during their studies [2], whereas students in the USA see loan-taking as the preferable way to cope with the financial costs of studies [3]. Both these populations recognize the importance of higher education. Research findings prove that higher education explains differences in earnings between those who have and do not have this education [4]. In developing countries, due to the difficulty involved in raising funds for covering the costs of higher education, gaps in earning power between academic graduates and those who lack higher education are especially significant [5]. In 2007, on average across the globe, only 25% of the national population was able to aspire to higher education. In developing countries the mean was 5-11%; in North America and Europe, the mean jumped to 70% [6]. Getting a scholarship is the best solution since tuition fees and living expenses are covered, and there is no expectation that the scholarship will have to be repaid. However, not every student earns a scholarship nor are there enough scholarships to go around. Accordingly, how should students finance their studies: work, take a loan or combine these alternatives?

Each option open to students has both advantages and disadvantages. Taking loans enables students to focus on their studies without having to find financial resources to cover living costs [1]. Repayment of loans is delayed until they finish studying, when the students join the workforce (as engineers, i.e., the students who participated in our research) and earn (significantly) more than student wages in regular work. However, the fear associated with the future need to repay loans may lead to mental stress, even to the extent of engendering suicidal thoughts [7]. In contrast, working at a job during studies makes it difficult for students to cope with academic tasks, in many cases even hampering their academic progress so that they may take longer than expected to complete their studies [3]. Does a suitable balance between these two options exist? And specifically, to what extent are Israeli students open to consider loan-taking, on the one hand, and able to estimate their future ability to repay the loan after they complete their studies, on the other hand? To what extent are the higher education institutions, financial institutions and government ministries equipped to help students financially during their studies? In order to investigate the first issue, and following an exploratory study conducted by the authors [8], a broader study examined the attitudes of students in Israel towards financing of tuition fees and living costs during academic studies, and the impact of decisions in these areas on their expected future earning ability.

1.1 The Research Questions

Engineering students' attitudes were investigated in regard to the following issues:

1. Loan-taking to cover academic fees.
2. The impact of working at a job on academic achievements.
3. The significance of academic grades when looking for work after graduating.

2 THE RESEARCH TOOL

Based on preliminary study's findings [15], a questionnaire investigating students' attitudes towards work and loan-taking during studies was constructed. The questionnaire related to five main issues: (a) loan-taking; (b) burdens and difficulties during studies; (c) implications for grades when working during studies; (d) student work as a norm; and (e) the significance of academic grades when looking for work after graduating.

The questionnaire included 30 statements, with 5-8 statements examining each issue. Participants indicated their agreement with the statements on a Likert scale of 1-5, where 1 = totally disagree and 5 = totally agree. Six experts validated the questionnaire content and only items approved by at least five members of this group were included in the final questionnaire. The reliability of the questionnaire according to Cronbach's α was 0.702. In addition to the 30 statements that related to students' attitudes, the questionnaire also included eight questions regarding students' personal details: age, year of studies, number of hours they work per week, financial support, if any, from parents, academic achievements, loans taken, if any, gender, military/national service.

2.1 Research Population

Students studying at an Israeli college answered the on-line questionnaire. As an incentive and to raise the participation levels, respondents automatically entered a raffle for a free dinner for two. 649 out of 2,500 engineering students at the college completed the questionnaire. The mean age of respondents was 25.38 years, with a standard deviation of 2.9 years. 36.3% of the respondents were women and 63.7% were men. 28.7% of the respondents were not working versus 71.3% who were working. 30.7% did not receive any financial support from their parents while the rest received parental support greater than NIS 5,000 (approximately $1,334) per annum. The distribution of the respondents' academic grades, as a measure of academic achievements, appears in Figure 1 (M=80.95, S=7.73).

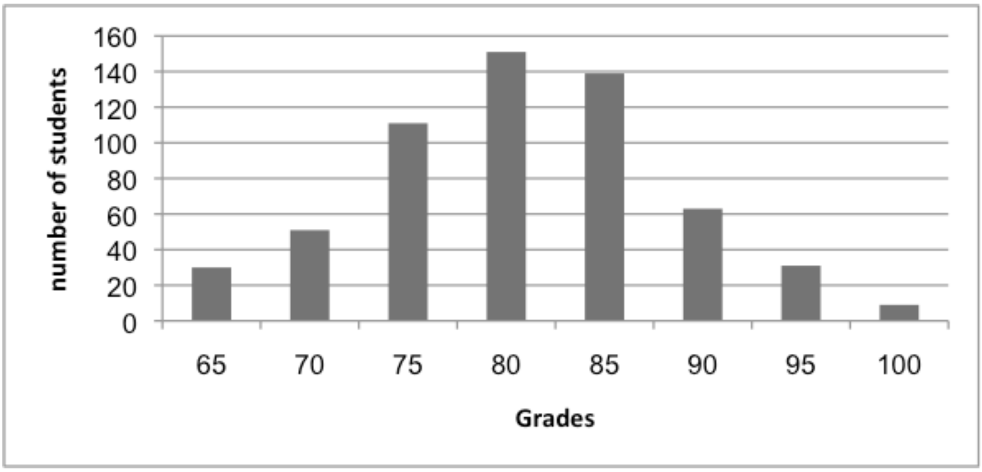

FIGURE 1. *Distribution of respondents' academic grades. Grades shown in the histogram constitute the upper limit with a differential range of 5 points, e.g., 80 indicates a range of 76-80.*

At the time when they filled out the questionnaire, 12% of respondents were at the end of their first (freshman) year, 27% at the end their second (sophomore) year, 32% at the end of their third (junior) year and 24% at the end their fourth (senior) year. 5% had extended their studies beyond fourth year. 85% of respondents had not taken loans to cover the costs of their studies and/or living expenses.

3 RESEARCH RESULTS

3.1 Loan-taking

As noted, most respondents (85%) had not taken loans to finance their engineering studies, but their actions did agree with their stated attitudes towards loan-taking. Table 1 presents the responses to the questionnaire's five statements relating to loan-taking. Table 1 also shows the mean responses of students who took and did not take loans.

TABLE 1. *Students' attitudes concerning loan-taking to finance engineering studies; the two groups' responses were compared using t-tests and the level of significance was determined by p.*

Statement No.	Statement	General mean	General SD	Mean for Loan Takers	Mean for Loan Avoiders	p
18	Taking a loan for engineering studies will help me succeed in my studies.	3.23	1.093	3.58	3.16	0.001
19	I won't have any difficulty in repaying a loan after my studies when I begin working as an engineer.	3.20	1.056	3.60	3.13	<0.001
24	I would consider taking a loan according to the accepted terms today for students.	2.87	1.187	3.51	2.77	<0.001
27	I hate to be in debt so I will not take a loan.	3.55	1.096	2.87	3.67	<0.001
30	Taking a loan is a reasonable act that creates a suitable environment for engineering studies.	2.99	1.041	3.33	2.91	0.001

The attitudes of students who took loans and those who avoided taking a loan, as reflected in their responses to Statements 20 and 21, were the same. Most students did not agree with Statement 20 that defined loan-taking as irresponsible (M=2.56, S=0.972). In regard to Statement 21, since the provision of guarantees by the educational institute is apparently likely to encourage students to take loans (M=2.85, S=0.986), students' attitudes differ somewhat. These general statements indicate that in principle, students view loan-taking as a reasonable strategy, irrespective of their personal behavior (taking/avoiding taking a loan). Questionnaire results show that students differ greatly in their responses to Statement 24, which deals with the individual's willingness to consider taking a loan. The findings indicate that resistance to taking a loan (M=2.77) is not extreme, just as support for this statement is not especially enthusiastic (M=3.51

3.2 Attitudes during studies

The annual expenses of a student in public college or university in Israel (tuition fees, rent, food, travel expenses, entertainment) are approximately NIS 35,000 (approximately $9,350). A student who does not take a loan, receive a scholarship or get help from a parent - must work. In order to cover expenses, a student will need to work 1,400 hours per annum, or approximately 30 hours per week on average in order to finance his or her studies. 39.1% of the respondents replied that they work more than 10 hours per week. Table 2, summarizing students' attitudes concerning work, shows no significant difference between the attitudes of students who work and those who do not work for four of the five statements. With regard to Statement 8 students agree that working while at college/university harms academic achievements (M=4.23, S=0.901). With regard to Statement 9, students agree that working tires them, leaving them less able to focus on their studies (M=4.08, S=0.967). Students' responses to Statement 11 show that they prefer to forego work in order to concentrate on their studies (M=4.13, S=1.143).

TABLE 2. *Comparison between attitudes of students who work and those who do not work regarding the impact of having a job on engineering studies.*

Statement No.	Statement	General mean	General SD	Mean for those who work	Mean for those who do not work	P
8	Having a job during studies harms academic achievements.	4.23	0.901	4.23	4.23	0.988
9	Working at a job means I am tired when I have to study.	4.08	0.967	4.08	4.07	0.947
11	I would prefer to concentrate on my studies and forego having a job completely.	4.13	1.143	4.05	4.33	0.015
12	Sometimes I waiver between devoting time to an academic task and going to work.	3.59	1.163	3.61	3.41	0.136
22	I work to pay my way since I have no alternative.	3.64	1.173	3.85	2.81	<0.001

The only significant difference between students who work and those who do not work appears for Statement 22 that relates to going out to work itself. While the students who work tend to agree with the claim that they go to work because they have no alternative (M=3.85, S=1.152), students who do not work, as expected, do not agree with this statement (M=2.81, S=1.364). Responses to Statement 12 reveal an interesting fact concerning students who do not work. Most students tend to agree with Statement 12 that they sometimes waiver between devoting time to an academic task and going to work (M=3.59, S=1.163). This means that even students who do not work consider going out to work, as a result of the financial constraints during college.

3.3 Success in academic studies and finding work after graduating

Following graduation, engineering students can expect to earn a higher salary than the mean national income, and in comparison to the student wage they earn in college. Data from the Central Bureau of Statistics [11] show that the mean monthly wage for a qualified engineer in 2009 was NIS 11,431 (approximately $3,053) and the mean hourly wage was NIS 67.1 (approximately $18). It is reasonable to assume that this is the mean wage that engineering students will be offered when they enter the work market. Students' attitudes concerning the link between success in their studies and their chances of finding work after graduation may influence their decision to take a loan or work during college.

TABLE 3. *Students' attitudes concerning the link between success in their studies and their chances of finding work after graduation.*

Statement No.	Statement	General mean	Standard deviation	Mean for those who work	Mean for those who do not work	P
13	My academic achievements will influence my chances of finding work.	4.48	0.732	4.50	4.46	0.624
14	Students with high academic achievements will have a higher income in the future.	3.67	1.205	3.62	3.72	0.357
15	Employers prefer hiring students with high academic achievements.	4.42	0.801	4.42	4.42	0.983
16	I believe that after my studies I will earn a suitable wage.	4.01	0.758	4.05	3.95	0.123
17	It's advisable for a student to concentrate on his or her studies in order to graduate as soon as possible.	4.17	0.910	4.20	4.09	0.185
26	I believe that I can complete my engineering studies successfully.	4.25	0.678	4.26	4.22	0.508

Students' responses to Statement 13 indicate that they all strongly agree that academic achievements are important ((M=4.48, S=0.723) and that these affect their ability to find a suitable place of employment upon graduation. This finding is supported by the responses to Statement 15: students believe that employers prefer hiring students who have high academic achievements (M=4.42, S=0.801). The students exhibit a positive attitude concerning their ability to complete their engineering studies successfully (M=4.25, S=0. 678), and according to their responses to Statement 17, aspire to shorten their period of studies. Responses to Statement 14 indicate that most students believe that graduates with high academic achievements will earn more in the future, but their support for this statement is low in comparison to their support for the other statements investigating this issue (M=3.67, S=1.205).

4 DISCUSSION AND CONCLUSIONS

The vast majority (85%) of the students in our study did not take loans to finance their studies. Prospect Theory [9] and Norm Theory [10] may help explain this action. According to Prospect theory, people tend to ascribe a larger risk to a small loss in comparison to the chance of gaining a certain profit. People avoid this risk even though the potential profit is quite large. Norm Theory suggests that students will decide to work during their studies if it seems to them that this is the accepted norm in their social circle. Despite the fact that most respondents did not take loans, their attitudes towards loan-taking were very moderate; we did not find any strong opposition to or strong support of the issue of loan-taking. Most students see loans as a way to create a more comfortable environment during their studies, one that would allow them to succeed in their studies and improve their achievements in comparison to the situation where they have to go to work. Though they recognize the advantages offered by loan-taking, most students reveal that they hate the risk involved in being in debt. The question, accordingly, is under which conditions would the participants in our study take a loan? If the terms of the loans available to students today offered lower interest to engineering students, more students would probably apply for loans to assist them financially during college. This hypothesis is based on the fact that most students assumed that they would not find it difficult to repay a loan, if they take one. Additionally, the results of a survey conducted by the Central Bureau of Statistics [11] about the period of studies and integration in the workforce, show that the average starting wage of engineering graduates is NIS 10,000 ($2,600). This salary increases to NIS 15,000 ($4000), on average, three years after graduation. On average, engineering students take 4.4 years to complete their academic requirements. Taking a student loan could improve students' learning conditions, and reduce the time they need to complete their studies. Taking a loan allows student to reduce the number of hours they need to work per week, giving them more time to study and not making it necessary to lengthen their college stay – at least as far as finances delaying their graduation. In the case student avoid from learning additional year, he could related to the loan as an investment return during the first year of working just after the graduation.

Careful planning of loan-taking and reduction of the number of work hours during their studies will help some engineering students who do not manage to complete their academic studies (35% of those who register for academic colleges) [4], and free others to focus on and improve their grades. A policy should be developed to encourage engineering students, who need loans, to consider loan-taking more positively, as an additional component for the financing of academic and living costs, alongside a limited amount of work and more scholarships. Caution is necessary to prevent situations in which students accumulate debt that they will have difficulty repaying, as happens in the USA [12]. Loan-taking should be included in follow-up studies of students' achievements during college and their ability to repay the loans after graduation [3]. If handled properly, taking a loan can help ensure that engineering students complete their academic studies by relieving them of financial anxieties both during their university years and after graduation, and ease graduates' successful professional development.

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49 ENGINEERING STUDENTS – READING HABITS AND FRAGILE KNOWLEDGE

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ABSTRACT

The study deals with the first year engineering students' perceptions of the importance of textbooks. Two worrying phenomena concerning engineering students' reading habits emerged from previous studies (a) most students rarely derive assistance from textbooks for basic courses (b) knowledge learnt in basic courses is 'fragile' knowledge that quickly dissipates. Students therefore gain little knowledge from introductory courses to prepare them for advanced courses. To overcome these phenomena, a teaching method was designed to guide students to derive regular assistance from textbooks. The method credits active reading in the final course grade. The research population comprised 34 engineering students studying a Physics course taught with the reading embedded approach. Respondents' attitudes were compared through an attitudes questionnaire administered at the course's end, with engineering students' attitudes from a previous study. Results indicated that students from the reading embedded course were helped by textbooks and thought they were very significant in contrast to students' attitudes in the previous study.

Keywords: Textbook, Engineering Students, Reading Embedded, Fragile Knowledge.

1 INTRODUCTION

Until two decades ago the textbook was one of the essential components of any basic science course. Today students are offered a variety of learning channels and most courses are accompanied by an on-line site, which usually displays presentations that were shown in the lectures, supplementary articles, video-clips, exemplary examinations etc. Studies in many world states indicate that only a small proportion of students read textbooks systematically during their studies in their first years of higher education, even if the textbook is written in their mother tongue [1].

This paper deals with the identification of special needs and preferences of a specific segment [2] - engineering students. It relates to the effect of the educational institution's teaching methods on students' ability to assimilate new learning materials. More specifically it relates to the way in which students are helped by textbooks during their studies for their introductory courses.

Student's needs and preferences are examined in light of existing teaching methods for the absorption of new materials that necessitate the student's use of textbooks. The paper therefore investigates freshman engineering students' attitudes towards textbook reading and the use of other available learning materials. It also investigates to what extent it is desirable that the textbook or learning environment should be in the global language: English, or if it should be available in the student's native language (in this case: Hebrew).

2 THEORETICAL BACKGROUND

2.1 The Status of the Textbook at the Inception of Academic Studies

Typically, Israeli students do not continue their studies in higher education institutes immediately after secondary school graduation. They only reach higher education 5-6 years after graduation, when most of the scientific knowledge and scientific thinking skills that were learnt in high school are barely accessible and need revision when beginning academic studies. This phenomenon is also prevalent in the USA where, in 2006, out of 17 million students who registered for higher education, only 18% began their studies immediately after secondary school, and more than 58% began academic studies after the age of 22[3]. A study conducted by Bruning [4] found that in their first year of higher education students find it difficult to read textbooks, since most of them do not have the necessary skills to organize and understand the ideas and terminology that appear in these books.

In basic science courses, an immense amount of material is learnt, and it is insufficient to memorise it. Students are also required to employ scientific thinking and need to be able to abstract, in contrast to the intuitive thinking demanded in daily living [5]. For many students the heavy load of their studies reduces their ability to learn meaningfully [6]. For some students their independent learning time is cut back even further because they need to work to subsidise their studies. The result is that most students focus on obligatory tasks and exercises, and very rarely, devote time to reading that would help them to understand scientific theory and its constituent concepts. Their attention is directed to completion of regular assignments and they are left with little time for academic debate concerning the scientific culture for which they are being trained [7].

The way in which students understand the importance of textbooks is connected, inter alia, to the lecturers' approach. Many lecturers prefer an expansive approach that does not allow the course's reading requirements to be reduced to a single textbook, which contains the complete explanation of subjects to be presented during the course [8]. Other lecturers take an approach that concentrates on a single textbook, directing students to read specific chapters before each lesson and integrating selected issues from the chosen textbook within their lectures, although additional textbooks appear in the syllabus bibliography [8].

Research indicates that the lecturer's set of expectations regarding academic learning differ from those of the students [9]. This discrepancy also exists with regard to the textbook use. While many lecturers expect that students will read chapters from the textbooks on their own initiative in order to deepen their understanding of the lecture subjects, the students only turn to textbooks when they need to cope with a task, which could not be answered after studying the notes that they wrote down in the lecture or from the lecturer's presentations [7, 10]. Research has found that students who received specific reading instructions regarding learning material that would be discussed in the next lecture, and were also tested on the learning material before the lecture, tended to study the textbooks more than students whose lecturer simply noted the textbooks at the beginning of the course. The difference in expectations of lecturers and students also relates to the language in which textbooks are written. The development of computerised learning has led to the development of electronic books, including all the features of a printed book but in an on-line version. Students' perceptions regarding the use of electronic books were examined by Noorhidawati and Gibb [11]. Their findings indicated that there are three ways in which electronic books are studied: searching for data and facts, finding relevant contents and broad reading of the learning material. Most of the students did not refer to electronic books for broad reading of the learning material but mainly used them to search for specific relevant information.

2.2 The Influence of Globalisation on Learning Language

Many lecturers believe that students who join the scientific community should converse in its language. The scientific community has created a language abundant with concepts, theories and assumptions on which scientific dialogue revolves. In addition, the scientific community has chosen English as the language for international communication. Students should therefore be exposed to and recognise this language from the initial stages of their academic studies [12].

Because of the difficulty involved in learning in a language other than the student's mother tongue, a bilingual teaching style is engendered in which there is a certain level of integration between the mother tongue and the second language. A study that investigated teaching that combined a native tongue with a foreign language [13] examined the perceptions of Arab chemistry teachers in Israel concerning bi-lingual teaching. The research findings related to three levels of bilingual teaching: (a) a combination of learning materials written in Hebrew while the teaching was conducted solely in Arabic (students' native tongue) (b) a combination of both languages throughout the teaching process (Hebrew and Arabic) (c) Writing scientific terms in Hebrew alongside the written term in Arabic. Each level had its advantages and disadvantages both from the viewpoint of the teacher and that of the student.

2.3 Reading embedded course

In order to cope with the engineering students' 'fragile knowledge' [13] a teaching approach was developed that integrated textbook reading within the teaching process. In this reading embedded course, the lecturer stressed the importance of reading the course text book, through the following activities: (a) referring the student to the relevant chapter in each lecture, (b) conducting short reading tests (3) crediting reading text in the final grade for the course, (4) including a question that resembles a question that appeared in the course book in the final examination. These activities aimed to reinforce the 'fragile knowledge' formed by most students in a typical basic academic course.

3 THE RESEARCH PROCEDURE

This study investigated the attitudes of 34 engineering students towards the use of textbooks. The students' average age was 33 years. Most of the study participants had a technician's certificate, having graduated as technicians 5-10 years before starting engineering studies. Given the conclusions from previous studies [14] regarding engineering students' reading habits in Israel, the special physics' course textbooks had been translated into Hebrew. The attitudes of students who studied this reading embedded course are presented in comparison with attitudes of 134 students in regular courses in an engineering college presented in a previous study [14]. The purpose of the present study was to examine the attitudes of students in the reading embedded course towards textbooks with reference to the following subjects:

1. To what extent were the students assisted by the textbooks?
2. To what extent was the connection between the textbook and the material studied in class clear to the students?
3. To what extent did the students think that the textbook was significant for the course studies?

The research employed a questionnaire dealing with the reading of textbooks for physics studies that had been developed in a previous study [14]. The questionnaire included 21 questions relating to the following subjects (a) reading habits before beginning academic studies, (b) reading habits during academic studies, (c) purposes for textbook reading, (d) the importance of the language in which the book is written (English or native language) (f) the importance of the textbook during the course. The subjects were presented in the form of statements that the students graded on a Likert scales of 1-definitely disagree to 5 - definitely agree. At this paper we will present some findings, at the next chapter.

4 RESEARCH FINDINGS

4.1 Extent of Textbook Reading during Academic Studies

The distribution of the students' extent of textbook reading in preparation for course lectures appears in Figure 1. These results were obtained in answer to Question 4: To what extent do you study the textbooks that you possess before lectures in the different courses?

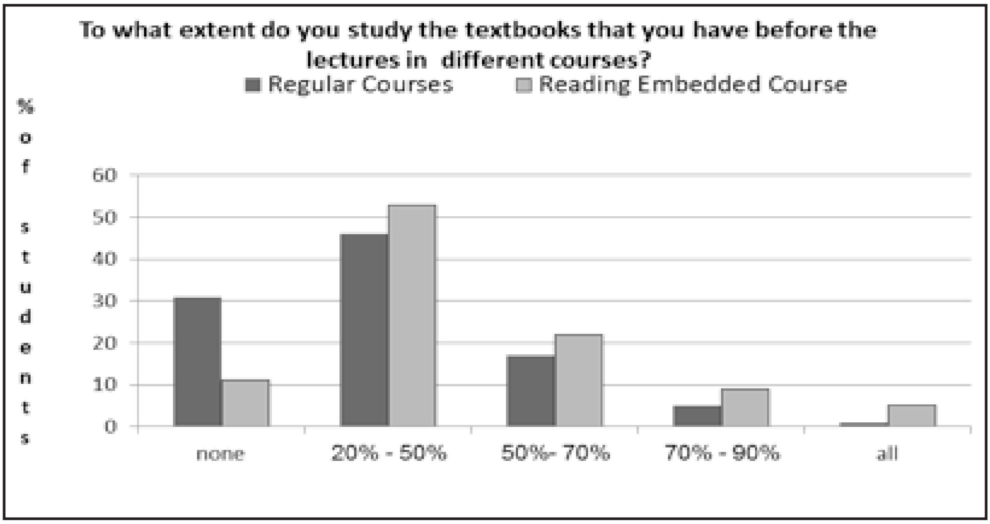

FIGURE 1. *Distribution of Students' Textbook Reading before Lectures.*

The results indicate a significant difference in the average level of reading before the lectures between the reading embedded course students (M=2.31, S=0.801) and the other engineering college students (M=1.56, S=1.128) that was mirrored in the t-test (T=1.839, P<0.05). The reading embedded course students read slightly more than the other college students. 11% of the reading embedded course students and 31% of the college students did not read textbooks at all before the lectures.

4.2 Comprehension of reading instructions

One of the problems stemming from 'fragile knowledge' relates to the students' ability to absorb subjects studied in the course in relation to previously accumulated knowledge. In many cases subjects studied in the course remain disconnected from previous knowledge. This makes it difficult for the student to construct consistent knowledge. The physics course book positions the subject studied in the course lesson within the context of a particular chapter and the chapters are arranged in a logical sequence to help the student to form consistent knowledge. Question 7 examined to what extent the students knew which chapters they had to study in preparation for the lecture. Figure 2 below compares responses to this question from the students in the special reading embedded course with responses from the engineering college students from previous study [14].

A significant difference was found between the two groups of students regarding instructions of textbook reading (T=2.87, P<0.01). In the reading embedded physics course the students' position is higher (M=3.47, S=1.552) compare the other college (M=2.49, S=1.147). It seems that reading instructions in the physics course encouraged the students to refer to the textbook, helping to form the links between the components of the course: lectures, recitations, lab and practicing.

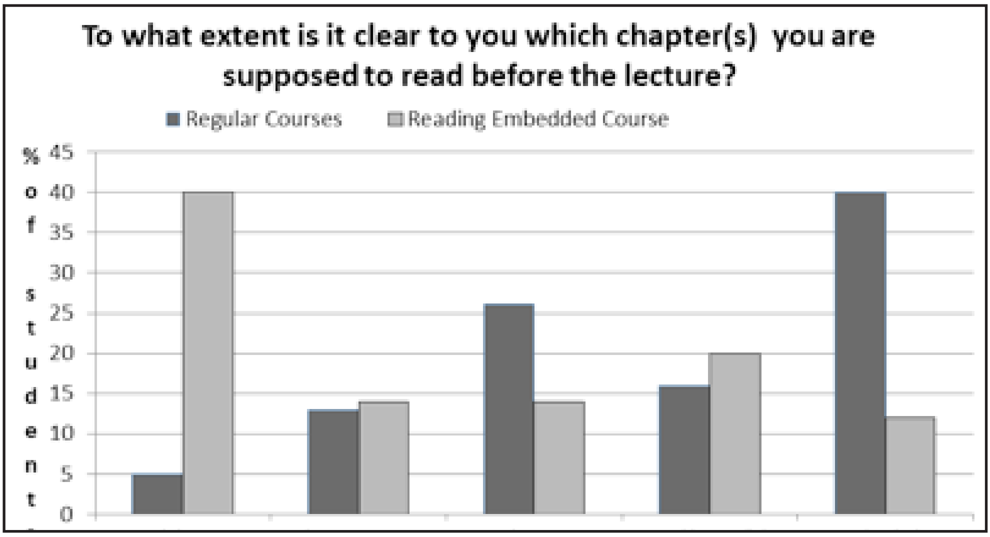

FIGURE 2. *Distribution of students' responses concerning the clarity of reading instructions. The higher rank is getting reading directions each lecture, the lower rank is getting only textbooks list at the syllabus.*

4.3 The Contribution of Textbook Reading

Textbooks were meticulously prepared to help students to understand the studied subjects, constructing links between theoretical subjects studied in the course and practical and applicable aspects relating to daily life. Yet, to what extent did the students think that the textbook was significant for their learning? Students were therefore asked: to what extent does textbook reading contribute to comprehension of the subjects learnt in the course? The responses of the students in the special physics course are compared with responses from the engineering college students in Figure 3 below.

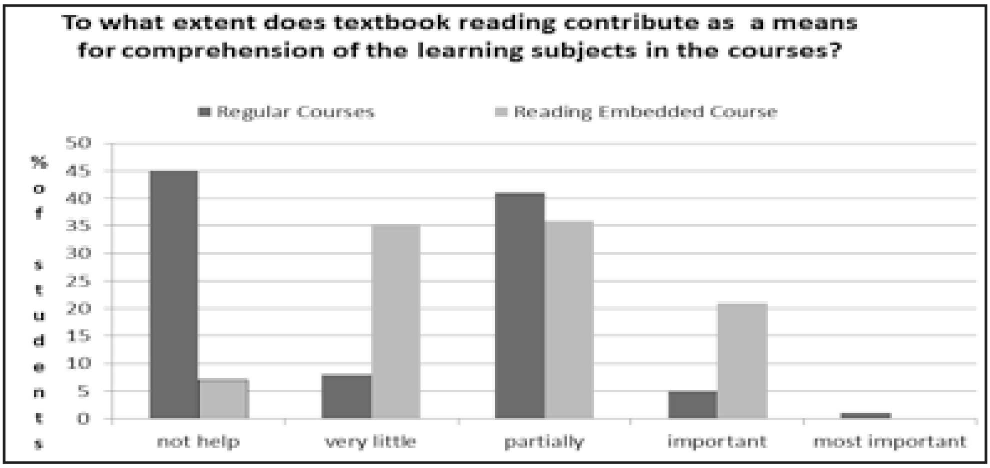

FIGURE 3. *Distribution of students' responses concerning the contribution of textbooks to learning.*

Comparison of responses of students (in Figure 3 above) indicated a significant difference between the attitudes of the two groups of students ($M=3.29$, $S=0.914$ for the reading embedded course and $M=2.67$, $S=0.995$ for the regular courses) concerning the perceived importance of textbooks for the studied course. According to the t-test ($T=2.21$, $P<0.05$) students in the reading embedded physics course had a far higher estimation of textbooks' contribution to their comprehension of the studied subject.

5 CONCLUSIONS

Findings of our previous study [14] showed that first year engineering students in Israel attribute relatively little importance to textbook reading. This corresponds with findings in other countries [15]. Three reasons for this situation were identified: (a) the serious burden imposed on freshman students, (b) most textbooks are written in English, a foreign language that makes it difficult for most students to gain assistance from them, (c) the lecturers rarely mention or refer students to the textbooks in lectures or tasks. In order to improve this situation, textbooks were translated into the students' native language for a special physics course and a reading-directed teaching strategy was adopted. This study examined the influence of these two alterations on engineering students' attitudes regarding the importance of textbooks for their physics course. Three conclusions were deduced concerning the effect of the reading–directed course:

1. Students studying the reading embedded course were more strongly inclined to refer to the course textbooks in preparation for and after the lectures in comparison to students in regular courses.
2. Students in the reading embedded course found it clearer to understand which chapters of the textbooks they should read in comparison to the students in regular courses.
3. Students in the reading embedded course thought that the textbook was an important component of the learning process.

The limitations of this study stem from the small number of participants, 34 students in only one reading embedded course. Additionally the study only examined the extent of importance that the students attributed to the course textbooks. There was no examination of other aspects relating to the learning process such as: learning achievements resulting from the special course, or consistency of knowledge as a result of the special course. These points need further study with larger populations and in other disciplines beyond those studied here.

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50 ENHANCING CULTURAL AWARENESS AND MOBILITY BETWEEN JAPAN AND FINLAND

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ABSTRACT

In global working life skills, experiences and awareness of different cultures and countries are valuable and essential. There is a need of knowledge of different market areas and their cultures, international business competence and language skills. The role and responsibility of higher education institutes is to create international networks and partnerships that enable and strengthen cultural and international competences for the students and staff. Turku University of Applied Sciences and Sendai National College of Technology started active co-operation in 2008. During 2008–2012, almost 100 staff and student exchanges and visits have been carried out. During these five years a strong trusting and understanding relationship has been built. The needs and special requirements can be openly discussed and solved. Altogether our collaboration has been very fruitful and successful. Based on our positive experiences we have created a larger network of higher education institutes between Finland and Japan. An agreement encompassing eight institutes was completed in February 2012. In this paper, we will introduce the international collaboration between Turku and Sendai in detail. We will discuss the challenges as well as successes and exemplify practical experiences of this kind of collaboration.

Keywords: Mobility, Cultural awareness, Japan, Finland.

1 INTRODUCTION

In global working life skills, experiences and awareness of different cultures and countries are valuable and essential. The workplace environment and duties will become increasingly international for everybody [1]. Global skills are a natural part of any business in the future and there is a need for knowledge of different market areas and their cultures, international business competence and language skills [1, 2]. The qualities we are required to acquire are respect for others, knowledge of other cultures and versatile interpersonal skills to promote a genuine dialogue and argumentation [3, 4].

The challenges of globalization are reflected in engineering education too. In addition to technical knowledge, future engineers are expected to have other versatile skills and knowledge such as good language, communication and interaction skills [4, 5]. Furthermore, international working life requires that engineers also have diverse cultural competence [5]. The international skills can be learned in traditional courses, in student exchanges abroad and working with foreign students in their own higher education institute (HEI).

Altogether the role of the HEI is emphasized in creating international networks and partnerships that enable and strengthen cultural and international competences for the students and staff. The HEIs should provide the competence to work in an international environment. Despite the progress in international activities, internationalization is still one of the key challenges in Finnish higher education [5]. In Japan, the international activities are even newer and work has to be done in promoting international activities.

International co-operation has been scattered, impressiveness has been low and resources have been wasted [2]. It is time to create strategic alliances and network with key partners in focus areas. Internationally networked higher education institutions support internationalization, competitiveness and well-being of society [2, 5]. The networking is highly important, as by international networking HEIs consolidate the development potential of their region, their overall competence level, available resources, competitiveness and innovation ability as well as make business life in the region more varied. Furthermore, we can improve the quality of education and support international activities of the students with the international experience and connections of the staff. [5]

Mobility is one of the key tools to promote students' internationalization skills [2, 6]. Students' language skills, understanding of the cultures and societies improve while studying and working abroad [5]. For many skilled students the incentive to gain international experience as part of their studies has been the internationalization of labor markets [7]. As a natural follow-up of mobility activities, HEIs have activated in providing language and culture education on the target countries to support the co-operation possibilities [2]. Still, HEIs can significantly increase language and cultural competence for practical needs all across the society [8].

In this paper, we will show how Turku University of Applied Sciences (TUAS) (Finland) and Sendai National College of Technology (SNCT) (Japan) have worked together to answer the challenges described above. In the next section, we will introduce the HEIs and describe the co-operation in general. Then we will describe the phases of our co-operation. Finally, we will discuss our experiences and give conclusions.

2 CO-OPERATION BETWEEN TUAS AND SNCT

The importance of international aspects in higher education is recognized in Finland and Japan by the Ministries of Education. In Finland, internationalization has long been one of the focus areas in the higher education policy [5]. In practice, part of the HEI funding has been connected with the international activities of the HEIs such as mobility [2]. In Japan, the Ministry has encouraged Japanese HEIs to activate in international relations. Supported by both Finnish and Japanese governments, Turku University of Applied Sciences and Sendai National College of Technology started active co-operation in 2008. The co-operation agreement emphasized the following activities:

a) Exchange of the faculty staff and students
b) Exchange of information and achievements related to education and research
c) Other programs agreed on through consultations between the two institutions.

2.1 Turku University of Applied Sciences (TUAS)

The Finnish higher education system is made up of two parallel sectors (Figure 1): Universities and Universities of Applied Sciences. The basic purpose of Universities is to perform scientific research and to provide higher education connected with it. The Universities of Applied Sciences are usually regional higher education institutions providing higher professional education with a close connection to working life.

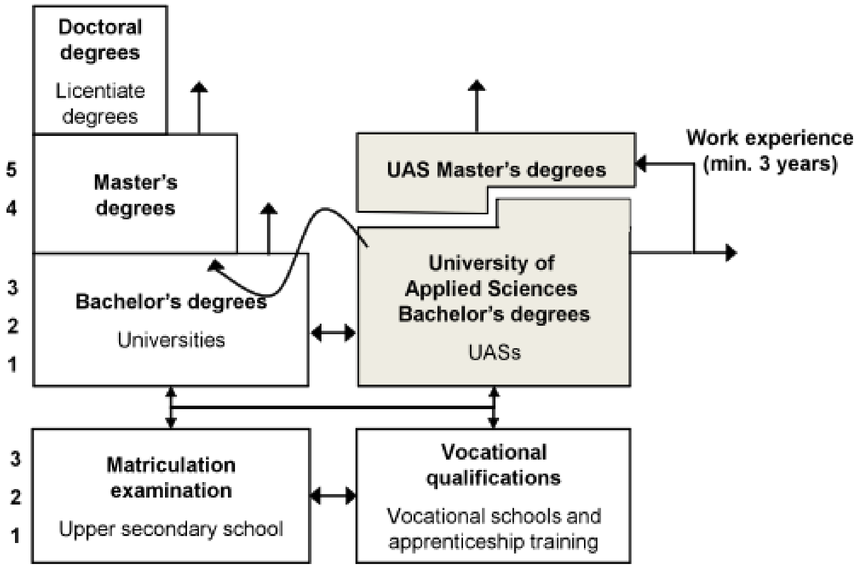

FIGURE 1. *Education system in Finland.*

Turku University of Applied Sciences is a multi-branch educational community of some 9,000 students and 750 experts. TUAS is one of the largest of its kind in Finland. TUAS arranges education in almost 40 Degree Programs in Bachelor's or Master's level in seven different educational fields. We offer education that develops working life and entrepreneurship, research and development services (R&D) and holistic development of organizations. Our main goal is to work in close co-operation with our region and to answer to the requirements of working life. The University is organized in six faculties that promote multidisciplinary learning. Engineering education is arranged in three faculties: the Faculty of Telecommunication and e-Business, the Faculty of Technology, Environment, and Business and the Faculty of Life Sciences and Business. The Faculty of Telecommunication and e-Business has been the driving force of collaboration with Sendai National College of Technology, but recently the other engineering faculties have also activated in this collaboration.

2.2 Sendai National College of Technology (SNCT)

KOSEN (Colleges of Technology) offer five-year engineering education for students from 15 years of age. They were established in 1961, in response to a strong demand from the industrial sector to foster engineers who sustained the high Japanese economic growth at that time, and a two-year advanced course system was introduced in 1991 (Figure 2). KOSEN's curriculum emphasizes not only learning in theory but also practical training such as project-based learning and internship programs in cooperation with local companies. In October 2009, two national colleges of technology in the Miyagi Prefecture merged into Sendai National College of Technology as a Super KOSEN with two campuses: Natori and Hirose. Approximately 1,750 students study and 140 experts support them in SNCT. SNCT's educational objective is to produce engineers with a strong sense of humanity and a creative mind who contribute to a sustainable society. SNCT offers seven standard five-year courses and two advanced courses. Both advanced courses have been accredited by the Japan Accreditation Board for Engineering Education (JABEE) as qualified engineering education programs and internationally accepted through the Washington accord. The Hirose campus covers the Information and Electronics fields and has been promoting strong collaboration with TUAS and Helsinki Metropolia University of Applied Sciences (HMUAS), but recently also Natori campus and other KOSEN in the Tohoku region and in Hokkaido have activated in this collaboration [9, 10]. Student exchanges in various fields are expected as a result of collaborating closely with these institutions.

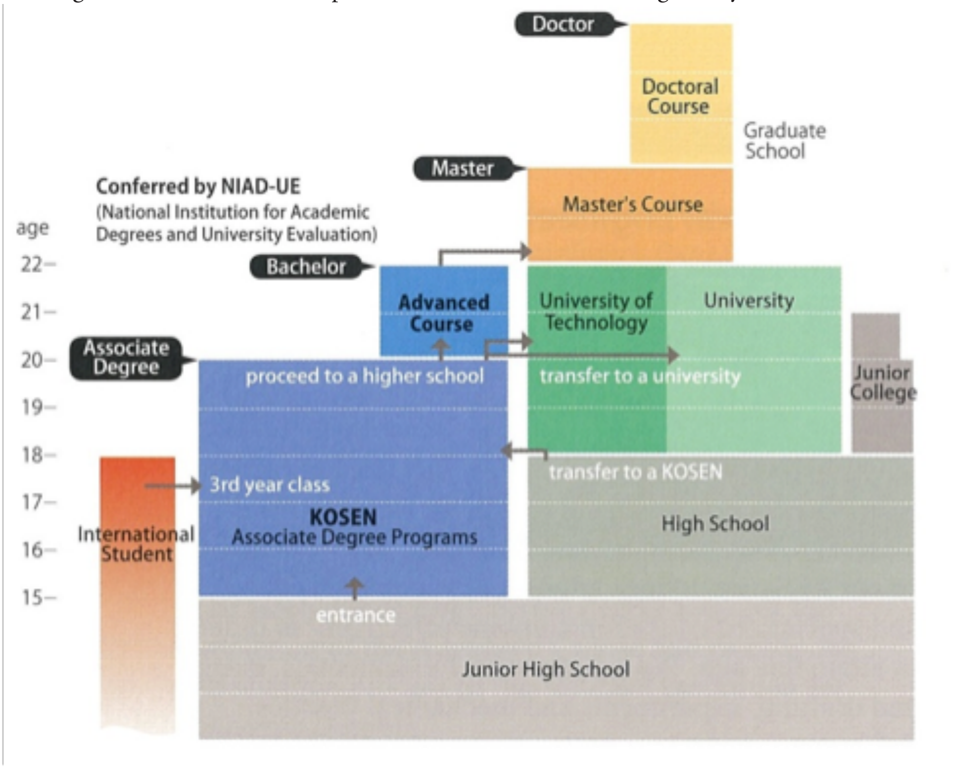

FIGURE 2. *Education system in Japan.*

3 PHASES OF THE CO-OPERATION

The co-operation between TUAS and SNCT has developed traditionally (Figure 3). In the beginning the focus was on creating a relationship and building trust between the institutes. The aim was to establish and create strong links between the key persons in both institutes. At this phase several administrative visits occurred and a number of meetings were held. The agenda of the meetings typically focused on introducing the institutes and the education systems of both countries. These meetings also served as planning stages for the next phases. Many discussions on teacher and student exchanges and practical issues related to those were held. After administrative visits, the first teacher and student exchanges started. During 2008–2012, almost 100 staff and student exchanges and visits have been carried out.

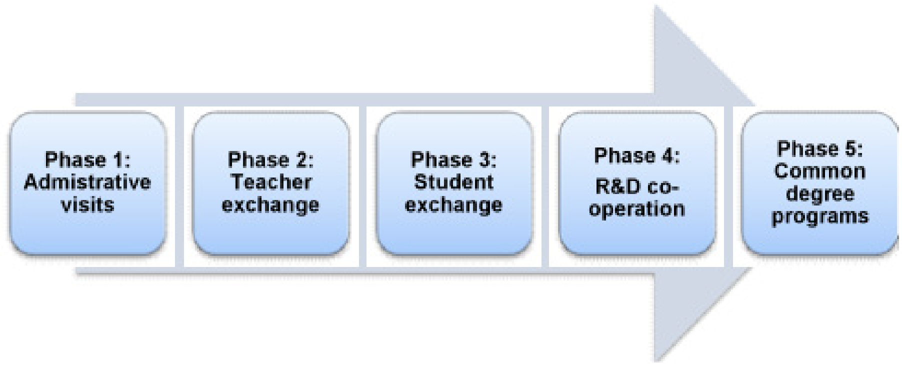

FIGURE 3. *Co-operation phases.*

At first teacher exchanges were short one-week visits. During that time the teachers normally had 3 to 4 lectures, one of which usually focused on their own country and culture. Furthermore, general knowledge about studying in their institute was given. In addition to teaching, the teachers had time for networking with the local staff – the idea was also to create personal relations and trust in the personnel level. The teacher exchanges have emphasized topics such as embedded software and health informatics. We have had some longer teacher exchanges as well. These long exchanges have provided a possibility to lecture for longer periods of time and to create even deeper understanding between the institutes and personnel. Altogether 53 staff exchanges have realized since 2008 (Table 1).

TABLE 1. *Number of staff and student exchanges.*

	Staff exchanges		*Student exchanges*	
	Finland to Japan	*Japan to Finland*	*Finland to Japan*	*Japan to Finland*
2008		4		
2009	6	4		3
2010	7	3	6	8
2011	6	7	0	7
2012	8	7	14	8
Total	27	25	20	26

Once the ground had been built by the administrative and teacher exchanges we started student exchanges. Since the beginning of the co-operation, 46 students have participated in the exchange programs (Table 1). This number could be even higher without the disaster in the Sendai region early 2011. Student exchanges have focused on learning the culture and on research and development activities in laboratory projects.

The exchanges of the Finnish students had lasted a maximum of 90 days, since that is the Visa-free duration of a foreigner visit. The 90 days also fulfills the requirement of the student exchange length set by the Ministry of Education and Culture in Finland. This period is also suitable for the content that was planned earlier. The Finnish exchange students work mainly in the laboratories of the hosting institute and this work is credited as part of their work placement (15 cr). In addition to the work in the laboratories, Finnish students study Japanese language and culture in the host institute. The students joining these exchanges have typically been in their third academic year.

The length of student exchanges of Japanese students had varied from one month to six months. Usually the students from the Advanced Course level have stayed in Turku for a month. On the other hand, students from the associate level have usually stayed six months in Turku. The Japanese students have also been located or associated with a suitable laboratory and a named tutor teacher. The exchange of Japanese students has been based on their own projects that they have continued in our laboratories supported by the tutor teacher. In addition, the Japanese exchange students have studied Finnish language and culture.

The first three phases focused on mobility – making staff and students move from one country to another. In the next phase, the focus changes to co-operation in research and development. R&D topics have been discussed several times during staff exchanges, but somehow the co-operation has not started yet. The newest idea to activate common R&D activities is to arrange a workshop where institutes' R&D activities are introduced and connected. The fifth phase aims at common degree programs. So far no discussions about common degree programs have been carried out.

4 DISCUSSION

The co-operation between TUAS and SNCT has been successful. The number of international activities is high and both partners are very satisfied with the co-operation. Still, our co-operation has had some challenges which we have had to overcome.

First, one big challenge is the language. Finnish students do not usually speak Japanese, but can manage with English. On the other hand, Japanese students do not speak Finnish and English is often difficult to them too. Of course there are exceptions, such as Finnish students who are fluent in Japanese, and also Japanese students who are fluent in the English language. Still, the challenge is recognized and some emphasis has been placed on the language abilities of the exchange students. In Finland, a new Japanese language and culture course (6 cr) has been introduced and it is mandatory for all students going to Japan for student exchange. The Japanese language courses have also been offered to Finnish students earlier, but since spring

2012 it has been mandatory. These language and culture studies are part of strengthening the prerequisites for the co-operation as mentioned in [2].

Second, the academic year and the timing of semesters are different in Finland and Japan (Figure 4). The different timing of semesters has added additional aspects on timing the student exchanges. Finnish students have normally started their exchange in the beginning of the Japanese semester 1. This has been a very suitable time because in their curriculum in Finland, the work placement period was placed at the same time. Japanese students that stay for six months in Finland have usually come to Finland in the beginning of the Finnish semester 1. In practice they have finished their semester break shortly and travelled to Finland. The shorter exchanges of Japanese students have happened in spring, in the Finnish semester 2.

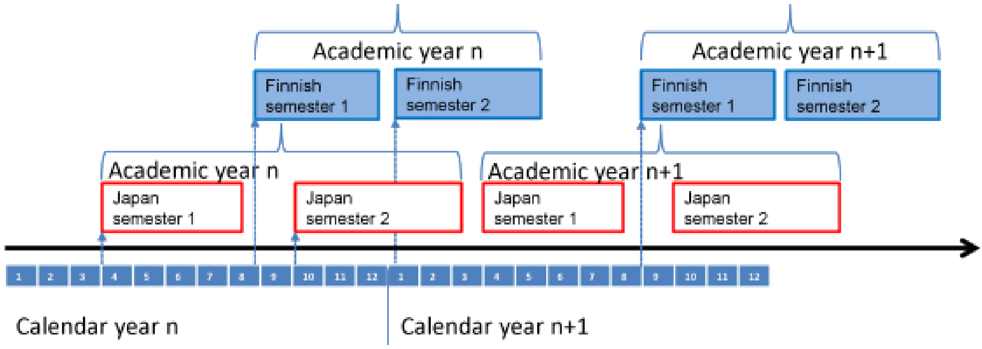

FIGURE 4. *Comparison of academic years.*

Third, student accommodation has been challenging, too. In Finland, the accommodation has been quite easy to arrange for students staying the whole semester. The accommodation has been arranged in the Student Village in Turku. However, more negotiations and arrangements are needed for the shorter exchanges. So far we have been successful with the accommodation arrangements, but we have kept this in our minds, because accommodation is an essential part of the exchange. In Japan, the Finnish students have been offered accommodation in student dormitories in the campus. The challenge in Japan has been the limited number of rooms especially when many exchange students are in Japan at the same time. Anyway, the housing of students has been managed at least satisfactorily.

Fourth, as the number of students and staff exchanges is increasing, it becomes essential to enlarge the network of HEIs active in these processes. In 2011, we started discussions on joining six national colleges of technologies from North Japan and two Finnish universities of applied sciences to one common co-operation agreement. An agreement with these eight HEIs was signed in February 2012. This agreement defines more precisely the number of student exchanges and the process of student exchanges. Furthermore, it identifies the need of certain language skills of the exchange students.

Fifth, the exchanges have focused on engineering students only. This limitation to engineering has been understandable, because engineering is the only field of education in Sendai National College of Technology. However, the faculties of TUAS are more versatile with different fields of education and many times, for example, business students have asked for exchange possibilities in Japan too.

5 CONCLUSIONS

During these five years a strong trusting and understanding relationship has been built. The needs and special requirements can be openly discussed and solved. We have been successful in the three first co-operation phases and are gradually moving to the R&D co-operation phase as well. Within the new network of eight HEIs, we are organizing a R&D workshop in Japan next October. The aim of this workshop is to disseminate the R&D activities of each HEI and to initiate co-operation in R&D.

The cultural awareness of Finland and Japan has remarkably increased since 2008. A large number of staff and students have participated in various presentations and meetings with the foreign partner. The almost 100 exchanges and visits have provided possibilities for own experiences on the foreign culture and the understanding of the other country has improved.

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51 VIRTUAL DEVELOPMENT LAB: CONCEPT, IMPLEMENTATION, EVALUATION

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ABSTRACT

Virtual Lab is a computer simulation which enables essential functions of laboratory experiments to be carried out on a computer. In recent years VL have emerged on the internet. Shortage of young well-trained engineers and a wish to share the industrial experience that the author has accumulated over a decade has led author to teach satellite navigation at a University whilst simultaneously leading an industrial R & D team. Author developed the Virtual Lab to provide students with hands-on experience in satellite navigation. It was reported earlier that VL has only partly bridged the gap between the University training and the needs of industry. An extension of the VL to the virtual development lab (VDL) allows the requirements of industry to be fully addressed. The paper introduces a concept of VDL. VDL is defined as a web-based platform which assists learning by enabling the whole development cycle (design, development, verification) to be conducted in a controlled environment which is similar to industrial one. VDL combines ease of use with real life task setting, thus allowing a student to focus on the essentials of the engineering task. The paper provides practical advice for VDL realization and discusses the results of the use of a virtual lab in University. It is shown that reality met the expectations. A gap between the university training and the needs of industry is bridged by the hands-on development experience obtained with VDL.

Keywords: Virtual Lab, Virtual Development Lab, satellite navigation.

1 MOTIVATION

Satellite navigation attracts a lot of interest these days, as it is an emerging and rapidly growing technology. This interest not only generates a stream of university students who wish to learn about satellite navigation, but also stimulates a growing market for professional and corporate education. Even a simple internet search brings up a list of dozens of universities (including the most prominent ones) offering courses on satellite navigation as well as copious relevant educational internet resources.

At the same time, the R & D office employing the author had been suffering from a lack of qualified graduates. The supply from Russian universities, once amongst the best in the world, did not meet modern industrial requirements. When the situation became business critical, author joined Saint Petersburg State University of Aerospace Instrumentation (SUAI) as an associate professor in order to share the industrial experience he had accumulated in over a decade and bring satellite navigation education up to the requirements of industry.

2 TASK SETTING

To specify the requirements for the course under development we reviewed some of the freely available and commercial education materials on satellite navigation, detail review results are given in [2]. Based on the gap between the university training and industry's needs the R & D center had been observing last years, we determined two major problems to be addressed. First of all, stress should be not only on technology applications, but also on the development of the user equipment, and the guidance should be provided on the application design and development. Secondly, the focus should be shifted from navigation processing to signal processing. This feature is explained by the fact that the course under development had an emphasis on digital signal processing (DSP); and the shortage in industrial R&D was in DSP engineers. The last but not least aspect to mention was the financial constraints typical for a Russian University - the procurement of even simple lab equipment was out of question.

3 VIRTUAL LAB – A BASIS AND A PREDECESSOR OF VDL

The task setting from the previous the above made the use of a virtual lab (VL) very reasonable. Virtual Lab (VL) is a computer simulation which enables essential functions of laboratory experiments to be carried out on a computer [1]. In [2] one can find a detail description of the VL implemented by the author as a web-site using web technology. We give only a short description of the implemented VL required for understanding of VDL concept and implementation.

The educational approach behind the VL involves self-directed learning with minimal tutorial assistance. The role of the tutor is limited to VL support and maintenance, the provision of an initial tutorial on each lab and answering unexpected questions (if any).

VL uses client-server architecture. Modern Web technologies enable a fully functional animated GUI without installation of any proprietary software. GUI is implemented using W3C standard elements only. All the software used in VL is license free. It makes the ownership and maintenance costs of VL nearly zero, as only server hosting is required.

Figure 1 shows an example of the GUI and the web technologies that have been used.

The VL currently includes four lab assignments that explore various aspects of GPS technology. Each of the lab assignments is a computer simulation of a specific aspect of the technology. Experiments made with every lab are repeatable. Many 'what-if' learning scenarios were created

The results obtained in the application of the VL are given in [2] and can be summarized in one sentence. Although a higher level of graduates' conformity to the industrial requirements was achieved, a gap between the university training and industry's needs still existed. The developed VL did not supply hands-on experience with the actual development projects and did not bring fragmented knowledge into a system through a practical development exercise.

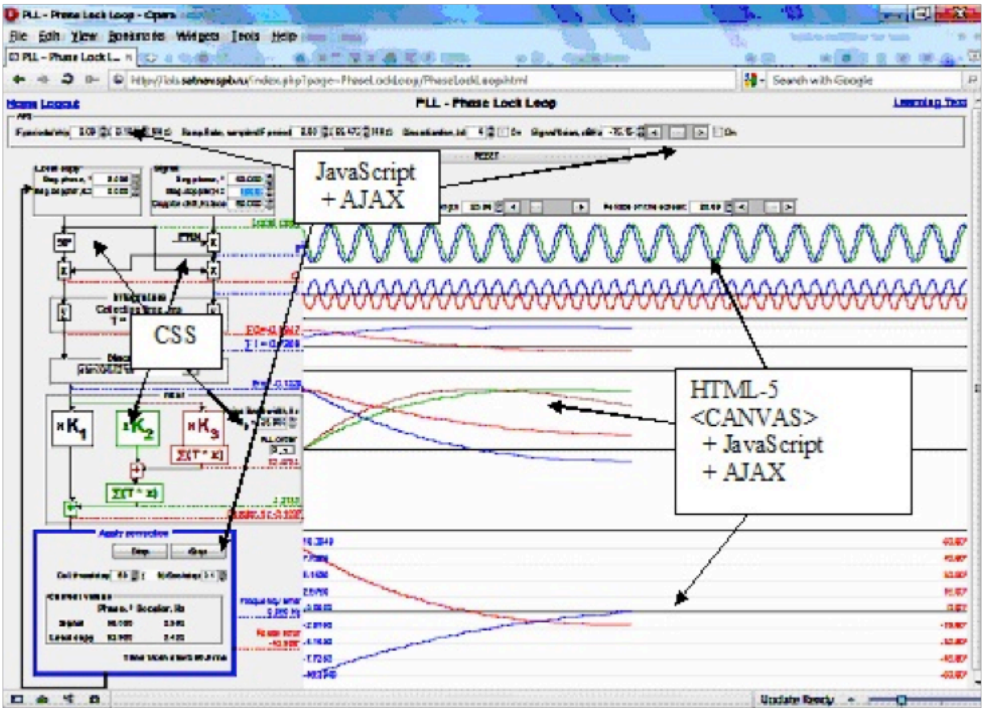

FIGURE 1. *Example of GUI with web technologies used.*

In order to bridge university-industry gap and to satisfy the requirements industry poses on the graduates, it was necessary to invent a computer-based platform that not only provided virtual experiments like a VL, but also enabled learning by doing, i.e. by incorporating the whole development cycle (design/development/verification) in a controlled situation which was similar to the industrial environment. We call such a platform Virtual Development Lab (VDL).

4 VDL CONCEPT

The educational concept for VDL is one of self-directed learning. VDL follows on from VL and we assume that students have already developed the competences required for the self-reliant and independent solution of a small well-defined task – a typical challenge a graduate faces when joining an R & D centre.

Two underlying ideas for VDL were i) the re-use of the existing VL; and, ii) the development of realistic projects. The former was required to ensure seamless transition from laboratory to this development; and, the latter stems from the fragmented knowledge of the graduates and requires further explanation. Typically (in Russian Universities, at least), software engineering is taught without connection to automated control, signal processing and other core courses. Lecturers of the core courses typically use in the labs, lectures and in the simulations programming languages for numerical and symbolic computing (MATLAB, Mathematica, MathCAD).

Such languages greatly simplify numerical calculations and the plotting of results without complicated programming, thus allowing a student to focus on learning the principles without spending much time on software details. This simplification, on the other hand, gives rise to poor programming practises which often distract students from the real life tasks by making them look for a ready-to-use MATLAB function instead of undertaking a routine development. C programming language is a kind of industry standard for embedded real time applications, so it was intended for use in the VDL.

Obviously, in order to realise the two ideas above and to implement the educational concept we had to expand the existing VL with a development platform to run, debug and test software developed by students. This development platform would provide much sought after practical development experience in a real life environment. The design of the VDL encountered some challenges considered in the next section.

5 VDL DESIGN

Some design decisions need to be made when implementing the VDL. They are summarised below.

- There is a trade-off between the realism of the development environment and learning efficiency. The closer the environment is to the industrial one, the more highly specific the development has to be. An industrial environment usually includes a development suite which even an experienced engineer needs to study before the use. Other potential hindrances with a fully realistic development include cross-platform and command-line issues, lack of visualisation features and lack of GUI.
- Few assumption may be made about the computer and computer software a student has access to. One cannot expect that a student has Matlab or Visual Studio licenses (to say nothing about development suites for DSP processors). Self-guided learning assumes remote access to the VDL by students and remote control by the tutor.
- A ranking system should be developed. Simple pass/fail criteria do not contribute much to efficient learning.

6 VDL IMPLEMENTATION

The solution that addresses all the above matters is shown in Figure 2. The overall architecture of the VL is kept with one important addition – students can develop their own code. A student is provided with a commented template of the code to be developed. The template is an implementation of the application programming interface (API) provided by the VDL. The template contains headers of the API functions and placeholders, i.e. empty functions that are to be designed and coded by the student. Parameters of these functions are editable in the student's UI as shown in Figure 3. API also allows definition of user parameters that will be shown by GUI (Figure 3).

As shown in Figure 2 and in Figure 3, student developed code is uploaded to the server and incorporated in the main program. The rest is accomplished by the server – the server-side script performs building (compilation and linking). Compilation/linking errors are output into student's UI (Figure 3). As soon as a student code is built successfully, it is stored in a database (code revision system) and can be viewed by a lecturer. It is important to emphasize that a student does not need any software licenses – any text editor, such as built-in MS Windows Notepad, and any internet browser are sufficient. Furthermore, the above mentioned difficulties with the use of industrial development suites (command-line, no GUI, etc.) are hidden from a student by server software. It allows student to concentrate on substantial functions instead of developing of routine input/output and testing features.

After a successful compilation, a student can run the application (with his code included) with different input values and analyse the results. A ranking system is implemented on the basis of predefined performance criteria (e.g. size of ROM and RAM used, time elapsed, etc.). The ranks are also stored in a database and accessible for a lecturer.

A lecturer can in real time monitor the activity of every student, control the progress, and assess students according to the ranks based on the code performance (Figure 4). The lecturer's GUI also provides administrative functions (add/edit/remove students' accounts). Obviously, automated testing greatly assists a lecturer, and all students' applications run on the same server. This ensures correct performance measurement.

The described VDL addresses the challenges discussed above:

- A reasonable trade-off between the realism of the development environment and learning efficiency is achieved.
- Very realistic assumptions are made about the computer and the computer software that a student has access to.
- Access to the VDL for both students and lecturers is provided through internet. The lecturer also has tools to remotely control and monitor the development by every student.
- A ranking system and automated testing ensures an objective assessment of the students.

Finally, it is apparent from Figure 1 and Figure 3 that the VL and the VDL share similar GUI. This helps students to transition seamlessly between VL and VDL.

7 VDL EVALUATION

At the moment of writing, the VDL is being evaluated. The VDL will be fully implemented and launched in the summer term in 2012 for the first time. It is interesting and useful to compare the expectations of the VDL with the results of its first use. These expectations can be summarised as follows[2]:"

- The gap between university training and the needs of industry will mostly be bridged by the hands-on development experience obtained by graduates. SUAI will be able to supply well trained graduates to modern industry.
- Lecturers will obtain deeper insights into every student's capacity and motivation.
- Students will gain greater stimulation and psychological engagement through realistic developments."

The first results differ considerably from these expectations. One fact we did not take into account when developing the VDL was the shortage of software development skills among students. Not every student had experience in the development of even simple software in the C-language. Those students who had gained some experience working as part time associate engineers did not have difficulties with programming in the C-language and demonstrated much enthusiasm for the VDL. Students who did not practice SW engineering were hindered by insufficient knowledge of even basic C-language. Evidently, this problem reveals the shortcomings of the curriculum.

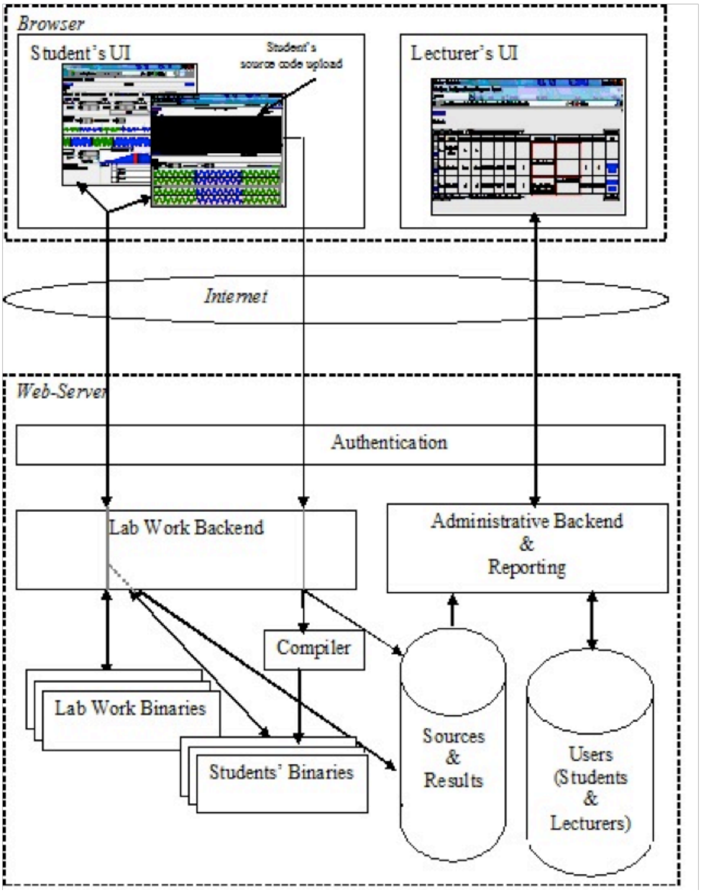

FIGURE 2. *VDL architecture*

The VDL presupposes some software development skills among the participants. The first evaluation result is that such a presupposition does not hold true for every student. Teaching the basics of software development in C was out of the scope of the VDL. Thus, only those students who demonstrated C-language skills were admitted to the VDL. The evaluation results below refer solely to this group of students.

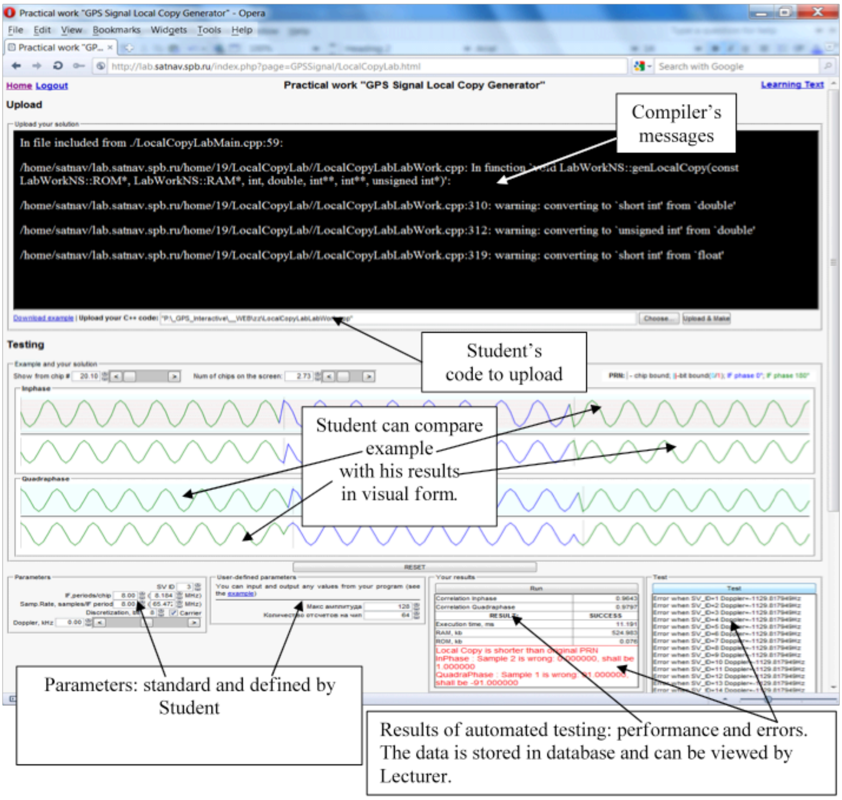

FIGURE 3. *GUI of VDL*

The second evaluation result is that the hands-on development experience obtained by graduates with the VDL greatly accelerated their learning in an industrial firm, thus making their learning curve very steep. No representative sampling is available at the moment. However, the following example is an indicative one. A senior student underwent practical training in our R&D center after completing a VL/VDL course. The student got involved in a real life development project after a month's training at the R&D center, whereas previously the typical training time required was about 6 months.

The third result of the VDL evaluation is greater psychological engagement by lecturers and (some) students. The psychological engagement of the lecturers was obtained by them gaining a deeper understanding of students' motivations and driving forces. Some students developed a feeling of being part of something bigger than themselves. The VDL became their first real life project, providing their first hands-on professional experience and gave them an opportunity to apply their knowledge to practical work.

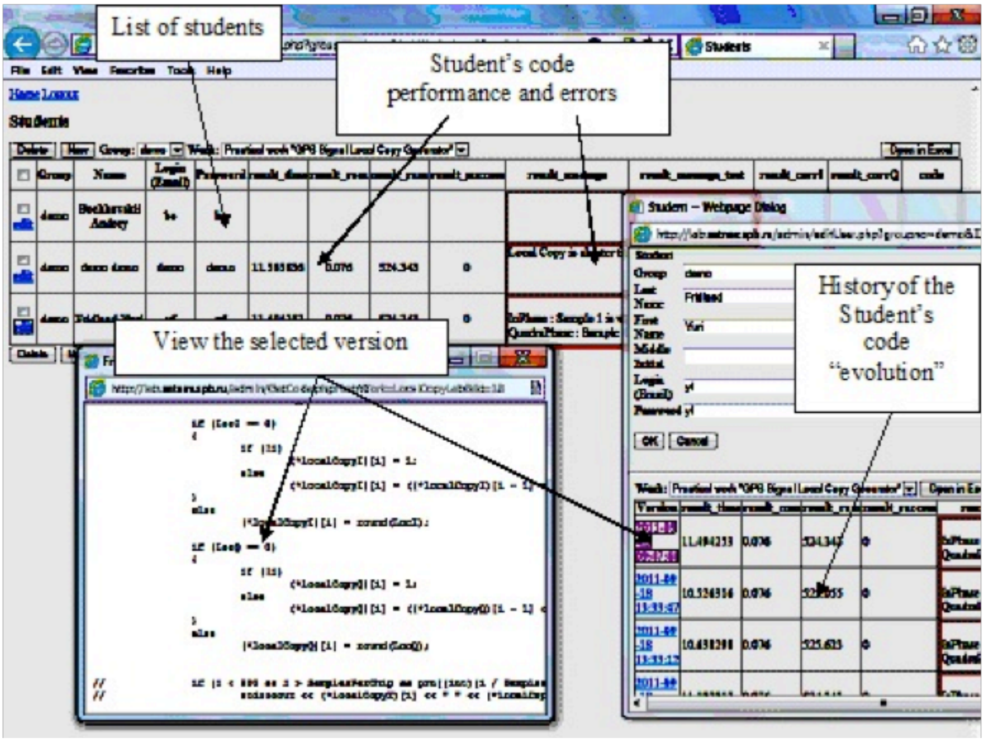

FIGURE 4. *Lecturer's GUI.*

8 CONCLUSIONS

The VDL is an educational concept that was born out of university-industry collaboration to satisfy the requirements that industry places on graduates. The first results are quite encouraging, but before VDL becomes a common and widely used teaching technique like the VL, a wider evaluation is needed. The VDL was implemented in one University on the request of one R&D centre, but to achieve mass application the author will require many colleagues to co-operate. The VDL concept can be applied to the teaching of many engineering disciplines – including applied digital signal processing and control theory.

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52 SPATIAL DATA INFRASTRUCTURE AS LEARNING ENVIRONMENTS FOR SPATIAL SKILLS DEVELOPMENT IN ENGINEERING EDUCATION

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ABSTRACT

The development of teaching methods adapted to the new European Higher Education Area requires a review and updating of content and learning methodologies. In this sense, our work addresses the task of studying a learning environment based on new Information Technology and Communication in the geographic area: the INSPIRE geoportal (Infrastructure for Spatial Information in Europe: SDI). The cartography, maps and street plan are an activity field where spatial orientation abilities are used. The aim of this research was determining, using a SDI-workshop with engineering students, whether the new geographic information technologies develop spatial abilities (spatial orientation) included as teaching objectives in the new European Space for Higher Education Engineering Degrees and analyze their usability through parameters of efficiency, effectiveness and user satisfaction.

Keywords: Spatial Data Infrastructure, Spatial Orientation, Usability.

1 INTRODUCTION

In the university context, on new degrees adapted to the European Space for Higher Education, competences related to obtaining, analysing, treating and sketching of geographic and cartographic information appear (following CIN orders from the Ministry of Science and innovation on the official state bulletin, no.42, 43 and 44 from February 2009).

The cartography, maps and street plan are an activity field where spatial orientation abilities are used [1], [2]. The spatial orientation is defined as the ability to self-orientate respecting the environment and the conscience of self-location [3]. Other authors define it as the ability to orientate physically or mentally in space [4].

When we check a map and/or plan, besides the perception of scale and interpretation of symbology, the orientation of elements appearing related to known links needs being determined. We start from the hypothesis that for working with maps we might learn to orientate them in space [5]. The interpretation and communication of figured information (maps, cartography) are abilities related to spatial orientation [2].

The spatial orientation is a subject which awakes great interest in teaching institutions. It's included as a subject that must be taught in curriculum directives of the minimum teaching decree of the Ministry of Education and Science for primary and secondary education (Fundamental

Law 2/2006, from 3rd May; R.D. 1513/2006 from 7th December; R.D. 1631/2006 from 29th December). Institutions like the National Council of Teachers of Mathematics (NCTM, 2000) contemplate among their aims the development of spatial orientation as one of the sources for describing and modeling the physical world. Fields like didactic mathematics research study teaching and learning processes of spatial orientation [6], [7] and [8]. Studies have proven that spatial abilities can develop through training when appropriate material is provided [9], [10].

According with this, It's advisable researching about methodologies, platforms and tools which allow developing teaching innovation strategies for the acquisition of competences related to spatial orientation of university students.

Having this in mind, a workshop called SDI-Workshop is developed where university students work with geospatial applications using Spatial Data Infrastructure as the main geographic information device.

The aim of this research was determining, using the SDI-workshop with engineering students, whether the new geographic information technologies develop spatial abilities (spatial orientation) included as teaching objectives in the new European Space for Higher Education Engineering Degrees and analyze their usability through parameters of efficiency, effectiveness and user satisfaction [11].

1.1 Spatial Data Infrastructure

There is a new emergent area in the geographic information available on the Internet: the Geographic Information Technologies (GIT). We understand by Geographic Information Technologies (GIT) as all those disciplines which allow generating, processing and sketching geographic information which is any variable that is or might be geo-referred in space through coordinates x,y,z [11], [12], [13], [14], [15].

The GIT´s are classified as one of the three industries of bigger growth in the United States, together with nanotechnology and biotechnology [16], [17]. In fact, the higher number of education centres teaching subject related with GITs in several learning levels are located in the States [12].

The INSPIRE geoportal (Infrastructure for Spatial Information in Europe) is a new Geographic Information Technology in the geographic area: it offers to users the chance of free online access available on the Internet to all geographic data and geographic information from the several state members' organizations. According this standard, each state develops their own spatial data infrastructure (SDI) portals, within their territory and all its regions. A spatial data infrastructure is a geographic information system consisting of a set of resources dedicated to management of Geographic Information (maps, orthophotos, satellite images, location names, thematic information...) available on the Internet.

2. PILOT STUDY

2.1 Justification and work hypothesis

This pilot study is designed aiming to check if using the new GIT´s develops the spatial orientation on students belonging to degrees where they use maps, plans and georeferenced information. At the same time, a usability test of the workshop is performed on terms of effectiveness, efficiency and user's satisfaction.

The work hypotheses we are starting from are the following:

Hypothesis 1: Improvement of spatial orientation. A short duration workshop using Spatial Data Infrastructure device is a valid tool for improving the spatial orientation.

Hypothesis 2: Usability. Validation through measurement of effectiveness, efficiency and user's satisfaction of the Spatial Data Infrastructure.

The objective data about the stated hypotheses are obtained through:

Hypothesis 1: Statistical inference methods.
Hypothesis 2: User survey results.

2.2 Participants and methodology

The SDI-workshop has been performed during the 2010/2011 academic course. 54 students from different engineering degrees took part in it (Table 1).

TABLE 1. *Tablet-GIT workshop: participants.*

Civil engineering degree. La Laguna University	14
Engineering Master. Haute Ecole Charlemagne. Liege University. Belgium	9
Agronomist engineer. La Laguna University.	16
Geography and land management. Laguna University.	15
Total number of students participating	54

The methodology consists of:

- SDI-workshop performance.
- Spatial orientation measurement.
- Usability surveys.

2.3 Hardware and Software

The hardware used in the SDI-Workshop are 22 iPads. The SDI-Workshop on the iPad device allows the consultation, edition and creation of geographic and cartographic information accompanied by themed additional information in several formats.

2.4 SDI-Workshop

The SDI-workshop is divided in two phases of 3 hours each (Table 2).

TABLE 2. *SDI-Workshop structure.*

Phase	Level	Description	Time
I. Introductory	1	Introduction	1 ½ h
	2	Training	1 ½ h
II. Improvement	1	Practical exercise (4 blocks)	3 h

Phase I. Introductory. Level 1 (Introduction): iPads description, functions, applications, menus and edition modes, navigation configuration. Level 2 (training): With the Spatial Data Infrastructure the work focuses on command's handling, visualization and gesture environment of 2D and 3D georeferenced visualization. Google Earth, Google Maps and Maps Application from Apple are used too.

Phase II: Improvement (practical exercise): Distances measurement exercises, surfaces and slopes. Routes through different scale denominators under different visualization modes (cartography and images – ortophotos); 3D visualization and relief interpretation; exercises with scales on plant and elevation; interpretation of geographic coordinates and thematic information consultation.

3 SPATIAL ORIENTATION MEASUREMENT

Spatial Orientation can be quantified through instrument measures (test) [18]. For taking this measurements we will use the Perspective Taking / Spatial Orientation Test developed by Hegarty, M., Kozhevnikov, M. & Waller, D. from University of California Santa Barbara, which has been already used in previous experiments [19] and [20], by the Department of Psychology, University of California, Santa Barbara, USA and Miami University, Oxford, OH, USA.

This version of the test was also used by Hegarty and Waller (2004) being a revised version of the test used by Kozhevnikov and Hegarty [20].This test consists of 12 exercises, where students should choose a direction between six different options. Table 2 shows the overall scores as well as average gains acquired. The score for each item is the absolute deviation in degrees between the participant's answer and the correct direction to target (absolute directional error).

A participant's total score was the average deviation across all items. If a participant did not point to any target, a 90° score was assigned for that item [19].

It is noticeable that the Perspective Taking/Spatial Orientation Test overall score is the deviation between the participant's answer and the correct one; so the lower the score obtained, the greater success rate.

Prior to course completion and after it, the students' spatial orientation ability was evaluated through the Perspective Taking/Spatial Orientation Test for evaluating if the student's spatial orientation has suffered any change as a consequence if the training held at the workshop.

4 DATA ANALISYS AND RESULTS

4.1 Hypotheses 1: Spatial Orientation measurement

For answering the first hypotheses, the results obtained from students in the Perspective Taking / Spatial Orientation Test, held before and after the test are shown below (Table 3).

TABLE 3. *Results from Perspective Taking Spatial Orientation Test.*

TEST	Persp. Tak/Spat. Orient. Test		
	Pre (s.d.)	Post. (s.d.)	Gain (s.d.)
Total n=54	46,37 (24,49)	28,16 (18,97)	18,22 (16,53)
Men n=33	44,20 (25,71)	27,29 (20,41)	16,91 (16,09)
Women n=21	49,78 (22,63)	29,51 (16,86)	20,27 (17,41)

The average gain was 18.22 for the Perspective Taking/Spatial Orientation Test. For the statistical analysis we start from the null hypotheses (H0): 'spatial orientation's average values have not changed after the workshop'. The t-student test has been applied for paired series (test results before and after the workshop) and the p-value is obtained representing the chance that statement is true (Table 4).

TABLE 4. *Significance level.*

TEST	Perspective Taking Spatial Orientation Test
p-value	0,000000000078

The significance level never came close to 1‰, so the null hypotheses is rejected in all cases and we may affirm with a significance level over 99.9% that average value of the studied group has underwent an increase.

4.2 Hypotheses 2: usability of the SDI-Workshop

A usability study has been carried out through surveys directed towards the workshop's participants. The usability study has been carried out in terms of effectiveness, efficiency and user's satisfaction, stating the survey questions according Likert's scale (1: strongly disagree; 2: disagree; 3: undecided; 4: agree; 5:strongly agree).

Effectiveness. Average value: 3,99 over 5,00: The SDI-workshop's structure has been well rated, with a 3.99 average value obtained. The explanations given by the teacher and the tutorials obtain values of 4.29 and 3.94 respectively.

Efficiency. Average value: 3,85 over 5,00. The SDI-workshop's efficiency offers values between 3.59 (minimum) and 4.08 (maximum). The students state having being able to solve the stated exercises (4.08) and had plenty of time for it (3.94).

Satisfaction. Average value: 4,51 over 5,00. The opinions shown on the survey express a high degree of satisfaction from user about SDI-workshop: their expectations are covered (4.15). The student thinks that teaching this workshop have improved his knowledge about cartography (4.49) as well being useful for getting introduced in the work of Geographic Information Systems (4.76)

5 CONCLUSION

Once the SDI-workshop is over, we may conclude that:

Answering to hypotheses 1: as an answer to first hypotheses, it's confirmed that there is an effect of the SDI- workshop over the average value of spatial orientation measured with the Perspective Taking Spatial Orientation Test; that effect is rising spatial orientation of those subjects receiving the training, with an average gain of 18.22 degrees. It's also observed that gains obtained on tests are higher for women (20.97) than for men (16.91) although the average values show a better score for men (44.20 before and 27.79 after) than for women (49.78 before and 29.51 after). So, according to these results, men have greater spatial orientation skills than women but women obtain a higher gain in spatial orientation by a narrow margin when they undertake the training.

Answering to hypotheses 2: from results obtained of the usability study, we may conclude that SDI-workshop on the iPad device are a valid tool for teaching subjects including contents related to geographic information. The tablet-PC characteristics, weight, size, battery life, start and turn off speed, Wi-Fi or 3G access, gesture interaction over tactile screen, keyboard interaction, profusion of low cost or even free specific applications together with its easy purchase and installation may turn them into a paradigm, change on teaching of Geographic Information technologies (GITs).

Final conclusion: the SDI-workshop is a valid learning environment for spatial orientation skill development in education. Using the SDI-workshop the teacher has got a free online tool available on the Internet to improve specifically the spatial orientation skill, according with the spatial competences contemplated in new degrees adapted to the European Space for Higher Education.

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53 EXPERIENCES WITH EXCHANGE STUDENTS AT THE COPENHAGEN UNIVERSITY COLLEGE OF ENGINEERING WORKING IN INTERNATIONAL PROJECT TEAMS

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ABSTRACT

This paper summarizes our experiences at the Copenhagen University College of Engineering (IHK), program in Electronics and Information Technology, with international project teams working with different engineering projects. Globalization makes it necessary to cooperate on an international platform and it is necessary to train the engineering students to cooperate and communicate internationally, with the students from different cultures and speaking different languages. IHK has more than 50 active Socrates-Erasmus agreements and bilateral agreements with many non-European countries. Usually the exchange students come to us after 2-3 years of studying in their home countries. Their prerequisites are in most cases the basics of mathematics and physics, but there is very big variety in their practical skills, like electronics and programming. Some of them do not have much experience in working with projects. In our program, students work in teams four to five students. It is worth to put time and effort at the beginning of the semester to teach students the fundamental skills like students' interaction and cooperation, team training, project management and leadership, communication and presentation skills, conflict management. We conclude with describing the benefits and problems we experienced during the last three years.

Keywords: Mobility, Teamwork, Globalization.

1 INTRODUCTION

Copenhagen University College of Engineering in Denmark has signed cooperation agreements with many technical universities and colleges all over the world. Most of the agreements are within the European SOCRATES-ERASMUS programmes which contain a wide range of measures designed to support the European activities of higher education institutions and to promote the mobility and exchange of their teaching staff and students. At the Copenhagen University College of Engineering we are well prepared to receive international students [1], because we have several programmes taught in English. In CITE - the Center for Information Technology & Electronics - we offer full bachelor programs in Electronics and in Information and Communication Technology [2], both taught in English. We also receive students from many other countries outside Europe on these two programmes. At our university college most of the courses use educational methods based on teamwork and project-based learning. The ability to work in teams and with projects involving international students may differ a lot depending on the educational traditions of the students' homelands. The exchange students' prerequisites are in most cases the basics of mathematics and physics, but there is very big variety in their practical skills, like electronics and programming. Some of them do not have much experience in working with projects. The challenge of supervising the international teams is to motivate the students with different prerequisites to study the theory and work together with other students from very different cultures with a practical engineering project. The goal of most undergraduates studying engineering courses, whether traditional or of a more modern structure is to work in an engineering company and most likely in their home country. Global market conditions today force engineers to work on projects, in teams, often international and sometimes working in different geographical locations. Engineers of the future must be able to operate in a team-based, multidisciplinary world where communication and skills are very important [3]. Graduates with experience in at least some of the named scenarios will fit more readily and more comfortably into these challenging roles. The Bologna Declaration of 1999 seeks to address these issues through the development of a common European Higher Education Area (EHEA), where increasing student mobility is just one of the many goals [4]. Many technical universities have promoted working on projects in teams and adopted project working into their programmes using different methods at different levels. In general, in project based learning (PBL), students go through a process of investigation and collaboration, sharing ideas [5,6]. The process tends to increase motivation, give the students a sense of satisfaction [7,8,9,10], and not least giving them knowledge of different cultures when working in international teams.

2 STRUCTURE OF THE BACHELOR PROGRAM IN ELECTRONICS AT THE COPENHAGEN UNIVERSITY COLLEGE OF ENGINEERING

In 2002 we went through the process to renew the educational study structure in our department and we decided to change the study structure of the Bachelor program in Electronics towards more projects and teamwork. The changes were made for all semesters in our program, involving the basic courses in mathematics and physics. Since 2002 we adjusted and renewed this program several times and at the moment our programme in Electronics is like in [2]. Project- based learning requires a high degree of concentration in particular topics, and in order to support this educational method we also changed the weekly time schedule. Students have only two modules/topics per day, one from 8:30-12 and one from 12:30-16:00. Each module includes four lectures of approximately 45 minutes and some necessary breaks in between. One module of tuition is usually related to a course of 5 ECTS credits, and one module of teacher tuition requires on average 4 hours of self-study for the student. Each semester the students carry out one or two projects connected to the theory they have learned. During the semester, the students also develop the following non-technical/scientific skills:

- How to work in teams
- How to make a presentation for tutors and other teams on seminars
- Define and describe the fundamental problems and concepts introduced in the course – using proper notation
- Define and describe the fundamental methods for solution introduced in the course – using proper language and notation.
- How to work out written reports in connection to the course assignments and projects

- How to collect information and acquire new information and knowledge
- How to communicate technical problems in writing and speech
- How to cooperate in teams.

The change of educational structure usually causes the following questions from our university partners sending students for exchange to IHK:

- Can we cover the syllabus?
- Are the students ready to study independently?
- Are all the students active in teams?
- How to manage the conflicts in teams?
- How to examine and grade the students?

Our experience since 2002 shows that the benefits of project based team work compared to traditionally taught classes in the basics of engineering are for instance:

- deeper level of understanding, and by that students retain information/knowledge better and for longer time,
- higher level of communication skills,
- ability to study new subject independently.

However, these benefits are not given automatically. Not all students starting at the universities are familiar with the teamwork, project management, conflict handling, communication, presentation and cooperation skills. Some of the students did practice teamwork and working with projects in high schools, but we cannot expect the students to be familiar with engineering projects requiring high levels of mathematics and physics.

Consequently project work, student interaction and cooperation, advising, and communication and presentation of the results of the projects are fundamental features in our program. In order to gain the most from this educational method, it is worthwhile to put time and effort into learning about teamwork and the structure of the project from the very beginning. To set off the learning process in relation to project work, new students are trained in teamwork and project management as a part of the introductory courses in the first semester. We introduce new students to the structure of the project and to the requirements for a finished product. It is up to the student – in cooperation with his or her fellow students and adviser – to put this knowledge into practice.

Danish students choosing IHK are mostly interested in practical aspects of engineering and are used to work in teams at high school. They are trained to work independently and are used to work towards finding their own solutions to the problems, and have no problems in getting in touch with different teachers or companies in order to get help.

For exchange students we usually make a short introduction and recommend the students to be a part of "mixed teams", which are the teams of IHK students and exchange students.

The introduction to team work and project work consist of the following parts [11]:

1. Introduction – what is a project?
2. Summary of the project's phases
3. Defining the project's subject
4. The role of the supervisor (teacher)
5. Teamwork
   • Academic cooperation
   • Social cooperation
   • Problems' handling
6. Project management
   • Meetings
   • Time schedule
7. Documentation - writing the final report
8. Oral presentation of the project
9. Deadline and the evaluation/examination

3 TEAMWORK AND COOPERATION CONTRACT

The first task of the supervisor is to start forming the teams. Our experience shows that for the projects we offer during the first four semesters the most effective teams are teams of four to five students. Usually we allow students to form teams by them self, but in some cases we need to force students into certain teams. The process of forming the teams must be finished during the first two weeks of the semester. The team acts as an independent unit, the participants control the process. The supervisor should be conceived as a consultant, not as an expert, whom the group can ask for advice. The supervisor is not a member of the group and cannot be held responsible for the lack of the results, the delays according the original time schedule, or the incoherent conclusion. The supervisor can bring the cooperation contract to the first meeting and fill it out with the students whereupon both parties receive a copy. Example of the contract [2,11] is shown in Table 1.

TABLE 1. *Example of the contract.*

The group has _______ hours available for advising whereof approximately ______ can be used for meeting. The group should hand in their work sheets including group meetings minutes ______ business days before the meetings. Agreements in cancellation, absence, and etc. should be reported to: _______________	
Supervisor's phone number:	
Supervisor's email:	
Supervisor's office hours:	
Group members, phone, e-mail:	1. 2. 3. ....
Group's web address:	

All meetings should be recorded for the documentation and in order to find out what was good and bad during the project. Example of a template for records of meetings with the supervisor [2,11] is shown in Table 2.

TABLE 2. *Example of the meeting template.*

Team no.:		Team leader:
Supervisor:		
Date:	Start time:	End time:
Location:		
Agenda: 1. Review agenda 2. Choosing a reporter 3. Follow-up on work done since last meeting 4. Evaluate team co-operation 5. Review time schedule 6. Planning future work 7. Evaluation of meeting		

4 THE ROBOT PROJECT - AN EXAMPLE

The robot project (PROE4) is closely connected to the course in Dynamical Systems and Control Theory (REG4E) [5,12] at the fourth semester. These two courses give students the interdisciplinary mix of knowledge, combining the theory and practical design of small autonomous robots. Both courses are mandatory part of the undergraduate program for engineering students leading to the degree of Bachelor of Engineering in Electronics. REG4E includes mathematical modelling, system dynamics, control theory, digital and analogue electronics, and microprocessors [13,14]. The practical project included in PROE4 is to design an autonomous robot performing two tasks: a compulsory task decided by the teachers and a free task decided by students. The team consists of 4-5 students and there is appointed a supervisor – one of the professors involved with these courses. Usually the tutors agree upon at least one weekly meeting with their project groups. It is required that teams make their own time schedules for the project, showing which member of the team is responsible for the particular parts of the project. At the end of the semester a new time schedule is made to compare with the first one, with an explanation of why any difference occurred and how to make more realistic plans in the future.

Each team gets basic hardware for the robot, which means two specific motors mounted on the platform and 10 rechargeable AA-batteries. Each motor is equipped with gearing and encoder. The rest of the hardware, like controllers, microprocessor or sensors, is their own choice, but it involves the responsibility for the possible delay of the project if the components are not available in time or if unexpected problems with those components occur. The compulsory task differs from semester to semester to prevent copying. Generally in the compulsory task, the robot has to follow a tape strip.

5 SUPERVISING MIXED TEAMS AND THE EXAMINATION

The early stages of the semester are mostly used to develop team-working skills and project management skills, especially in groups with international students. As the semester continues, at the weekly meetings with the supervisor, the progress is regularly reviewed. Each team makes two or three presentations during the semester – the first to show their initial planning; the second to show progress (optional) and the third is the final presentation which takes place after submission of the final report and is part of the final examination. Dealing with students having different background and coming from different cultures makes it necessary to train the students to manage the basic work skills like self management, presentation skills, project management, leadership, communication and presentation/sales skills, and not least conflict management.

The last three years we have run this course, we have had 21 groups with only Danish students and 31 groups with mix of Danish and international students from countries like: Poland, Serbia, Croatia, Slovakia, Turkey, Russia, France, USA, China, Pakistan, Uganda, Tanzania, Sri Lanka, Iran, Rumania, Bulgaria, Austria, Albania, Chile, Spain. The combinations were:

- Teams with only Danish students
- Teams, Danish students and international Electronics- students.
- Mixed teams, Danish and international Electronics-students and exchange students.
- Teams with international Electronics-students.
- Teams with only international exchange students.

Our robot project is undoubtedly a success. In the case of the international students, it increased student mobility and provide a positive environment for our Danish students. Students experience the difficulties of cultural differences and develop skills to communicate effectively. Student's motivation, both Danish and international, to learn is very high and the teams work very hard to make their robots to win the robot competition at the end of the semester. Our department has the tradition to invite the students' family and friends for the last day event, which takes part the last day of the tuition period, before the examination period begins. Students at all levels are present and demonstrate their projects for the guests and all the other students. A part of this tradition is the robot race, where the fastest, most precise and most elegant robots win prizes. This is an additional motivation factor for the teams; they try to optimise their robots for the competition.

The examination for the students taking both the theory (REG4E) and robot project (PROE4) is common, but the grading is separate. At the examination each student is allocated 30 minutes. The evaluation is based on a general impression of the level achieved by the student relative to the objective of the course. The evaluation is based on the reports, the mandatory exercises, the oral performance and the functionality of the project. The examination is organized in the following way:

1. The group presents the project by giving well-prepared presentations including robot demonstration. The group is required to coordinate their presentations in such a way that the major aspects of the project are covered, that the presentations are different and that each individual presentation has a good technical span.
2. After the group presentation come individual examination for the robot project - PROE4, the supervisors and the external examiner pose questions inspired by the presentations and the reports.
3. Next is REG4E examination. The individual examination in the randomly selected topic, one of the 8 topics listed for the students in advance.
4. Afterwards the student leaves and the internal and external examiners grade the student's presentations.
5. The grading will be explained to the students, both individual and as a team. If a student doesn't pass the examination, guidance on how to improve the chances of passing is given.

6 CONCLUSION

After several semesters of completed courses with Project Based Learning and team work were implemented in our program in Electronics and Information Technology, we can make the conclusion, that the objectives like lower drop-out rate and increased pass-rate have been achieved. The students' evidence and evaluations show increased motivation to learn the theory in a practical approach. About 45% of the exchange students apply for permit to stay for one semester more to study at IHK, which is the sign that they are satisfied with this method of education. All the students, our students and exchange students, like the freedom to choose their own solutions in project work. The exchange students participating in our courses adapt very well to this form for studying, even if they did not try it before. It takes about 3-5 weeks on average for exchange students to adapt to teamwork and project based learning. The motivation to learn the theory, to design and implement hardware in connection with their projects is very high. In general the following conclusions could be drawn from our work with international teams:

- Exchange students are usually good in theoretical skills, but too often look for "the right s olutions".
- Teams with only international exchange students usually have problems with how to manage the project, because they are often too late in asking the supervisor, the tutors or other students for help.
- Teams with only Danish students are best in managing the practical skills.
- Looking at the outcome of the project- the performance of the robot - there is no evident difference between teams (Danish or mixed teams).

However, there were some common problems like:

- Some team members do not keeping their agreements and hence contribute to the delay of the project, Danish teams are best to solve these problems internally. Teams with only i nternational students must be always helped with these problems.
- Conflicts according to cultural differences in mixed groups, like who decides how to hand out the tasks. It is very important for the supervisor to write a contract where all group members are obliged to solve certain parts of the project.
- Communication or language problems in mixed groups. It is easy to avoid these problems if the supervisor requires frequent meetings, more than once a week, or a written report at each weekly meeting.
- We have had some cases, where a single team-member left the team, mostly because of the insufficient contribution to the teamwork, but also due to cultural differences.

More than 60% of the students achieve grades over the average and the teams work very hard to make their hardware and software work properly before the examination.

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54 TECHNICAL WRITING COURSE DESIGNED FOR THE REALITIES OF AN ENGINEER

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ABSTRACT

Engineering students are regularly called upon to produce written communications in project courses and courses requiring technical or laboratory reports. Teachers noted recurring problems in the writing of technical reports for a client: students do not know how to communicate technical solutions in writing. Currently, students receive support to improve their written communication skills as part of CIV3100; however, this course is of a general nature and does not allow students to develop specific skills in writing technical reports, a type of writing that will become part of their regular activities as civil engineers. The goal of the proposed project is to completely redesign CIV3100 so that it is coordinated with all project courses and courses that require technical writing so that students can develop skills in specialized written communication. The new course was created based on the results of a survey conducted among all civil engineering teachers in order to involve all teachers in the process and to create a course that meets shared needs. The results of this study clearly showed that the teachers share a common vision.

Keywords: technical writing, program integration, communication skills.

1 INTRODUCTION

Students are regularly confronted with technical writing for their project courses as well as for technical reports and laboratory reports. They will also be faced with this task in the course of their future professional practice. Major weaknesses in students' technical writing skills have been noted by a number of teachers in the civil engineering program at Polytechnique Montréal. Some students have not mastered the basic skills of written communication, while others have mastered these skills but do not know how to use them in the context of specialized technical writing. The difficulties encountered include choosing content, developing ideas, effectively using figures and tables, structuring a text and adopting the right tone for this type of communication. Currently, students receive support to help them improve written communication in CIV3100 – Written and Oral Communication. However, this course is general and does not allow students to develop specific skills to write technical documents, such as technical opinions, service offers, quotes, and plans and specifications, which, as civil engineers, they will be regularly called upon to do.

The goal of the project is to improve course CIV3100 and help students realize the importance for engineers to master written communication by using concrete examples taken from engineering practice, by adding content that is specific to specialized technical writing, and by coordinating the course with all project courses and courses that require technical writing. This will allow students to develop their specialized technical writing skills throughout the undergraduate program. This paper will first describe the background and development of CIV3100 and then look at the proposed adjustments to CIV3100 along with the methodology required to apply these changes. The article concludes with an overview of the expected benefits.

2 BACKGROUND

In 2005, Polytechnique Montréal completely reorganized all of its engineering programs.[1] The bachelor's engineering degree is a four-year program that includes 120 credits, 108 of which are for compulsory courses. One of the changes made was the addition of a project course to each undergraduate year to help students absorb technical concepts and apply the skills developed in complementary studies, such as interpersonal relations, team work, and written and oral communication. Team work is evaluated throughout the undergraduate program by specialists in team work and interpersonal relations; however, the evaluation of written communication skills is left to the discretion of each teacher. The current structure does not allow teachers to closely monitor the development of students' writing skills during the engineering program, nor does it allow students to effectively develop them. Each teacher establishes his or her own technical writing requirements that students must fulfill, which does not let students develop long-term skills, as each term they must adapt to a specific teacher instead of an overall method.

2.1 Development and history of CIV3100

Created in 2005, CIV3100 is structured so that all students must complete a written communication assignment in the first term of the undergraduate program. This assignment reveals each student's areas of difficulty so that the Complementary Studies Centre can offer workshops to address these problems. Each student is assigned workshops that correspond to his or her specific needs in written communication. Up until 2009, students' progress was evaluated through a final written communication assignment on a subject of their choice relating to their studies. Since 2009, the final assignment has been coordinated with the report of the mandatory practicum, which students take once they have obtained between 55 and 80 credits, during the third year of the undergraduate program. The content of the practicum report is graded by the Practicum and Placement Service, and the quality of the writing is graded by the written and oral communication team of the Complementary Studies Centre. This change allows students to work on a concrete report meant for a client and to improve the quality of practicum reports submitted to employers. Despite these adjustments, teachers as a whole still note difficulties in technical writing. This observation has also been made by employers, who would like graduates to have a better mastery of this skill. The course is unpopular with students, as demonstrated through the official evaluations of the Pedagogical Support Office, with an 80% dissatisfaction rate on average. Students believe that the workshops are unnecessary and bemoan the fact that they do not reflect engineering practice.

To better understand the current limitations of CIV3100, the entire process was studied from the initial assignment to the final assignment, including the workshop content. The teachers in the civil engineering program were also consulted so that students' strengths and weaknesses in technical writing could be better identified.

The main weaknesses are as follows:

1. The workshops created for students are general. They cover the basic rules of writing without clearly showing how these rules pertain to engineering;
2. The quality of written communication does not improve in courses that require technical writing (e.g., project courses, technical reports, laboratory reports);
3. Students have difficulty choosing content, developing ideas, effectively using figures and tables, structuring a text or adopting the right tone for written communication in an engineering context. This observation also holds true for students who are excellent writers;
4. The students adapt their writing to the requirements of the teacher rather than to the rules of technical writing;
5. The students have difficulty writing communications that are meant for clients and regularly write their reports for the teacher in question in order to get a good grade;
6. Figures and tables are not well utilized in their reports.

The following are the main strengths:

1. The quality of practicum reports has improved a great deal;
2. Students receive individually prescribed instruction tailored to their needs so that they can work on basic written communication skills through workshops.

Students do not realize the importance of technical writing to the career of an engineer. They try to get a good grade by adapting to the requirements of a specific teacher instead of trying to develop overall skills in specialized technical writing. The main weaknesses of CIV3100 are the lack of direct connection to the reality of engineers in terms of technical writing and inconsistency in the evaluation of this skill during the undergraduate program. The main strengths of the course are the practicum report, which is a final individual assignment completed as part of a concrete engineering experience, and individually prescribed instruction adapted to each student's needs in basic written communication.

2.2 Objectives for redesigning the course

There is a blatant need for students to improve technical writing skills, especially since this is a valued and necessary skill in the workplace.[2] The Canadian Engineering Accreditation Board has identified this skill as essential:

"Communication skills: an ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions."[3]

To design a written communication course that better meets the specialized technical writing needs of engineers, and especially to engage students in a continuous improvement process throughout the undergraduate program, the following objectives were set for the course redesign:

- Make students aware of the importance of technical writing to the career of an engineer through concrete examples taken from engineering practice and through contact with engineers;
- Present the concepts of specialized technical writing[4-7] through lectures, and promote active learning through assignments that involve immediate feedback;
- Help students develop a solid work method through the teaching of individual and collaborative writing strategies;[8]
- Evaluate the development of written communication skills transversally throughout the entire undergraduate program, for example, through project courses;
- Maintain the strengths of the course, i.e., individually prescribed instruction through workshops for basic writing concepts and coordination with the practicum report.

3 METHODOLOGY

To promote participation in the project, the work had to be done transversally and had to involve everyone who could make this new course a success, i.e., all teachers in the civil engineering program, the coordinator of the written and oral communication courses at the Complementary Studies Centre, the coordinator of the civil engineering program, and the director of the civil engineering program.

First, all teachers in the civil engineering program were contacted and asked to fill out a questionnaire (appendix A) that covered their requirements regarding written communication for engineers along with the strengths and weaknesses observed in students and particular needs. All teachers who give project courses participated in the project, answered the questionnaire and were met with so that their questionnaire answers could be validated. A number of other teachers answered the questionnaire and were met with; these were mainly teachers who give courses that have a required writing component (e.g., technical reports, laboratory reports). Overall, 70% of teachers in the civil engineering program responded positively to the request. The analysis of the questionnaire answers and the evaluation of reports from the meetings clearly showed that all teachers have a common vision when it comes to technical writing. Different teachers formulated certain elements in a different way, but they clearly meant the same thing. The majority of teachers were enthusiastic about the project and agreed to implement elements in their courses that allow students to develop their technical writing skills throughout the undergraduate program. A number of these teachers also suggested interesting ideas to improve the course.

4 NEW COURSE PROPOSAL

The new written and oral communication course will now be coordinated with the project courses (CIV1910, CIV2920, CIV3930, CIV4940 and ING4901) and with courses that have a required writing component to promote the development of skills in specialized written communication. In the courses involved in the project, the quality of written communication will be verified with a shared marking grid. This will promote the development of skills, as students will be graded according to the same system and the same requirements in a number of courses. The students will have to adapt to an overall work method instead of a specific teacher.

The basic structure of the current course has been maintained: initial assignment, workshops suggested to address each student's difficulties, final assignment (practicum report). New mandatory workshops for all students will complement the existing workshops. Two major components have been addressed: writing itself (e.g., style, writing adapted to different audiences—clients, colleagues, etc.—, writing of brief or elaborate texts, structure and content of technical reports, use of effective figures and tables to support arguments) and individual and collaborative writing strategies supported by effective writing tools, for example, computer-based tools or word processing programs (e.g., to create tables of contents, create lists of figures and tables, set parameters for a document template, generate automated reference lists, share and revise documents). The content of the new material was created to help students develop specific skills for writing technical reports based on the weaknesses noted in the courses, meetings with teachers, and the technical writing needs of civil engineers. A writing guide not only will be used for the new written and oral communication course but will also serve as a reference for technical writing in the other civil engineering courses.

The orientation of the new written and oral communication course is fully in line with the 2005 redesign of Polytechnique Montréal's engineering programs, which was meant to achieve a "program" approach,[9] meaning an approach centred on the development of transversal skills in the engineering programs.

5 CONCLUSION

By having the new CIV3100 course reflect the reality of civil engineers and by providing concrete examples of writing (such as technical opinions, technical reports, and plans and specifications), the course will allow students, from the beginning of the undergraduate program, to realize the importance of developing effective technical writing skills in the engineering profession. Helping students understand this in their first year should have a positive impact on their performance in courses that require a writing component.

Secondly, this course will give students the skills they need to write effective reports and perform other technical writing tasks: adopting an appropriate writing style for client reports; creating an effective report structure; incorporating figures, tables, appendices, and reference lists; using computer tools; employing team-based writing strategies; and writing e-mails in a professional setting. These skills will be helpful to students throughout the undergraduate program and their future professional activities.

Finally, the coordination of this course with all undergraduate civil engineering courses that require technical writing will help students develop and maintain technical writing skills throughout the undergraduate program, as their writing will be evaluated in the same way in all courses. From now on, students will no longer adapt to the requirements of a specific teacher but will instead adhere to best practices in technical writing—practices that meet industry requirements and that are employed by all civil engineering teachers who include technical writing in their courses.

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APPENDIX A: SURVEY

Identification

Teacher:	
Course number and title:	
Type of report written in the course:	

Report structure

1.	Does the following general report structure is adequate for the needs of your course? ○ Cover page (with name and number of the course, title, student's name and identification, teacher's name, due date) ○ Summary (1 to 2 pages) ○ Table of content; list of figures; list of table ○ Introduction ▪ Context ▪ General objectives ▪ Mandate ○ Main body ○ Conclusion and recommendations ○ References ○ Appendix	☐ Yes ☐ No
2.	Which elements wish you to find in the body text (e.g. material and methods, design method, discussion, etc.)?	

References

1.	Do you allow importance to references in a technical report?	☐ Yes ☐ No
2.	Would you like reference cited in-text in addition to the reference list at the end of the report?	☐ Yes ☐ No
3.	Witch reference style do you prefer:	
	APA: Citations in the text: (name of authors, date), listed in alphabetical order in the reference list.	☐
	IEEE: Citations in the text: numbered, between [ ], listed in numerical order in the reference list.	☐

Progress report

1.	When students must submit progress reports and a final report, do you which that: ☐ The global context presented in all reports, ☐ The general(s) objective(s) of the project and the specific(s) objective(s) of the report both presented in the reports, ☐ The specific(s) objective(s) of the report is enough, no need to present the general objective.

Plans / design drawings, tables and figures

1.	Do you prefer that plans / design drawings to be presented: ☐ Throughout the text in the main body of the report, ☐ Presented in a plans booklet at the beginning of the appendixes. (only design plans are concerned by this question, not figures and graphs)	
2.	Does this way to present tables and figures is adequate for you course: number and title of a figure placed below the figure and number and title of a table placed above the table.	☐ Yes ☐ No
3.	Are you according importance to the following elements:	
	☐ Design of the tables and integration in the text;	
	☐ Tables and figures annonced at the beginning of the explaination;	
	☐ Use as much as possible sketches, figures, graphs to illustrate the matter	

Writing style

1.	When students write a report in your course, who is the target reader? ☐ The client, ☐ The teacher, ☐ Both.	
2.	Do you allow importance to neutral tone? Example : do not use us, our bridge, our team, our project, etc.	☐ Yes ☐ No

Open questions

1.	What are the most common mistakes done by students in technical reports written in your courses? Could you provide some examples?	
2.	What are the weakest points in the technical reports written by your students?	
3.	What are the strongest points in the technical reports written by your students?	
4.	Do you have any other specific requirements for the reports written in your courses? Could you specify those requirements?	☐ Yes ☐ No
5.	Do you already have a document presenting all the requirements for the writing reports in your course? Could we have a copy?	☐ Yes ☐ No

Comments

55 CONTEXTUALIZING FUNDAMENTAL SCIENCES INTO ENGINEERING CURRICULUM

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ABSTRACT

The scientization of engineering curricula, at Australian universities, from the middle of the twentieth century has had a profound influence on engineering education in Australia. The prevailing culture that embodied scientific method in the engineering curriculum determined the nature of student entrants into engineering schools and faculties in Australia. A large proportion of students enrolling in engineering at Victoria University have a poor knowledge platform in fundamental sciences and mathematics. This paper deals with the implementation of a half semester subject (unit) concerning with chemical literacy. The design of this unit departs from the traditional stand alone fundamental science subject by integrating and embedding it to engineering philosophy and practice. The main themes of the syllabus are energy and sustainability where the introduced chemical principles are applied in context to engineering problems. Though the unit was notionally delivered in problem-based learning mode, constructivist tools such as enquiry-based learning and threshold concept pedagogy was used. The dynamic pedagogical component in this subject closely resembled pedagogies found in creative arts and music than in the traditional mode of teaching. This was essential to cover large amount of material. Despite the crowded syllabus and great demands on student time, the progression rates were above average of other subjects and student subject satisfaction was high.

Keywords: Problem Based Learning, constructivism, engineering curriculum.

1 INTRODUCTION

This paper will first focus on the way the chemical science curriculum was developed and organized for a traditional mode of delivery and then and then its evolution into an integrated PBL subject in a challenging educational environment.

The inclusion of chemical science into the engineering curriculum occurred in response to the recommendations put forward by the Institution of Engineers Australia. (IE Aust). This was to meet the needs of manufacturing industry and environmental technologies where chemical sciences played a significant role in the technical engineering practice. Such inclusion of chemical sciences in the curriculum also anticipated recommendations issued by the Australian Science and Technology Council (ASTEC) and the Report into Engineering Profession and Education edited by Professor Johnson, [1], [2].

This subject had a chequered history. Till 2003 the relative high pass combined with a low attrition rates ensured that the subject became a victim of its own success. In 2003 it was transferred, into the first year of the undergraduate engineering courses to stem a high drop-out rate. In 2006, the subject returned to second year level to facilitate the introduction of PBL pedagogy in engineering at Victoria University (VU). The subject was to be delivered in one semester with the reduction of 50 percent and 16.7 percent in lecture and total time subject allocation respectively. Two hours per week were allocated to problem based student activities and seminars and two hours per week were set aside to lectures. Constructivism through team based project- problem semester assignments provided the anchor of the course with lectures, tutorials and laboratory work focused on the disciplinary canon of knowledge. In developing this subject the two learning components cognitive and social constructivism were hoped to be addressed [3] [4].

2 INITIAL DELIVERY OF CHEMICAL SCIENCES

2.1 Background

In a traditional course design learning objectives are identified and actions are formulated to meet these objectives that included the development of skills for life-long learning [5]. The reality concerning students' platform of academic abilities and knowledge needed to be taken into account in designing the syllabus and its organization.. The minimum admission to engineering at VU is at least 10 points below the minimum entry requirements to engineering at other universities in Melbourne. Chemistry is not a requirement for entry into engineering, though at some universities secondary students wishing to pursue studies in chemical engineering are strongly advised to undertake chemistry at year 12 level.

Only a minority of students enrolling in engineering at VU undertook chemistry subjects in their last two years of high school. Some 10 percent of students, many of them mature entrants, undertook voluntary bridging summer chemistry classes. This lack of exposure to chemistry presented a major pedagogical challenge. The lack of adequate platform of chemistry knowledge of students in engineering courses necessitated a subject design that would capture students' interest as a tool for solving engineering problems. It was hoped that by using chemical principles as a vehicle for solving engineering problems, students would acquire a deeper understanding of the subject and its role in engineering.

2.2 The Curriculum

The subject was developed in the context of engineering technology. It was delivered as an engineering science not fundamental science. The subject syllabus was designed on the kind of epistemological questions that arise within a discipline of knowledge shown in table 1.

TABLE 1. *Syllabus construct.*

1.Structure of atoms and atomic bonding	2. Relationship between the mechanical and physical properties of solids and the nature of atomic and molecular bonding.	3.Subject principles and theory. Conservation of mass and energy	4.Calculation of mass and energy balances around process units involving recycle and by-pass streams.
5.Stoichiometric balances of chemical reactions	6.Calculations around process units involving chemical reactions such as combustion and smelting processes and introduction to production of processes such as sulphuric acid, smelting of ores, setting of cements and calculations of reactions in the environment.	7. Environmental issues; greenhouse effect, Global warming potential	8.Chemical equilibrium
9.Extent of reactions around process units. Acid-base reactions. Application to processes involving chemical equilibrium.	10.Extent of reactions around process units. Acid-base reactions. Application to processes involving chemical equilibrium.	11.Rate of reactions and reaction mechanism. Application to adhesives, cement.	12.Examples from processes. Calculation of process units involved in the manufacture of polymers and pharmaceuticals. Illustration of reactions in atmosphere.
13.Thermochemistry. Applicationto fuel technology.Calcula tion of adiabatic flame temperature and carbon intensity.	14.Heat balances around process units. Calculation of process temperatures for material selection in chemical reactors.Effect of temperature on the reversibility of reactions.	15.Electrochemistry. Application in the study of production of electricity with emphasis on batch and fuel batteries. Application to corrosion and corrosion protection of metals.	16.A study in the production of aluminium.
17.Production of steel	18.Full material and energy balances in production of steels.		

Much of the student learning was performed in the highly problem solving focused tutorials and outside class times during periods of group consultations. The tutorial problems were carefully designed and were based on case studies such as comparison of fuels in terms of economics, energy intensities and carbon footprint, or designing glass bottles for fermentation of sparkling wines. Other problems were derived on topics from health, waste water treatment, mineral and food industries. Areas of knowledge, both in fundamental sciences and engineering sciences, not covered in lectures were introduced on need to know basis [6]. The subject was delivered in a narrative style that focused on learning modes 1 and 2 as representations of intra and interdisciplinary discourses respectively [7]. The subject relied on student active learning which elsewhere has been shown to be a positive pedagogical tool [8]. In order to ensure that the subject was of university standard, the course material was delivered in a non-linear fashion as a series of topics in which chemistry played a role as a knowledge tool of engineering practice. The narrative approach was under-pinned by case studies which encompassed areas of materials extraction and manufacturing, material deterioration, environment and sustainability, fuel technology and food processing (see table 1).

2.3 Validation

Students' subject evaluation surveys were based on a simple questionnaire [8]. The surveys pointed, in table 2, to a general satisfaction with this subject.

TABLE 2. *Subject Assessment.*

Statement	Year of Assessment and average score					
	1998	2000	2001	2003	2004	2005
The lecturer has a good command of the subject	4.3	4.6	4.5	4.7	4.4	4.6
The subject objectives are clear.	3.9	4.1	3.8	4.4	4.0	4.2
Lecturer interacts well with the class	3.8	4.3	4.3	4.1	4.1	4.2
Lecturer is accessible for individual consultations	3.9	3.8	4.0	3.8	3.9	4.0
Lecturer arouses curiosity in the subject	3.8	4.1	4.0	3.6	4.0	4.1
The subject widens the scope of engineering knowledge	3.9	4.3	4.1	3.9	4.5	4.7
The subject is satisfying and would recommend to others.	4.2	4.0	4.3	4.0	4.2	4.1

Students rated this subject as among the two most demanding and difficult subjects. Yet, they also rated this subject as the most interesting and most satisfying. A Student Educational Satisfaction (SES) survey, conducted by the University in 2005, rated this subject as 4.1 on a 5 point Likert scale.

The relationship between previous students' exposure to chemical sciences, including those who undertook bridging chemistry course prior enrolling in the engineering course, and student performances in this subject are shown in tables 3 and 4. Table 3 shows little disparity in the subject performance between students who studied chemistry in secondary schools at the highest levels and those who had not studied chemistry before. The pass rates varied between 75 and just above 80 percent and were well above the pass rates of mathematics and other engineering science subjects at second year level. The yearly variations in pass rates occurred due to annual changes in the mix of mechanical, civil, building and architectural students. The relatively good average scores for the student group who undertook bridging courses are distorted its small sample size and the high proportion of mature students in this group. The significant decrease in the subject pass rates can be attributed to its transfer into the first year. However its pass rates compared well with the first year pass rates in mathematics and physics. A marked difference in academic performance in this subject is observed between students who have completed year 12 chemistry and those who have studied less or no chemistry in secondary schools (table 3). Unlike the other fundamental science subjects such as physics and mathematics, this subject was designed without the reliance on senior secondary school pre-requisites. In a way it resembled, to most students, an introductory engineering design subject because it introduced new knowledge, and a different way of thinking inclusive of open-ended problems and solutions. But unlike an introductory engineering design subject, this subject was introduced in a non-linear way with the common thread across the topics based on energy and mass balances based on discovery learning principles [9].

TABLE 3. *Comparisons of student performance in second year.*

Preparation	Yr	GRADES (% of student population)						Av. score(%)
		HD	D	C	P	N1	N2	
Year 12	2000	12.8	13.1	19.6	26.1	7.5	20.9	60.0
	2001	13.2	15.2	18.9	26.1	8.1	18.5	61.2
	2002	13.1	14.9	24.1	29.2	8.1	10.6	63.2
	2004	12.9	14.1	24.1	28.6	9.1	11.2	62.2
	2005	15.4	14.6	22.7	27.6	10.0	9.7	63.4
Year 11	2000	10.1	12.8	19.9	27.1	7.9	21.4	57.8
	2001	13.1	12.8	21.6	27.6	7.9	16.9	59.5
	2002	13.6	14.1	22.4	26.9	8.1	14.9	60.5
	2004	13.1	14.4	23.6	27.6	9.1	12.2	60.6
	2005	13.2	13.6	23.9	27.1	8.7	13.5	59.8
Bridging course	2000	8.4	14.0	23.1	32.1	5.9	16.5	58.0
	2001	10.7	13.6	23.6	31.8	9.5	10.8	58.1
	2002	10.7	12.9	23.1	30.9	8.6	13.8	58.0
	2004	9.6	14.1	24.0	30.3	8.3	13.7	60.7
	2005	9.8	14.6	25.3	32.6	8.6	9.1	61.1
None	2000	9.9	10.0	26.1	33.0	8.0	13.0	57.6
	2001	11.1	10.0	24.3	31.8	8.6	14.2	57.7
	2002	10.0	9.9	24.3	32.1	9.9	13.5	56.7
	2004	12.2	14.5	27.1	34.9	11.1	0.2	61.7
	2005	12.3	15.1	28.6	24.9	10.7	0.4	61.1

HD (High Distinction) = 80+ %, D (Distinction) = 70%-79%, C (Credit) = 60%-69%, P (Pass) = 50%-59%, N1 (Fail) = 40%-49%, N2 (Fail) < 39%

3 CHEMICAL SCIENCES IN PBL FORMAT

In 2007 the new subject was designated to be delivered in Problem Based Learning (PBL) mode The PBL approach placed greater emphasis on inductive approach to teaching [10]-[11]. The pedagogical mix included problem-based learning as well as cases based learning, just in time teaching, and inquiry based learning (IBL). The subject organization is outlined in table 4.

TABLE 4. *Structure of the PBL course.*

FORMALISED AND STRUCTURED KNOWLEDGE (Lectures)	
Part C: Student - Centred Activities	Part D: Student - Centred Activities
Open-ended Research and Discovery • Team Report • Oral Presentation • Reflection on Ethical, Social and Environmental Issues	Experimentation and Observation •Experimental Techniques and Data Analysis •Literature Research •Written Communication •Teamwork
Individual portfolios including reflective journal and tutorial tasks	

In open-ended research and discover activity, each student team was set an open-ended and ill-defined problem. A team report concerning the problem was submitted in week 12 and relied heavily on knowledge acquired in chemical science component of the subject. Typical problem assignments allocated to student teams were:

- Energy and Environmental Audit and Assessment of various fuels and mixture of fuels at combustion efficiencies varying between 80-98 percent and excess air varying between 5 and 250 percent.
- An environmental assessment and LCA (life cycle assessment) of three selected bio-degradable polymers
- Examination of the feasibility of production of ethanol, methanol and diesels from sustainable sources.
- Production of paper from garden waste.
- Environmental feasibility of production of diesel and petrol from coal and natural gas.

3.1 Evaluation of Chemical Sciences in the PBL Format

In the PBL subject the assessment of students' knowledge and application of chemical principles to engineering problems was based on their contribution to the team project and their performance in a written test. Students had to clearly demonstrate satisfactory knowledge of chemical principles, both in their section of the team report, and in their oral presentation. Students' individual contributions to team work were further assessed by the team members in the submitted individual reflective journals. The written test provided further information on whether the student had attained the desired educational outcomes. Despite the tight assessment criteria, there pass rate in the chemical sciences section of the PBL subject of 74 percent was of similar magnitude to pass rates when the material was included in a traditional second year single semester subject. Subject assessment survey, taken at the end of the semester showed a general satisfaction with the subject, as shown in table 5.

It can be argued that even if there has been no significant change in pass rates with the introduction of PBL pedagogy, the improved education outcomes in student development of research and self-learning skills was a worthwhile educational strategy. However the pass rates are based on students who were notionally enrolled in the subject. There is a concern about increased attrition rates in PBL subjects. There is also a concern that the quality of submitted project and laboratory reports were just above satisfactory levels. Students had, by and large, put little thought and time into their projects. This is not surprising given the large proportion of students who were either doing subjects across years or had outside work commitments (see table 6). Timetable clashes and workplace commitments made it difficult for many team members to organize common free time for team meetings.

TABLE 5. *Student Subject Assessment of the PBL subject.*

Statement	Score			
	2007	2008	2009	2010
The lecturer has a good command of the subject	4.4	4.5	4.2	4.6
The subject objectives are clear.	3.5	3.8	4.0	4.0
Lecturer interacts well with the class	4.3	4.4	4.3	4.5
Lecturer is accessible for individual consultations	3.6	3.9	3.7	4.0
Lecturer arouses curiosity in the subject	4.0	4.3	4.2	4.5
The subject widens the scope of engineering knowledge	4.5	4.5	4.5	4.5
The subject is satisfying and would recommend to others.	3.8	4.1	4.0	4.4

TABLE 6. *Student commitments precluding team meetings.*

Statement	Student numbers
Undertook less than 5 hours per week of outside work during the semester	6
Undertook between 5-10 hours per week of outside work during the semester	24
Undertook between 10-15 hours per week of outside work during the semester	38
Undertook between 15-20 hours per week of outside work during the semester	19
Undertook more than 20 hours per week of outside work during the semester	10
Not Applicable	4
Enrolled only in second year subjects	48

The socio-economic background of the student body affects the effectiveness of PBL. A high proportion of students at VU come from more disadvantaged socio-economic backgrounds than students at other universities, and cannot rely on the financial support from their families the need for earning support income becomes obvious. A situation thus develops where a large number of students are enrolled in a full time course but attend the university on a part-time basis. PBL subjects rely on a synergy of learning derived from the collaboration of team members. Such collaboration requires student face to face meetings and they are highly time intensive. Finding a common meeting time has been a theme of complaints about PBL subjects.

4 CONCLUSION

The teaching of fundamental science such, as chemical sciences, in an engineering context has been shown to be fairly effective both in traditional and PBL deliveries. It can be introduced without assumed pre-requisites provided it arouses students' curiosity in the relationship between fundamental science and professional engineering discourse. When a fundamental science is used as a vehicle to tackle engineering problems it can lead to a better understanding of both the fundamental science and the messiness of professional practice. However, introducing fundamental sciences in a non-linear way, discussed in this paper, relies on students' maturity and is most effective when introduced in the second year of the course. Though the introduction of chemical sciences in a PBL inductive teaching format was seamless and worked well, there have been issues concerning such pedagogical approaches. The inductive approach demands intensive efforts of both students and school staff. It seems that while PBL drives student-focused learning process, it relies on collaborative student participation. Such learning synergies occur when students interact with each other when faced with common projects and problems. Such synergies improve with increased student peer contact. It is most effective when students are full-time on campus.

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58 SKILLED ENGINEERS THROUGH INTERNAL COMBUSTION ENGINE RESEARCH

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ABSTRACT

The internal combustion engine (ICE) laboratory at Turku University of Applied Sci¬ences has been engaged in applied engine research for more than 15 years. The main targets have been and are to reduce exhaust emissions and to improve the effi¬ciency of various engines. New renewable fuels are also being developed, as well as different exhaust aftertreatment systems. The main clients and co-operation part¬ners of the R&D work are Finnish engine, ex¬haust aftertreatment and fuel manufactur¬ers, energy consul-tants, and other universities and research institutes. Since the first projects, a large number of B.Eng., Master and Licentiate students have been involved in the ICE R&D work. Primarily, the students produce their theses within the projects and work as re-search assistants under the direction of the senior research engineers of the labora¬tory. Students also act as trainees in the laboratory before starting their the¬sis project and younger students perform minor projects within the ICE studies. The industrial clients have employed several new engineers who have graduated within the pro¬jects of the laboratory. The present four laboratory test benches are almost fully-booked and the auxiliary systems are no longer effi¬cient enough. Therefore, new premises will be rented for the laboratory. Up to six test benches are planned for the new laboratory.

Keywords: internal combustion engine, research and development, education.

1 INTRODUCTION

A decade ago, research and development (R&D) became one of the statutory tasks of the universities of applied sciences in Finland. At Turku University of Applied Sciences (TUAS), the R&D of internal combustion engines (ICE) had, however, been started already in the mid-1990s.

At that time, the Mechanical Engineering Department decided that, in addition to basic education purposes, the ICE laboratory would be systematically developed to also en-able applied and scientific research. The marketing of the R&D opera¬tion of TUAS was also started to inform important and potential clients about the possi¬bilities of TUAS.

In the early phase, the ICE laboratory had one test bench equipped with an eddy-current dynamometer. Another test bench, also suitable for engine R&D, comprised a hydraulic dynamometer. Both test benches had modern non-road diesel engines. Both engines were turbocharged and the bigger one could also be equipped with an intercooler.

The first development tasks were to acquire a comprehensive instrument set for the measurements of cylinder pressure and gaseous exhaust emissions. Temperature, pres¬sure and flow measurements were also to be increased and improved. A data acquisition system needed to be built.

The first R&D project consisted of the modernization of the turbocharging system of a non-road diesel engine [1]. The engine performance and smoke emissions could be im-proved in the project realized by two B.Eng. students who also completed their B.Eng. theses in this R&D work. At present, both students have high positions, one is a general manager at Wärtsilä Finland Ltd. and the other works as a director in the car trade.

Next, several biofuel studies were performed adopting raw mustard seed oil as the fuel. The engines were optimized and exhaust emissions were reduced. In each project, some stu¬dents wrote their theses, and trainees were also employed. Parallel with experimen¬tal investigations, a large literature review was conducted concerning diesel and gas engine driven power plants.

To market the R&D operation of TUAS, the results of all the early studies were pub¬lished mainly in international series, e.g. the SAE Technical Paper Series and ASME publi¬cations, but also in do¬mestic magazines and series.

Due to this early systematic development work, the ICE laboratory was ready for in¬creasing its R&D operation when the new legislation entered into force in the early 2000s. In the course of the past years, the commercial R&D operation of the ICE labo-ratory has stead¬ily increased. New test benches have been built and new analyzers pur-chased. Cur¬rently, there are four test benches in the laboratory, all equipped with eddy-current dy¬namometers. A large variety of performance and emissions measurement in-struments are available, also comprising special tasks, such as exhaust particle mass and number determination, ammonia slip detection, and analysis of unregulated gaseous compounds.

At present, non-road transient cycles can also be driven, required by the newest emis¬sions legislation coming into force in 2014 and beyond. Modeling and simulation of engine processes have also been started in order to improve client services and to train the students even for the use of modern tools.

The main aim of this paper is to describe how the co-operation between industrial com¬panies and TUAS has contributed to the accomplishment of the statutory second task of Finnish universities of applied sciences, or R&D, at the same time improving ICE edu-cation.

2 TARGETS OF ICE R&D

The main targets of the ICE research at TUAS are to

- develop low-emission diesel and gas engines
- improve the energy economy of different engines
- study exhaust after-treatment systems and make them compatible with engines
- perform heat transfer analyses within engine technology
- write fuel and energy economy scenarios

- build engine models and conduct simulation studies, and
- take care of education concerning ICE technology

In many respects, the ICE education is based on a new approach called innovation pedagogy including methods such as Project Based Learning and Problem Based Learn-ing. These methods support innovative actions and solutions during the studies and pro-vide environments producing competences required by working life. [2] The ICE labo-ratory and its R&D work form an important part of this approach at TUAS.

3 CLIENTS

The engine R&D of TUAS serves all clients needing support within the fields of ICE, fuel, lubricating oil, catalyst, filter, or heat transfer technolo¬gy development.

At present, the main clients of the ICE laboratory are Finnish engine and exhaust after-treatment manufacturers and fuel producers. Agco Sisu Power Inc. (ASP) is the biggest client and TUAS also has a strategic R&D contract with ASP. Wärtsilä Finland Ltd. is another important client. The Finnish catalyst and filter manufacturer Ecocat Ltd. is also a big client but aftertreatment studies have also been con¬ducted for the Finnish company Proventia Emission Control. Fuel investiga¬tions have been performed for a few biofuel and fuel additive manufacturers but even for Wärtsilä and the University of Vaasa. Ab Nanol Technologies Oy is a lubricating oil additive sup¬plier currently involved in the TUAS projects. A few measurements have also been con¬ducted for Valtra Inc., one of the Finnish off-road machine manufacturers.

In addition to private companies, TUAS has also performed publicly funded engine, catalyst and fuel research. Currently, TUAS is involved in a large national R&D pro¬gram, called Future Combustion Engine Power Plant (FCEP). This autumn, a new pro¬ject will be started concerning the effects of engine technologies on the particulate mat¬ter (PM) number emissions. Over the years, a certain number of other public projects have also been conducted including biofuels and specific cycle inventions.

4 METHODS

The industrial R&D projects are demanding both in terms of the timetable and results quality. Continuous weekly or monthly communication between the TUAS staff and the client is necessary. In the laboratory, each research engineer is responsible for the stud-ies of his or her own test bench. One or more students work as assistants with the re-search engineers, writing their B.Eng. theses or working as trainees. The research en¬gineers instruct the students and tutor them in results analysis, Figure 1.

At present, there are three research engineers in the laboratory and one laboratory man¬ager, each fully competent for R&D measurements and test runs. The laboratory staff have B.Eng. degrees and all have graduated from TUAS.

FIGURE 1. *Discussion about the results between Laboratory Manager and B.Eng. student.*

Additionally, the ICE R&D employs several senior researchers who plan and sell R&D projects for the industrial partners, organize the laboratory operation, analyze re¬sults, revise reports, publish results, participate in the operational R&D work, and develop the laboratory. One of the senior researchers has a doctoral degree (DTech) and he also works as a fixed-time university professor. Two other senior re¬searchers have Lic. Tech. degrees and the remaining two are Masters of Science or Engineering, one of them spe-cializing in ICE modeling work. Most senior researchers have graduated from Helsinki University of Technol¬ogy (Aalto University) in Espoo, Finland.

5 SOME RECENT RESULTS

During recent years, emissions reduction has been the main driver in most R&D pro¬jects of the ICE Laboratory at TUAS. Simultaneously, it has been necessary to keep the fuel consump¬tion figures as small as possible to limit the increase in CO2 emis¬sions and to keep the fuel costs moderate. Another way to reduce CO2 is to develop waste-derived and other biofuels and adapt the engines accordingly. Below, a few result ex¬amples are presented concerning some of the above mentioned issues.

5.1 Miller timing

In Miller timing the intake valve closure of an IC engine is advanced. The valve is closed even far before the piston reaches the bottom dead center. The cylinder charge expands and cools down and the cycle temperatures are lower than normally resulting in lower emissions formation of oxides of nitrogen (NOx).

Miller timing also improves cycle efficiency and, thus, brake thermal effi¬ciency which means lower fuel consumption, as shown in Figure 2. Miller timing has been applied in several projects conducted for ASP.

5.2 Turbocharging

One of the drawbacks of Miller timing is the reduction of the air quantity trapped in the cylinder since the intake valve opening period is much shorter than in an ordinary sys-tem. This lack of air can be compensated for by increasing the charge pressure. One option is to exploit two-stage turbocharging.

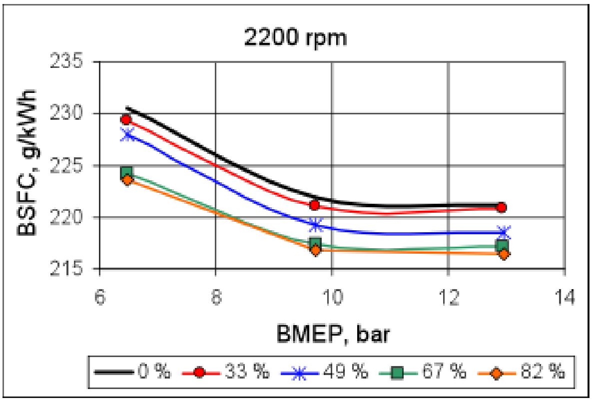

FIGURE 2. *Brake specific fuel consumption (BSFC) versus engine load (BMEP) at constant engine speed (2200 rpm); the higher the percentage, the earlier the intake valve closure [3].*

The optimization of the turbocharging system has been one the most common ICE re¬search subjects at TUAS. By means of an appropriate turbocharger the exhaust emis¬sions can also be reduced, as depicted for NOx in Figure 3. Even here, ASP has been an important client and co-operation partner.

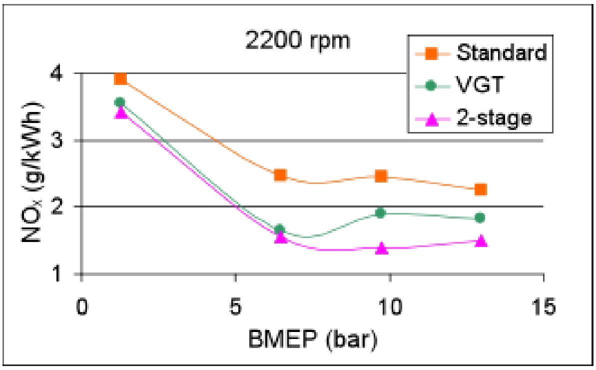

FIGURE 3. *NOx emissions against engine load at 2200 rpm with different turbochargers; VGT, variable geometry turbine; 2-stage, two-stage turbocharging [4].*

5.3 Transient cycles

According to the newest emissions legislation, exhaust emissions also need to be meas-ured within a transient test cycle. Different engine applications have their own test cy-cles. At TUAS, non-road transient cycles (NRTC) can be driven.

Regarding exhaust aftertreatment, one of the most significant problems is that the ex-haust tem¬perature is far too low to light off the catalytic reactions or to regenerate the filter. Therefore, new methods to raise the exhaust temperature must be found. At the same time, exhaust opacity peaks and particulate matter (PM) emissions should be re-duced by promoting combustion through, for instance, more rapid charge pressure de-velopment. Figure 4 illustrates how one special method improved the charge pressure and decreased PM emissions during an NRTC cycle. Again, ASP was the main co-operator but catalyst and filter companies have also been involved in this kind of pro-jects.

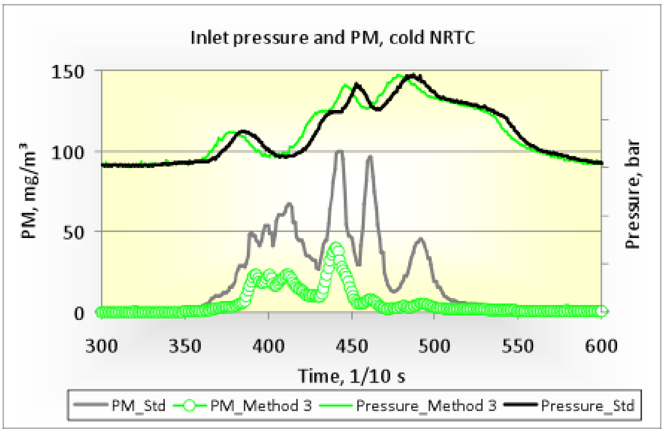

FIGURE 4. *Inlet manifold pressure and exhaust PM concentration during an acceleration phase of the NRTC.*

5.4 Exhaust scrubber

For some years, the ICE Laboratory of TUAS has also participated in the R&D work of exhaust scrubbers. In marine installations, sulfur oxide (SOx) emissions must be reduced consid¬erably. One option is to use a scrubber, whereby exhaust gases are washed with alkaline water neutralizing SOx compounds. A scheme of a scrubber in¬stallation is il¬lustrated in Figure 5. In this project, Wärtsilä Finland Ltd. has been the main client.

5.5 Publications

Since 1994, a large number of B.Eng. theses have been published related to the exe¬cuted ICE R&D projects. Additionally, one Lic. Tech., one M.Sc. and one M.Eng. The¬sis have been written in the ICE laboratory at TUAS. Although most of the studies have been confidential, it has been possible to publish some results in international confer¬ences, symposia and congresses. In total, more than 20 original scientific and app. 15 other publications have been published. Furthermore, a few scientific publications have recently been offered or are currently being written or planned.

6 EMPLOYMENT

The students that have produced their theses within the ICE R&D projects have been successful at finding employment. The main client ASP has offered work for several Bachelors of Engineering. A few ICE oriented graduates work at Wärtsilä Finland Ltd. and some at large power plants in Finland.

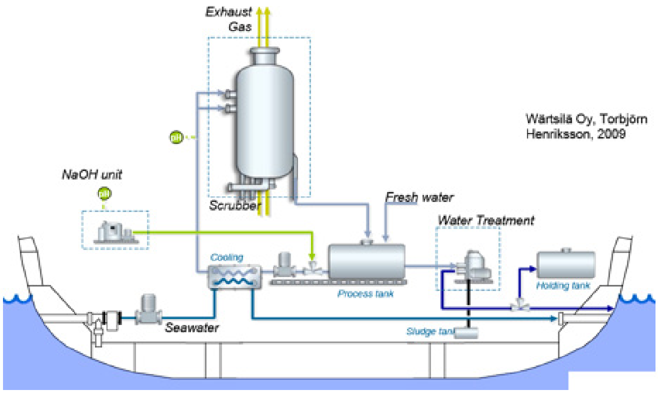

FIGURE 5. *Exhaust scrubber for abatement of sulfur compounds [5].*

Systematic working within R&D projects with its constantly increasing challenges has produced skilled engineers for the needs of the engine, fuel, and aftertreatment industry. Some students have also continued their studies at scientific universities.

7 INCOME

As a result of a few years of active marketing and laboratory tuning work, the external funding of the ICE R&D work has increased steadily during the first decade of the cur-rent cen¬tury, Figure 6. (The scale for the vertical axis concealed; confidential data.)

Since 2010, the increase in the income has leveled off because the present premises do not allow more projects to be conducted. The auxiliary systems of the laboratory also have limited capacities. Recently, an important decision was, however, made, according to which new laboratory premises will be rented and new test facilities built.

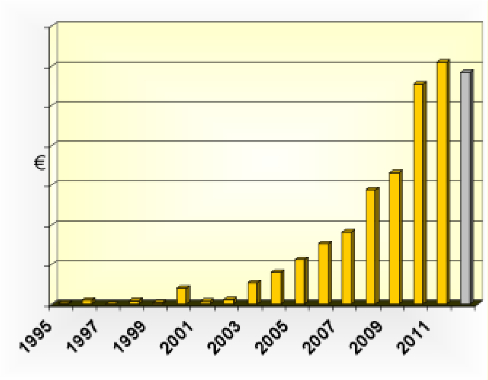

FIGURE 6. *Development of the external funding of the ICE R&D work at TUAS.*

8 CONCLUSIONS AND FUTURE

During the last eighteen years the R&D activities of the ICE laboratory at TUAS have increased steadily. The main clients and co-operation partners are Finnish engine, ex-haust aftertreatment and fuel manufacturers.

Good personal relationships between the industrial partners and university staff are the sine qua non of the emergence and success of profitable co-operation. In the beginning, con¬fidence had to be created by proving the scientific R&D level of the laboratory by means of, e.g., publications and high-quality results. Contracts followed.

Within the projects, the research engineers have the main responsibility for the studies at their own test benches and students work as assistants or trainees. Senior researchers plan and sell the projects, guide the laboratory work and theses, and publish the results.

The employment opportunities of the graduated students have been very favorable. Sys-tematic working within R&D projects, becoming more challenging phase by phase, has produced skilled employees for the needs of the engine, fuel, and aftertreatment indus-try.

The future of the ICE laboratory looks bright since new premises are being rented and the facilities are being designed. The number of the test benches will increase from four today to five or six in the near future.

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59 UNIVERSITY-INDUSTRY COLLABORATION IN NETWORK SECURITY EDUCATION FOR ENGINEERING STUDENTS

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ABSTRACT

Our industry collaboration has resulted in building a network security lab for research and education. In our lab, modern powerful computing equipment is used together with specialized firewall and IPS hardware and software from a recognized manufacturer to provide students with hands-on laboratory experience and skills on using and administering state-of-the art network security solutions. The hands-on work is organized into a laboratory course where theory learned in lectures is put to test in lab work. At the end of the course, most successful course participants have an opportunity to attempt the vendor's certification as system administrator, firewall architect and IPS architect. The collaboration has been going on for three years, and the experiences are very positive both from the point of view of the university and the industrial partner. Student feedback is also very positive, leading us to the conclusion that tight co-operation with an industry partner in organizing hands-on network security laboratories to engineering students is extremely fruitful for all parties and reaches the planned student learning outcomes very well.

Keywords: Information security, engineering education, industry collaboration

1 INTRODUCTION

Gaining experience in hands-on laboratory work is essential for engineering students to facilitate their development as future professionals in their specialization. In network security, one cannot become an expert professional in administering firewalls and intrusion prevention systems (IPS) just by reading textbooks: proper and adequate laboratory experiments are needed. For a brief introduction to firewall and IPS concepts, see e.g. [1]. Unfortunately, building a research and teaching laboratory environment with powerful computing equipment and specialized hardware and software for the target lab works is often extremely costly and a public institution like a university may be reluctant to invest money in an expensive new laboratory. A very beneficial solution to the problem is to find an industrial partner from the research area and start negotiations for university-industry collaboration in building a laboratory. All parties of the collaboration benefit from the co-operation: students have the possibility to perform hands-on laboratory work, the university is better able to include work-life relevant education in its curriculum, and the industrial partner gets visibility among students and is able to contribute to university education planning from the educational needs of professional careers point of view.

Our industry collaboration has resulted in building a network security lab for research and education, where modern powerful computing equipment is used together with specialized firewall and IPS hardware and software from a recognized manufacturer to provide students with hands-on laboratory experience and skills on using and administering state-of-the art network security solutions. The hands-on work is organized into a laboratory course where theory learned in lectures is put to test in lab work. At the end of the course, most successful course participants have an opportunity to attempt the vendor's certification as system administrator, firewall architect and IPS architect. The collaboration has been going on for three years, and the experiences are very positive both from the point of view of the university and the industrial partner. Student feedback is also very positive, leading us to the conclusion that tight co-operation with an industry partner in organizing hands-on network security laboratories to engineering students is extremely fruitful for all parties and reaches the planned student learning outcomes very well.

2 NECESSITY OF NETWORK SECURITY EDUCATION FOR IT ENGINEERS

Communication networks have spread to all facets of our society. The use of Internet on many things has become completely ubiquitous and engineering students need to be aware of the challenges posed by this development. These challenges range from basic network security issues to large-scale software security and safety problems, which have demonstrably affected the world in the form of, for example, the high-profile attacks against corporations and government contractors [2]. On a smaller scale, the responsibility of the end user to protect their own data and privacy by understanding the hazards and realities of security has increased. For example, the widespread password leaks [3] that happened in Finland in late 2011 are a prime example of this, as the attackers used the low expertise of message board and website admins to their advantage. Therefore it is imperative that students are familiar with the basic concepts of network security and software security, even though they will not work in the security industry after graduation. The multi-domain skill sets acquired from this kind of education are important for students working in the IT field [4].

At the University of Turku, the societal need for engineering education in information security was recognized already a long time ago. The Technology Industries of Finland Centennial Foundation decided to start funding an information security minor subject in our department for IT engineering students starting in 2008. In 2010, the university recognized the value and importance of information security engineering education and research, and placed this discipline among its four strategically important research areas in a strong development stage. This development led to the inauguration of our information security engineering Master's programme that had its first student intake in 2011.

Our department's previous curriculum on information security contained only precious little hands-on exercises and focused on traditional lecture teaching. However, previous research has determined that when students are required to find significant amounts of information required in their curricular work themselves rather than have the instructor provide the information directly, learning results can be expected to improve [5]. Application of self-regulated learning theory to motivate students towards more independent work has also produced good results in the form of more successful learners [6]. In our department, we organized our information security study modules in new ways that require considerably more independent work throughout the course duration than our average lecture courses. The techniques we applied to achieve this were strict requirements for weekly group work, weekly independent reporting and term papers with strict deadlines always enforced by an online learning platform [7, 8]. Even with this increase in the requirements for independent working, we still found our curriculum to not include enough practical hands-on training in key issues. Also the CDIO standards [9] that nowadays guide the curriculum planning in our department emphasize the amount of independent and hands-on work in engineering education. The idea for building an information security laboratory to support our curriculum arose from these needs. The goal of this laboratory environment was to provide the opportunity for a wide range of practical tasks and exercises for information security students. Information security is a field that can be taught only to a certain extent in the classroom. Practical experience in using all relevant security solutions, software and hardware is an important aspect of building the expertise required for security practitioners. While theoretical studies of the principles of information security such as cryptography, network technologies and software engineering and computer science are naturally important, actual hands-on experience cannot be ignored. By having up to date laboratory facilities for information security teaching and research, it is possible to provide this opportunity to the students.

Industrial collaboration also provides more opportunities for the students to expand their skill sets. Information security software and especially hardware is expensive, and enterprise solutions are usually out of the consumer market – and thus out of reach for the vast majority of students – due to prohibitive costs and because they are designed for networks and traffic of a whole different scale. Without such an opportunity for the students to familiarize themselves with at least one enterprise solution before entering the job market, they will not have the crucial hands-on experience that potential employers seek in new employees.

3 LAB SPECIFICATION

To make it possible to provide the latest technologies to the teaching environment, we first started with the specifications of the lab. The natural first requirement for such a lab is that it should be expandable and easily scalable to different situations. The information security education environment for the lab is based on the StoneGate firewall and intrusion prevention system [10], so the lab must be able to run the environment without any problems. The first instance of the training environment had physical stand-alone devices as firewalls and IPS devices, and the updated environment is wholly virtualized. The stand-alone devices required less computational capacity from the lab infrastructure, but were more rigid as an infrastructure than the virtualized environment. When industrial collaboration is an important part of an information security lab, the specifications and development plans for the lab are closely tied to the developments at the industrial partner and their products, as our example shows.

The network infrastructure for the lab is another important design aspect. Because of the nature of the work done in the lab, for example handling malicious code and malware, or performing network attacks or disruptive traffic, the lab network must be totally isolated from the rest of the network. On the other hand, a connection to the intranet and the Internet is also required for several basic tasks, so the network must be configured so, that it is possible to reconnect it to the Internet easily. Practically this is achieved by either physically removing the connection from the switches, or if all traffic should be routed through one host, using several network interface cards, with one card dedicated to the external connection.

The lab has 12 high-end desktop PCs for students, and one PC for the lab instructor. The backbone of the lab network is a pair of 24-port Gigabit Ethernet switches, with additional smaller switches for isolating smaller network segments for the lab environment. Wireless LAN USB dongles are available for all PCs, with 802.11n-compliant base stations, providing the environment for wireless security projects and research. After three years, it has become clear that the hardware requirements of the lab can and will change over time, and this should be accounted for in any plans for hardware acquisitions. This was the case with our switch to a virtualized environment.

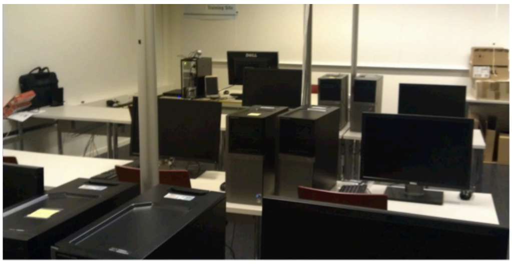

FIGURE 1. *Information security lab.*

The instructor computer currently runs the VMWare vSphere ESXi 4 hypervisor [11], which provides the possibility to flexibly add and remove different computers to and from the lab. An another benefit of virtualization is that creating multiple instances of a teaching environment is possible, and it is trivial to roll back changes or change the environment on the fly for different teaching groups, for example. By creating snapshots of virtual machine states, it is possible to have a very fine-grained picture of the lab environment, which can be changed in the order of minutes instead of hours. This is a huge benefit for the lab administrator, as doing infrastructure and operating system changes manually on dedicated hardware is time-consuming and requires more effort. The streamlined experience achieved with virtualization is a definitive advantage that should be explored in any similar computer lab projects.

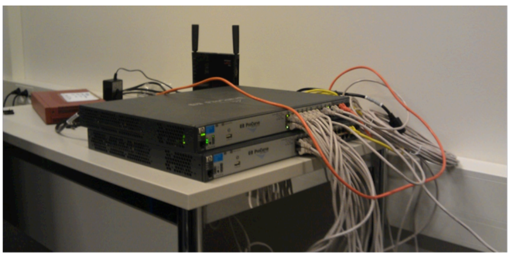

FIGURE 2. *The backbone network switches and wireless router.*

The administration of the lab of this size and scope is not a trivial task. Because of the wide use of the lab in different courses and projects, the schedules of courses and projects must be taken into account when planning teaching curriculums. A good approach to administration and scheduling is to have a well-documented plan on who has access to the lab, what equipment should be available at any given time, and what courses or projects have precedence over others. A single administrator can find the task of managing all aspects of the lab time-consuming, but this is partially remedied by the use of virtualization in the teaching environment.

4 EXPERIENCES FROM TEACHING USING THE LAB

Our lab has been operational in teaching and research for three years, and some concrete benefits can be readily derived from this experience. All parties – the students, the university and the industrial partner – can be seen to benefit from this co-operation.

4.1 Benefits for the university and the students

The main benefit for the university is the use of enterprise hardware and software in teaching situations. This gives more opportunities for forming a well-rounded teaching curriculum, and given the addition of training materials from the partner, saves time and effort. It must be noted that although these materials must be analysed and supplemented with additional information and theory to broaden their scope and make them viable for use in the classroom. Training materials are specific to the product in question and usually assume that the students have the required background knowledge in the field. We have found that this kind of a hybrid model of industrial and academic training materials works well in teaching situations. The advantage of using industrial state-of-the-art products in classes also gives the lecturers a feel of what is the latest in the field of commercial products. The gap between academic and industrial state-of-the-art can vary significantly. This also guarantees that teaching is actually relevant to what is happening in the industry at any given time.

The students are able to get hands-on experience with state-of-the-art products, something which is not usually possible without industrial co-operation. This is an important factor in their professional profiles, even more so if they have passed the vendor certification tests. The students may be also able to do their master's thesis for the industrial partner, thus gaining important experience from industrial R&D. Usually one supervisor is provided by the company, which means more efficient allocation of university staff supervisory resources.

4.2 Benefits for the industrial partner

When software and hardware which are usually available for enterprise users is made available to students and the university, it does not only benefit the students. By getting students familiar with vendor hardware and software during studies, the vendor also increases the visibility of their own products among students and new graduates. The skills learned during studies will obviously affect the way those students work and operate after graduation, and it is not inconceivable that students who have certified themselves will pick that particular vendor's product, should they be in charge of procurement.

An important aspect of the collaboration is the possibility of the industry partner to provide research topics for students. These topics can range from individual smaller projects to master's theses. This frees research resources from the industrial partner to other research tasks, and simultaneously benefits the student as well. Also, the partner receives valuable feedback on the functionality of their products, and is able to benefit from this feedback in their own quality assurance processes.

5 CONCLUSION

The benefits from a dedicated lab to teaching and research in the field of information security are concrete, and these benefits increase substantially with university-industry co-operation. Our lab has been operational for three years, and the experience has been positive for students, university staff and industrial partner. From our experience, careful planning in hardware selection, lab schedules and use and is required for successfully implementing such a lab, with a lot of focus on the requirements from the industrial partner to guarantee that the lab stays operational and up to the specifications. The practical experience gained by students when working with state-of-the-art technologies and industry certificates provide distinct added value to their studies, and researchers have access to an environment where they are able to implement their research in a secure, controllable environment.

The use of cross-discipline education in information security gives students important skill sets that are required when assessing and analyzing security and privacy issues in modern systems. The use of biometrics in travelling documents and the problems such an infrastructure has [12] is a good example of a multidisclipinary problem which requires information security expertise, even though it is not the focal problem. By having the necessary infrastructure in place and having good ties to the industry by means of co-operation, universities can prepare students to face these new challenges and provide them the tools they need to succeed.

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60 CASE STUDY: THE PROGRESSIVE INQUIRY LEARNING METHOD IN COURSE REAL ESTATE BUSINESS AND MANAGEMENT

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ABSTRACT

This article examines the application of progressive inquiry learning in higher construction education. Progressive inquiry was tested in a Real Estate Business and Management course at Tampere University of Technology. The main purpose of the research was to find new ways to improve students' learning outcomes and make learning more meaningful. A course plan based on progressive inquiry learning was developed first and then implemented in 2011. Subsequently the course plan was improved based on student feedback to lend more support to progressive inquiry learning. A second course was conducted in 2012. Feedback was collected during the course, and it was compared to feedbacks of the previous years. According to the feedback, inquiry learning has facilitated the learning process of the students. Students considered that the tasks and learning events based on progressive inquiry learning, the best parts of the course. The research demonstrated that the progressive inquiry learning method is a good way to improve higher engineering education courses. The results can also be used to develop other courses so that learning outcomes improve and students find learning more meaningful.

Keywords: progressive inquiry, teaching method, collaborative learning, knowledge building, course development

1 INTRODUCTION

In Finland, the development of education at universities of technology should be more student-centred since the most important development needs are in the curricula, learning environments and teaching methods that support development of the students' ability to think [1, 2]. In the fields of hard science, including the technology industry, teaching focusses on transmission of information and is more teacher-centred than in soft sciences where teaching is more student-oriented and the aim of learning is conceptual change [3]. Several researchers emphasise the importance of conceptual change in learning [eg. 4, 5, 6]. The main objective of the research was to find new ways to improve learning results of students, make learning more meaningful and meet better the future competency needs of industry. The subject of this study was a progressive inquiry learning-based Real Estate Business and Management course conducted in 2011 at Tampere University of Technology. The course plan was developed based on student feedback and experiences of the teachers. A repeat course conducted in 2012. The empirical data of the research consists of student feedback from these two courses and from corresponding courses based on traditional methods conducted in 2007-2010.

2 PROGRESSIVE INQUIRY AND FUTURE COMPETENCIES

Inquiry-based learning is presented in a variety of models. This research focuses on the model of progressive inquiry learning developed by Hakkarainen with his colleagues [6, 7]. It consists of the following parts: setting up the context, distributed expertise, presenting research problems, creating working theories, critical evaluation, searching deepening knowledge, developing deepening problems and creating new working theories. Progressive inquiry learning -experiments and related studies have been conducted at universities in Finland since the late 1990 [see e.g. 8, 9]. Progressive inquiry learning is a pedagogical model based on the theory of knowledge building [see 10]. It is designed to support typical data acquisition by the specialist and emphasises the activity of the learner and the impact of co-operation in a shared research project and the creation of new knowledge. [6] Social interaction and group work in general are seen as important for learning [eg. 11, 12, 13, 14]. In the future, engineers will need to be better prepared for collaborative learning and distributed expertise [2].

Learning in universities is primarily based on pre-defined, limited problems, which are expected to have one correct answer [15]. The difference between progressive inquiry and traditional project-based learning is particularly in the presenting of research problems. In traditional project-based learning the tasks and problems are given and students do not define research problems. Often results are valued more than deep learning. [6.] Engineering students are also usually given limited tasks. Yet, in reality there are several answers and one of the most important development needs in higher engineering education is to make students able to formulate the key questions and problems. [2.] The objective of progressive inquiry is to organise teaching so that there is room for students' questions and the research approach is possible.

Progressive inquiry can best be conducted in interdisciplinary teams. There, the learning situation is similar to the cross-industrial co-operation of working life situations. Engineering education in Finnish universities is mainly subject-specific. Many researches emphasise interdisciplinary knowledge and cross-industrial team work as key future competencies and skills of engineers [1, 2, 16, 17]. Creativity and innovativeness are also emphasised as necessary future competencies [see eg. 17, 18]. Creativity and ability to work with innovations enhance life-long learning. But education systems have difficulties in finding ways of adapting the needs of innovation and creativity to existing teaching and learning processes. [19.] Creation of innovative ideas is one of the key principles and benefits of the knowledge building model [20] which is the basis of progressive inquiry. Meta-cognitive knowledge and skills are also important competencies in the information society [6].

3 METHODOLOGY AND RESULTS

The subject of this case study, the Real Estate Business and Management course, was planned and conducted based on progressive inquiry learning in 2011 and 2012. The research data consist of student feedback from 2007-2012. The feedback was collected during the last lecture from students who were present. A totel of 95 students provided feedback during in 2007-2010. Eighteen participants of 21 in the 2011 course gave feedback. The received feedback was compared with the feedback from corresponding courses in 2007-2010. Based on the experience of the teachers and student feedback, the course plan was made more supportive of progressive inquiry learning and the course was repeated in 2012; this time 29 participants of 32 gave feedback.

The data analysed in this research consist of feedback where students rated the content, material and manner of presentation of every learning event on a scale of 0-5. The Net Promoter Score [see 21] was also applied to the student feedback from the new courses in 2011 and 2012. The NPS-question asked was in a form “How likely is it that you would recommend the course to other students? (on a scale of 0-10)”, and the follow-up questions “What is the primary reason for your score?” and “What would be the most essential improvement required in the course to give it a grade closer to ten?” The responses to the follow-up questions have been analysed by inductive content analysis. The data were reduced based on the research problem and divided into classes according to material. The classes were defined from the perspective of student-centred course development. Numerical feedback was analysed by descriptive statistical analysis based on the average of the student feedback and theNet Promoter Score.

3.1 Application of Progressive Inquiry

The course plan was built on the basic idea of progressive inquiry where the students themselves define research questions and problems [6]. The objective of the first learning event was setting up the context, i.e. to provide an overview of the course subject and help understand the course’s learning principles and the progressive inquiry learning process. The event adhered to the traditional lecture method, even though some activation methods were used during the lecture. Their aim was to start group formation and show active involvement of the students is hoped for during the course. Progressive inquiry within the groups of students began in the second week, when the students were divided into groups of 4-5 people. Most of the course participants were civil engineering students. Students from other study programmes were divided among the groups so that the interdisciplinarity goal was partially met. The event started with a short presentation on shopping centres by the teacher. Then, the students prepared a concept map for “user-oriented development of shopping centres”. On the basis of the concept maps, the students continued the setting up the context.

Distributed expertise was a key part of the study during the whole course. After making their concept maps, the groups examined the maps of other groups in rotation, spending 4-5 minutes on each concept map and added their own comments to it. The next step was the presenting research problems. The groups were to come up with 5-10 research questions on the basis of the concept maps. The questions were posted for all to see and each group selected two of them. The current knowledge-based working theories of the students were created by thinking about the preliminary answers to the research questions. After the event, the creation of working theories continued with the research planning process.

Traditional lectures were held during weeks 3-6 in addition to the research plan presentations by students. The aim of the lectures was critical evaluation, searching deepening knowledge and developing deepening problems. The first traditional lecture in week 7 was delivered in the university lecture hall. The subsequent combined excursion and lecture took place at the office of University Properties Of Finland Ltd. Five weeks after the last lecture, a seminar where students presented their own studies was held. New working theories were created and new knowledge was shared at the seminar based on the studies. A group exam was held one week after the seminar. The groups were to make a peer evaluation of the two studies by the other groups. The objective of the group exam was to familiarise the members with the studies of the other groups as well as to get feedback on their own work. Peer evaluation also honed the meta-cognitive skills of the students.

The plan for the second course was developed based on teachers' experiences from the first course and student feedback. The students found that traditional lectures did not support progressive inquiry learning and hoped for more activating tasks during lectures. In addition progressive inquiry was considered unrelated to lectures, which focussed more on office properties. The main idea and structure of the second course remained the same in the first one. Traditional lectures were modified so that each lecture began with presentations by student groups. The presentations were related to the research questions formulated by the students. During the first lecture hour the groups were expected to lead the discussion of the students on the topic of the lecture. Meanwhile, other groups were preparing for the debate themselves. The weekly tasks allowed students to receive feedback and guidance for their own research from the lecturers and other students throughout the learning process. The meta-cognitive processes, which are typically the responsibility of the teachers, were transferred to the students through the weekly tasks [see 6].

Another aim of the weekly tasks was to improve the connection between lectures and the research process of the students, to make the lectures more communicative, to hone the presentation skills of the students, and to help prepare the students for the lectures. Another significant change in the new course plan was to add a new topic, "user-oriented development of the university campus". After all, university properties are more like office buildings than shopping centres, which makes the connection between lectures and the research process better while university properties are also more familiar to the students.

3.2 Students' experiences from Progressive Inquiry

Responses to the NPS-question (Table 1) demonstrate that the improvements to the course have impacted positively the students' experiences. The Net- Promoter Score increased from 33-% to 41-%. The students found the biggest needs for improvement in lectures also in 2012 although there was slight improvement over 2011.

TABLE 1. *Responses to the Net-Promoter Score questions in 2011 and 2012.*

	2011, n=18	2012, n=27
How likely is it that you would recommend the course to other students? (scale 0-10)		
Net-Promoter Score	33 %	41 %
Mean	8,31	8,28
What is the primary reason for your score?		
Teaching method or the way of completing the course	16	19
Subject or content	4	11
Lectures	1	3
Other	2	4
What would be the most essential improvement required in the course to give it a grade closer to ten?		
Lectures	10	9
Practical works and group tasks	7	7
Subject or content	-	4
Learning spaces	-	2
Other	2	3

In 2011 four lecturers delivered traditional lectures the same way as in previous years for corresponding courses. Three learning events were directly linked to progressive inquiry: the start of the progressive inquiry, the seminar and the group exam. There were also two other events that differed from traditional lecture: a course opening lecture and a combined excursion and lecture.

The students' evaluation of each learning event (Table 2) attested to the need to develop traditional lectures to support progressive inquiry. According to the means of the feedback, students considered the events that differed from traditional lectures the best learning events of the course in 2011. The start of the progressive inquiry was rated the highest in every respect: contents, material and manner of the presentation. That event was based mainly on the students' own work only supervised by a teacher. All five different learning events, except the seminar, were preferred over all traditional lectures. Feedback grades for all lectures decreased compared to previous years. The means for lectures decreased an average of 0.43 points for content, 0.28 points for material and 0.67 points for the manner of the presentation. The combined means, which describes the overall success of the event, decreased an average of 0.46 points.

TABLE 2. *Means of student feedback for learning events in 2007-2010, 2011 and 2012.*

n=18 - 66 *	Content			Material			Manner of presentation			Combined mean		
Year / Learning event	2007-2010	2011	2012	2007-2010	2011	2012	2007-2010	2011	2012	2007-2010	2011	2012
Opening lecture		4	3,73		4	3,55		3,86	3,83		3,95	3,70
Start of PI		4,35	3,88		4,18	3,56		4,65	3,69		4,39	3,71
Lecturer 1	4,05	3,5	3,38	3,9	3,39	3,12	3,62	3,11	2,42	3,85	3,33	2,97
Lecturer 2	3,9	3,32	4,23	3,8	3,4	3,96	4,66	3,73	4,59	4,12	3,48	4,26
Lecturer 3	4	3,85		3,71	3,77		4,41	3,85		4,04	3,82	
Lecturer 4		3,57			3,54			3,46			3,52	
Lecturer 5			3,71			3,29			3,86			3,62
Exc. and lecture		3,9	4,27		3,8	4,08		4,3	4,42		4	4,26
Seminar		3,8	3,68		3,67	3,68		3,5	3,70		3,66	3,69
Group exam											4,14	4,05

The exact form of the question "Evaluate on a scale of 0 – 5 (5 = excellent … 0 = fail)"
* 2007-2010 Lecturer 1 n=66, Lecturer 2 n=59, Lecturer 3 n=29.
2011 n=18
2012 n=29

In 2012, lecturers, who managed to modify their lectures to support progressive inquiry, were rated better than in 2011. The ratings of lecturers, who lectured the same way as the previous year, decreased further. The evaluations of all progressive inquiry-based learning events stayed almost the same or decreased slightly, except for the start of the progressive inquiry. The combined mean for the start of the progressive inquiry decreased 0.68 points although the event was held the same way as in 2011.

4 CONCLUSION AND DISCUSSION

The results confirm the need to develop the teaching methods of the universities of technology in Finland. Students found that the learning events implemented by new methods, provide better learning than traditional lectures. The overall evaluation of the previous courses corresponded to that of the progressive inquiry-based implementations. Closer examination of the learning events reveals that progressive inquiry helped the students in their learning. When the more student-centred methods, which differ from traditional lectures, were used, the ratings of traditional lectures dropped substantially and the progressive inquiry based learning events were found more meaningful. Verbal feedbacks confirmed this assumption and indicated that the higher scores based on a better learning experience.

In the second implementation of the progressive inquiry-based course, the lectures were modified to be more student-centred. Some lecturers managed to modify the learning events to be more supportive of progressive inquiry. The evaluations of those lecturers improved. The evaluations of the progressive inquiry-based learning events, which remained unchanged, slightly worsened. The reason could be that the students did not find these events exceptional because there were also other learning events involving active participation of the students. For example, the start of the progressive inquiry event, which lost the most favour, was thought just as the start of the course. In the first implementation, the students found this event the best part of the course.

The main results of the empirical part of the research are based on the learning experience of the students. Thus it cannot be definitely said on the basis of the results that learning outcomes improved. However, the experiences of the responsible teachers of the courses are in line with the experiences of the students. So it can be reasonably assumed that progressive inquiry improved the learning outcomes of the students. The method trained students to meet the future competency needs of the industry, such as formulation of key questions and problems, building of new knowledge, innovative thinking skills, distributed expertise, social and collaborative learning and meta-cognitive skills. Researchers can also benefit from the progressive inquiry method. They can get new viewpoints and knowledge for research by using their own research topics as a starting point for the progressive inquiry learning during a course, they are teaching. However, more detailed studies and teaching experiments are still needed in this field.

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61 VALIDATING SOCIAL COMPETENCIES AS LEARNING OUTCOMES OF INNOVATION PEDAGOGY –EXPERIENCES IN FINLAND AND POLAND

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ABSTRACT

Organizations aim to create innovations and need employees who possess the competencies essential for creating added value within specific eco-systems. Higher education institutions in EU are challenged by the demand for innovators and the lack of tested methods to teach and validate social competencies which have become more crucial to working life than knowledge alone. Innovation pedagogy aims at developing complex educational system contributing to local and global eco-systems of innovation. The purpose of this study is to discuss the challenges to validate the students' social competencies as learning outcomes of innovation pedagogy in higher education perceived by stakeholders. The study extends the individual-based learning used in many contexts to include interpersonal and networked learning to develop social competencies and support ability to create innovations. The authors offer some solutions based on Polish and Finnish experiences. The study combines the results of literature review on the topic with Appreciative Inquiry done with key stakeholders. The results are useful both for students, lecturers, and employers, and for all those who want to outreach and engage in the validation of learning and increase the impact of the higher education institutions among their stakeholders.

Keywords: Social competencies, validation, innovation pedagogy, higher education, Poland, Finland

1 INTRODUCTION

Working life increasingly needs innovators and knowledge brokers so employers put more pressure on universities to engage students in educational processes enhancing their social competences necessary to create and manage innovation. This in turn calls for finding new ways to bring research, teaching and learning closer.[1,2,3,4.]

Professional activities which could be described as not-by-the-book kind of working and requiring the expertise or synergetic contribution of others are on the increase worldwide. Such changes in the working life structures must be taken into account by higher education institutions when designing curricular and rating the competence of future graduates. The aim can only be reached by making sure that the graduating students are able to participate in the different innovation processes in their future working life positions and bring added value to these processes. Organizations aim to create innovations and need employees who possess these competencies essential for enabling them to participate in the different innovation creating processes of their organization. [3,4.]

2 INNOVATION PEDAGOGY AND INNOVATION COMPETENCIES

The contribution of innovation pedagogy is to provide the students, once they are ready to enter the working life, with innovation competencies which include defined knowledge, skills and attitudes needed when being involved in diverse innovation processes. Innovation pedagogy combines learning with information creation and its application. It can be defined as a learning approach, which defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations. [1,2,3,4.]

According to innovation pedagogy the goal of educating innovative graduates can be reached by defining innovation competencies which are set as the aim of education. So called meta-innovations are needed to reach the innovation competencies. The meta-innovations include all kinds of operational solutions supporting the development of innovation competencies, covering e.g. flexible curricula and multidisciplinary learning environment. During their studies, students, often in cross-disciplinary teams, work with real-world development tasks, in which working-life representatives typically participate. Sometimes faced with difficult and even chaos-like situations, students' expertise evolves during the process through cooperation and dialogue; at best, the process itself might result in creating new innovations. [7]

As a result of the development work at TUAS three categories of innovation competencies were defined [8] : 1) Individual innovation competencies, 2) interpersonal innovation competencies and 3) networking innovation competencies. The defined innovation competencies cover generic individual competencies, and also generic interpersonal and networking competencies, following the guidelines presented by EQF [9, 10]. Individual innovation competencies include independent critical thinking and decision-making; target-oriented and tenacious actions; creative problem-solving and development of working methods; self-reflection and development of own skills and learning methods. Interpersonal innovation competencies focus on the ability to co-operate in a diversified team or working community; ability to take the initiative and to work for the public benefit; ability to work in research and development projects by applying and combining knowledge and methods of different fields; ability to work along internalised principles of ethics and social responsibility; and ability to work in interactive communication situations. Networking innovation competencies cover the ability to create and maintain working connections; ability to work in networks; ability to co-operate in a multidisciplinary and multicultural environment; and ability to communicate and interact in an international environment. Innovation competencies, therefore, cover the entire range of social competencies, as often listed as learning outcomes within EQF.

3 CHALLENGES OF VALIDATION

There are several approaches to learning outcomes in higher education and their assessment. The OECD's initiative to assess the feasibility of an Assessment of Higher Education Learning Outcomes (AHELO) focuses especially on the assessment of student's individual competencies, such as critical thinking, analytic reasoning, problem solving and written communication [5]. We believe that individual competencies do not assure alone that working life expectations are met. There is a need for more performance-related and eco-system oriented competencies [6], which we call interpersonal and networking competencies. By defining these innovation competencies we believe to be able to significantly give added value to AHELO and to the assessment of the targeted outcomes.

Most of generic competencies assessment is going unreported in those instances where they are inferred but not recorded, reported or certified. In some universities an informal system for certifying key competencies is in place, and learners are provided with a statement of attainment outlining key competency achievement. This documentation is being used by learners as supplementary evidence to their formal academic records. The lack of formal identification and validation system is largely due to the fact that there is neither European level nor national policy to underpin the formal recognition and certification of performance-related and eco-system oriented social knowledge, skills and attitudes of graduates.

From the perspective of managing innovation, social competences of current creative workers have been validated as cumulative articulations of individuals or groups to create added value within organizational systems. Although the concept of social competencies is used widely by management researchers, government agencies and other working life stakeholders in their drive for economic development, the core concept, its measurement and its relationship to entrepreneurial performance and actual innovations is still in urgent need of further rigorous research and development in practice [12]

The methodological challenge to validating competences in general is just the top of the iceberg. The true barriers are more deeply rooted in on-going social debates on education of ideological, philosophical and cultural nature. Since social competence is most simply defined in terms of somebody's judgement on how effective behaviour of an individual is for a performance of given tasks [13] the key questions arise: who is making the judgement and to what extent this behaviour can be measured through specific output performance.

We argue that prevailing understanding of competence rooted in Skinnerian behaviourism is the main obstacle in promoting validation of capabilities required for innovation as it reduces complex human activity and agency to performance of measurable tasks by an individual [14]. Behaviouristic approach is still dominant because the interests of industries recruiting workforce for very specific technical tasks prevail in educational polices. Partnerships of stakeholders ready to invest in caring for social development of labour through nurturing, advancing qualities needed for innovation are far from reaching the tipping point needed for educational change [15]. In order for working life to break out of the vicious circle where innovation is not possible due to dominance of repetitive task specialists on the market, innovation pedagogy must expose the conflicting interests and offer alternative approaches to validation of social competences as learning outcomes.

European Qualifications Frames with their shift from input orientation (what shall be learned?) to learning outcomes (what should students know, be able to do and stand for?) has the chance of becoming the needed vehicle to validate innovativeness. EQF interpretations of competence are located on a continuum from integrative model based on motivational, volitional and social dispositions, abilities that allow the individual to successfully and responsibly solve problems in various situations to the task-focused model rooted in behaviorism.

4 VALIDATION EXPERIENCES IN FINLAND

The special emphasis in Finland at TUAS was first put on the definition of the innovation competencies, and currently, on the development of a measuring tool, the innovation competence barometer, ICB, for assessing them. The innovation competence barometer ICB as well as the research hatchery (REHA) method, both investigated in the INCODE project started in October 2011 and financed by Life Long Learning Programme, are value adding methods when moving towards the European Union aims.

The project will first face the challenge presented by the need to conduct several measurements during the study time in order to be able to measure the impact of teaching and learning methods in a reliable way. The second challenge lies on the assessment criteria; for example how to measure ability to co-operate in a diversified team or working community or ability to co-operate in a multidisciplinary and multicultural environment. This will set requirements also on the test environment and means that the learning environment must also include group processes and multidisciplinary teams. The third challenge is presented by the assessment methods; diagnostic, formative and summative assessment will all be applied and will require several assessment tools in this context. In addition to traditional and easy-to-use quantitative tools, such as surveys and questioning, some other tools, such as, participatory evaluation, collaborative dialogue, peer assessment and self-reflection might turn out to be useful.

External evaluators, or 'raters', from companies and other organisations, will participate into the process, not only in the external evaluation process, but during the whole validation process including the definition of assessment criteria. This is necessary in order to ensure that the working life expectations and needs are taken into consideration at each stage.

5 VALIDATION EXPERIENCES IN POLAND

Poland has recently undergone unprecedented growth in its human capital indicators. Number of students of higher education doubled in the last 10 years but in order to ensure the continued growth Polish society must develop creative capital generating added value in place of cheap workforce and foreign know-how. For such transformation social capital based on trust and ability to self-organize is crucial. Unfortunately, Poland and Romania are at the bottom of EU member states in terms of social capital level [16]. Social competences required for innovation should be therefore of highest priority for the educational system to nurture future innovators and for the working life to gain competitive advantage and solve social problems creatively in Poland.

Introduction of Polish Qualification Frames (KRK) to Higher Education in Poland pushed for more integrated efforts in validating competency (autonomy and responsibility). Appreciative Inquiry followed by focus interviews with academics and employers [17] showed that both researchers/university teachers and working life representatives shared preference for validating competences necessary for doing R+D projects according to the model developed by team of experts at Educational Research Institute in Warsaw [18]. The integrative model combining three main approaches to describing social competences: 1)Measurements of self-reported or expert ratings of individual attributes, 2) Accumulation of descriptors within individual profiles and 3) Competence portfolios [14]

The first two are rationalistic approaches combining student as a worker-orientation with actual job/profession-oriented perspective and they regard development of social competence as transmission of desired attributes to such synergies of knowledge, skills and attitudes that allow either individuals or teams to perform specific tasks or solve open-ended problems (create added value). The third element of the Polish (IBE) integrative model comes from action and understanding-based interpretative or relational tradition. [19] Standard measurements tools like Bandura's self-efficacy tests [20]) or O*Net international standard classification [21] will be only reference points for piloted new constructs.

Within the rationalistic tradition two alternative measurements have been piloted:

1. Creative problem solving test which uses the experience of competent judges from worldwide educational program Odyssey of the Mind [22] and tests interpersonal and networking competences through both performance and judging of peers on self-designed open-ended challenges.

2. Social Network Counter questionnaire which assesses dynamics of students networking capabilities for brokerage and social capital generation. The construction and mathematical model for analyses is based on complex systems (emergency) theory developed by Polish psychologists Andrzej Nowak [23] and Ryszard Praszkier involved in identification of top social entrepreneurs (Ashoka – Innovators for the Public Association) worldwide

Social competence portfolios have been generally accepted in the course of Appreciative Inquires as core element of the Polish model. The method assumes that students set goals independently, develop and test strategies within expected outcomes, and learning from the resulting experiences. Portfolios focus on social competencies as self-organizational dispositions composed of knowledge, experiences, and abilities for the application and implementation of more subject specific knowledge, strategies, abilities, and skills [24].

The student's performance in new, unpredictable contexts can be documented in order to make competencies visible and therefore assessable through such diverse forms used in portfolios as: project reports, photos, documentaries and interviews, video clips etc. The material coming from different course modules must include student's reflection on learning process and outcomes. It is evaluated within the framework of qualitative text analysis. By applying the coding paradigm of grounded theory, Polish experts of competency validation have accepted the method of examining and describing how students reflect on competencies in the portfolios, treating the material as empirical data. The "competence explorer" [25] which is based on this interpretive approach have been assumed as orientation point for devising artificial intelligence program for interpretation of natural discourse. Student's reflective essays or scripted interviews about their projects will be submitted in the electronic form for coding which will allow validation of competences. More importantly it will offer students the feedback loops to help them understand their work in a qualitatively different way so the development of social competences becomes circular rather than linear. The highly sophisticated software for analyzing students' natural language in English and Polish has been devised by University of Gdansk partner Fido: Intelligence linked to Blackbox Accelerator LLC from Silicon Valley. The first pilots will take place in the academic year 2012/13 on the population of UG students.

Both desk research and Appreciative Inquires show that while Polish stakeholders of innovation pedagogy at higher education level share preference for integrative model for validation of social competences they are skeptical of university professors being able to be competent raters. Employers wish to be involved in evaluations of performance-based competences but expect universities to design transparent system for validating internalized ethics of innovation minded graduates.

6 DISCUSSION

In spite of deep differences in social and creative capital in the two countries both Finish and Polish stakeholders of innovation pedagogy share the need for credible model of validating social competences which are crucial to foster and manage innovations. The comparative study shows that outcomes of interpersonal and network learning at universities present a whole range of challenges in terms of their predictability as the enduring effects of education for innovation eco-systems. While Finish specialists are challenged by objective needs for ensuring reliability of innovation competence assessment tool Polish experts must deal with lack of trust in other validation methods than testing. While development of Innovation Competencies Barometer will solve most of the problems in Finland, where performance-based assessment and self-reflection is already part and parcel of higher education, Poland will need more complex models for validation, using information technologies and artificial intelligence to compensate the low level of social and creative capital. The expected changes in both cases will be facilitated by employers and other stakeholders of innovation pedagogy who seem to be committed to support universities as main engines of innovation eco-systems. New methods of interpersonal and network learning, linking research and development (e.g. REHA), will integrate various actors of the local eco-system around validation of social competences.

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62 TOWARDS SELF-STEERED STUDIES BY WORKING IN R&D PROJECTS

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ABSTRACT

A pilot project as a part of the development of the engineering education in the Faculty of Life Sciences & Business, Turku University of Applied Sciences (TUAS) was conducted by integrating a research project and a normative course in the BEng program. A pilot group (n=3) completed a course in biochemical engineering in a separate research project during the 3rd year of studies. The project was based on team work including students' own planning, practical laboratory work and reporting. After the pilot project, the students continued the work in further studies, i.e., several normative courses were replaced by the work packages conducted in the research project. It is discussed how the students advanced their knowledge through self-discovery and found the project work motivating. This high motivation resulted in activities where they on their own initiative extended the project learning to other courses and to company collaboration, i.e., working in the R&D project was also self-steering towards project-based learning. In addition, the pilot project was successfully expanded to a larger group of students (n=36) so that they experienced the same positive effects of the project-based learning.

Keywords: Self-discovery, self-steering, learning in R&D projects.

1 INTRODUCTION

Learning-by-doing and by self-discovery can be thought to have many positive effects of which high motivation is essential. High motivation does not only create a deeper approach to learning, but it also prevents students from quitting degree programs prematurely. Thus, it may also relieve funding pressure that is all the time increasing in the institutes providing engineering education.

Self-discovery is often experienced in project-based learning involving practical work, problem-solving, integration of theory and practice, communication skills and team work. Project-based learning is based on problem-solving that is by nature multidisciplinary. Multidisciplinary problems require development of diverse skills in information seeking and in applying theory and results to real-life problems. Thus, the project-based learning produces also diverse experiences of self-discovery.

Many established project-based pedagogic methods and initiatives, such as problem-based learning (PBL) and specifically for undergraduate engineering students designed CDIO ("Conceiving, Designing, Implementing and Operating"; Initiative on educational framework for producing the next generation of engineers) emphasise that they increase motivation. [1] The idea of better motivation is supported by Savage et al. who studied factors affecting motivation of engineering students in higher education. They found in their student interviews that practical tasks relevant to the real world were especially motivating. [2] There are also studies that suggest that the difference in intrinsic motivation between PBL and lecture-based learning is not as clear as it is usually claimed, but still the PBL students scored higher on competence. [3]

Learning in real research projects has also been observed to decrease the attrition rate among undergraduate university students due to increased excitement about the research. An apprentice role of undergraduate students in the research projects had also a positive influence on experienced faculty members. They become more excited about their own research work due to the eager and good questions of the students. [4] The CDIO initiative emphasizes also another important aspect related to the R&D work and learning. By attending in the project-based learning the students have a possibility to better understand the importance and strategic impact of research and development on society. [1]

1.1 Learning in R&D project in TUAS/Life Science

A pilot project as a part of the development of the engineering education in the Faculty of Life Sciences & Business, Turku University of Applied Sciences (TUAS) was conducted by integrating a R&D project and a normative course in the BEng program. Three engineering students specializing in biotechnology were chosen to a pilot group. The pilot group took part in a course on biochemical engineering in a separate R&D project during their 3rd year of studies. The R&D project involved the preparation and testing of injectable biomaterials for tissue engineering and bioprocesses, requires versatile knowledge on (bio)chemical engineering, (bio) materials science, biomolecules, cell biology and rheology. According to experience, lecture-based, theoretical teaching is challenging in this kind of multidisciplinary subject and a project-based learning was one of the natural choices to overcome the problems. A long-term goal is to extend this pilot project to cover larger student groups in corresponding courses.

The conduction was based on team work including students' own planning and scheduling, practical laboratory work including testing of biomaterials properties in a bioprocess and reporting. After the pilot project of 3 ECTS, the students were also provided the opportunity to continue the work in further studies, i.e., to replace a practical training period (12 ECTS), a continuing course on chemical engineering (3 ECTS) and bachelor's thesis (18 ECTS) by working in the R&D project. They were also told that there is a possibility for exchange with partner universities. After completing the pilot project, two of the students in the original group of 3 chose to continue the R&D work and they also chose to do a part of their bachelor's theses in the exchange in Austria. High motivation resulted in activities where they on their own initiative extended the project learning to other courses (Basics of Industrial Design (5 ECTS) and Entrepreneurship and Organisations (3 ECTS) and to company collaboration.

This paper aims at describing how the students advanced their knowledge through self-discovery and found the project work motivating and how it produced self-steering to project-based studies. The pilot project was also expanded to a larger group of students and the feedback from the students attending the new, project-based implementation is also briefly discussed.

2 METHODS

This is a qualitative study based mainly on interviews and discussions with two students during the project meetings. In addition, their project reports including reflective summaries on learning outcomes are utilised. These interviews and reports are also compared with feedback from the students that recently attended a course that was developed based on the experience in the pilot project. The feedback is from the reflective summaries in the project reports.

3 FROM SELF-DISCOVERY TO SELF-STEERING

One of the most important things for the students in the beginning of the pilot project was "a license to fail". They were told that it is not essential to achieve all goals right away, but to do research work in practice, to analyse the results and to make conclusions that can be utilised in further work. As expected, the students found the research task challenging, but the license to fail gave them courage to conduct various experiments, to use different measuring techniques and to test new ideas for the preparation process. The experiences of self-discovery in laboratory experiments resulted very quickly in effective information seeking (both from the scientific literature and expert interviews), amendments to the research plans and improvements in the experimental set-up and results. This created a positive spiral resulting in more independent work in further studies after the pilot project, which finally resulted in self-steering, i.e., the students took more responsibility and extended the project-based learning to other courses and even to collaboration with a local biotech company.

3.1 Pilot project and application to larger group of students

The goals of the pilot project included replacing one of the normative courses in biochemical engineering (3 ECTS) but were not tightly bound to the core goals of the research project. However, the conducted tasks, among them the preparation process of a biomaterial, preservation of activity of biological agents added into the biomaterial and testing of the biomaterial in a bioprocess, required the same skills that are needed in the actual research project. The new observations and development of the experimental set-up could also be utilised in the actual research project.

The students started the pilot project by project planning including a general research plan, work plan and a Gantt diagram with detailed schedule and distribution of work between the students. The students were also introduced to working culture of the research project including regular research meetings and research reports on the progress of the work. The method of the practical work was mostly trial and error in the beginning, but towards the end the research become more systematic. However, the more important thing was that they learned to research and become familiar with the research project culture and methodology at the same time as they conducted a course in biochemical engineering.

In addition to final report on the research, the students answered to separate learning tasks. The learning tasks (including bioreactor design, critical points and validation of the preparation process and scale-up problems) had a direct connection to the conducted research work and the students found it satisfying that they could link the learning tasks to the practical work done. When analysing both the reports of the students in the pilot project and the reports of a larger group of students (n=36, 3 students/group) that later attended the biochemical engineering course, implementation of which was based on the experiences in the pilot project, it was seen that the conclusions were about the same. The students could discuss in detail about the important phases and parameters in the bioprocesses and many students were able to suggest improvements that required integration of theory and practical work. Conclusions made and opinions given in the reflective summaries indicated that the practical work helped understanding of the learning tasks, i.e., (bio)process planning. Some of the groups mentioned separately that they now had to use their own skills to solve problems, which indicates that this feeling is not very common. Some groups mentioned also the general project skills that developed during course; collaboration, importance of discussions, responsibility and importance of a proper project scheduling.

3.2 Other studies within the R&D project

After the pilot project the goals of the project-based studies were directly bound to the research project. Due to the multidisciplinary nature of the research project, it was possible to design several work packages that could be directly used to replace the normative courses. The research requires knowledge of chemical synthesis, chemical analysis methods, chemical engineering (e.g., evaporation, distillation, mixing of two-phase systems, reactors, aseptic processing and controlled flow rates), nanotechnology and colloid chemistry, biomaterials & general materials science, interaction between synthetic materials and biomolecules and cells, preservation of biological activity, bioprocesses, biocatalysts, tissue engineering, and rheology.

After the pilot project (3 ECTS) two of the students continued by working 8 weeks with specific topics of the research. The work was planned so that they could replace the compulsory practical training period (12 ECTS) by working in the research project. They started to concentrate on their own specialities, though still collaborating closely. One student concentrated more on chemical engineering (controlled preparation process of the biomaterial) and the other on the testing of the biomaterial properties in different applications. The experiences of self-discovery become more diverse and this was partly due to one of the typical aspects of research, viz communication with different actors, experts and collaborators both at and outside TUAS. The collaboration with a partner university in Belgium created new and regular contacts with researchers of different background and research culture (cell biologists), but also a logistic challenge that required planning and communication skills. The research group at TUAS delivers the biomaterials for the collaboration university in Belgium for tests in biological environment. The biomaterial properties may change with time depending on the storage conditions (e.g. temperature) and it has to be taken into account during the delivery. The students took again more responsibility and arranged the delivery with courier companies and collaborators. When communicating with the courier companies the students become also acquainted with the bureaucracy of customership. Due to the regular deliveries to Belgium the students had to plan carefully the schedule for the preparation processes of the biomaterial so that it matched with the delivery timetables.

After the work package replacing the practical training period, the students continued the research work in the work package of which goals were planned so that it could replace a continuing course on chemical engineering (3 ECTS). The goals were related to a controlled and aseptic preparation process of the biomaterial. The students had to consider and test different sterilisation methods (e.g., membrane filtration, autoclaving) and set up a closed reactor system in order to keep the process aseptic. During this work package both students decided to continue the work also in Bachelor's Thesis (18 ECTS) and at the same time the signals of self-steering become clear. They started on their own initiative to communicate with another collaboration university of TUAS/Life Science in Austria in order to do half of the thesis there (testing of the biomaterial in interaction with living cells). In addition, they suggested that they could utilise their research project experience in 2 different courses, Basics of Industrial Design (5 ECTS) and Entrepreneurship and Organisations (3 ECTS). In the course of industrial design they used the biomaterial preparation process as a basis to plan a production plant including production and product cost calculations and in the course on entrepreneurship they reported a business idea based on the production of the biomaterial. The report on the business idea included a short business plan, brochures on the possible biomaterial products, competitor analysis (hence, they become also familiar with many biomaterials companies), product manual and investment calculations. The plan for the production plant was additionally extended by one of the students to collaboration with a local biotech company, which was at the same time estimating the costs of setting up a corresponding manufacturing process. The student received a separate reference on the planning work from the company.

After all the work packages, courses and bachelor's thesis the students were asked to give a reflective summary on their experiences. They concluded that the multidisciplinary knowledge was a key factor in the work they conducted. Thus, they are for their part verifying the idea about a need of "Renaissance engineers" in future, the concept named after one of the most well-known, but self-educated engineer, Leonardo da Vinci. He was also a supporter of the learning-by-doing philosophy and he questioned openly the theoretical teaching at universities. [5] Another important conclusion was that they have learned a lot, but they also learned that there is still very much to learn. In other words, they understood the importance of life-long learning. They emphasised also the importance of collaboration and communication skills in the project work and suggested that these could have a greater role in the curriculum. They also learned how to utilise the scientific literature and said that working in the project was also an effective method to learn theory. In general the extensive information seeking, planning of the research and reporting including evaluation of the results were found to be useful and an essential part of an engineer's professional skills. The students felt occasionally difficulties, but in the end the project-based research work was found to be motivating and rewarding.

4 CONCLUSIONS

It can be concluded that by working in the research project the students learned a lot through self-discovery and they advanced towards self-steering as they become motivated and faced new challenges. The multidisciplinary nature of the research project made it possible to design different work packages that could be directly used to replace several normative courses in the curriculum. The pilot project conducted by 3 students was successfully expanded to a larger group of students (n=36) so that they experienced the same positive effects of the project-based learning. However, the continuum of studies undertaken by the pilot group was based on the students' individual needs and the challenge remains to adapt and continue with larger student groups.

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65 PEELING AN ONION: MARKETING ENGINEERING COURSES THROUGH NEW COURSE PEDAGOGY?

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ABSTRACT

In order to enhance its educational capital to attract a higher calibre of students to maintain high educational standards and reduce the relatively high attrition rates, Victoria University (VU) decided, in 2005, to adopt a different educational paradigm. Engineering was the first cab off the rank to introduce problem-based learning (PBL) pedagogy in the two engineering schools. This new pedagogical paradigm was followed by an extensive publicity and marketing at secondary schools in Melbourne. Despite a mix of PBL models, by 2007, all first year engineering courses had integrated PBL into their curriculum. This project of monitoring students begun in 2008 with the purpose to evaluate whether marketing engineering courses through distinct pedagogy had any effect in attracting and retaining students, and as such it is still a work-in progress. Simple surveys of second year engineering students over the period 2008-2012 have shown that the proportion of students who chose engineering in high schools as the their first choice of study has increased to over 88 percent and the number of students who were considering transferring to other courses or universities has decreased to less than 25 and 34 percent respectively. The survey has also shown that engineering courses at VU have grown in popularity among secondary students.

Keywords: marketing, perceptions, engineering curriculum

1 INTRODUCTION

In contrast to professional courses such as medicine, dentistry and law, students entering engineering education in Australia have diverse tertiary enter ranking (ENTER) scores which is distributed unequally between the more highly and the lesser ranked universities. Universities in Australia are perceived as institutions of social reproduction and Victoria University (VU), sited in the lower socio-economic western Melbourne regions, attracts students with lower cut off ENTER scores for most its courses than the other universities in metropolitan Melbourne. This is also true for engineering courses at VU.The result is that at the cut-off scores spectrum students enrolling in engineering at VU are poorly prepared for university studies with inadequate knowledge platform in the fundamental sciences and mathematics and possessing poor communication skills. There are issues concerning intellectual abilities needed in tackling university-based professional engineering courses. The relatively poor calibre of student body enrolling in engineering courses at VU not only affects course standards and the student attrition rates but also the attractiveness of engineering education at VU and is often perceived by outside secondary students to be an entry of last resort to university engineering education.

The decision by the university in 2005 to change its educational paradigm in order to address the issues of high attrition rates and the external perceptions of academic standards and to reposition itself in the student market. The university's particular concern about the poor student intake combined with the high attrition rates in engineering, ensured that the two engineering schools agreed to institute a change in the educational paradigm. The engineering "market" for domestic students is very tight and competitive with less than 6 percent of domestic students entering universities enrol in engineering. It was hoped that the introduction of the new educational paradigm would lead to:

- Educational differentiation from other universities. Senior students in secondary schools who would not, normally, consider engineering as a course of study at VU, would now express greater interest leading to increased intake of students with higher ENTER scores;
- Generation of greater interest in engineering amongst senior students in secondary schools lead, in time, to greater participation in engineering education at all universities. Such situation could address fears concerning current and future shortage of professional engineers in Australia [1],[2];
- The enhancement and the development of professional graduate attributes such as the ability to work in teams and autonomously, communication skills and social awareness, ability to contextualize engineering work in terms of economic, sustainability, social, ethical and political frameworks and instil good habits of life-long learning-curiosity; and
- There would be likely reduction of attrition rates in engineering at VU as a result of the introduction of a new educational paradigm due to greater interest generated among students in engineering and the enrolment of student intake with abetter knowledge platform and appropriate intellectual skills.. Reduction of attrition rates and increasing retention rates of engineering students has the same effect to increased engineering enrolment. The rather poor completion and retention rates of domestic students are of particular concern [2][3].

The decision, in 2006, to introduce problem-based learning (PBL) pedagogy in 50 percent of the curriculum in both engineering schools at VU was immediately followed by an extensive publicity and marketing campaign in the press and at secondary schools in Melbourne. Whereas prior to 2006 the marketing of engineering at VU was largely based on course offerings, the new and more intensive marketing included pedagogical differentiation as a selling point. The objective of this project is to ascertain the effectiveness of the marketing campaign and evaluate whether any positive outcomes could be attributed to either pedagogical differentiation or just increased marketing of engineering courses at VU.

2 RESEARCH METHODOLOGY

The inquiry, so far, was based on surveys over a period 2008-2012 of students enrolled in undergraduate courses offered originally by the School of Architectural, Civil and Mechanical Engineering (ACME) and its successor the School of Engineering and Science. The surveys were conducted in Engineering Materials classes, which is a compulsory subject in the first semester of second year of undergraduate engineering curricula. The added bonus was that all students enrolled in this subject were required, as part of their assessment, to submit a personal and confidential reflective journal. Many students in addition to reflecting on the subject material conducted a kind of a conversation with the course where all course subject syllabi were subject to interrogation. The journals allowed some qualitative sneak preview into students' perceptions of the engineering curriculum and pedagogy.

The survey was conducted manually because of low student responses were experienced when to electronic Web CT was used for other surveys and course evaluations. It consisted of 9 simple questions, shown in table 1, and the student response was restricted to binary responses of yes and no to minimize ambiguities and time taken to perform the survey. Students were also informed that if course pedagogy would not play a role in their choice of the course they should provide the same answer for both questions 7 and 8 (see Table 1) either both yes or no. Considerable information could be extracted from responses to these questions. The first survey was conducted in 2008 as a pilot study in a relatively small class containing 37 engineering, students. Since this group was heavily weighted towards architectural engineering students, the result of this survey needs to be considered with caution. The surveys taken in 2009 and 2010 were more encompassing with sample survey sizes of 157 and 138 students. Student survey taken in 2011 focused on mechanical engineering students, and in 2012 the sample surveyed consisted of mechanical and infrastructure second year students.

Second year student cohort was chosen for the survey because at the beginning of first semester they could still be considered as first year students who were already exposed to PBL subjects in the first year which constituted 50 percent of the first year curriculum, and were also at the stage of their course where other educational options were open to them.

TABLE 1. *Survey questionnaire.*

(Tick the appropriate column)	Yes	No
1.Did you place engineering as a preferred course prior enrolling at VU? (Was engineering amongst your top two preferences?)		
2.Given another chance would you enrol into a different engineering discipline course?		
3.Are you considering transferring into another (other than engineering) course?		
4.Was VU amongst your two preferences (before change of preferences) on your selection of university 6 months before enrolling at VU?		
5.Are you considering transferring to another university?		
6.Were you aware of PBL course delivery prior to enrolling at VU?		
7.Would the knowledge of PBL as a teaching method make enrolment at VU a more attractive option 6 months before you selected your preferences?		
8.Would the knowledge of PBL as a teaching method make enrolment at VU a less attractive option 6months before you selected your preferences?		
9.Do you prefer PBL subjects to subjects delivered in the traditional instructional way?		

3 SURVEY RESULTS

Table 2 and 3 display the overall and disciplinary results of the survey. The results were a bit of a mix bag. The period of data collection was too short to ascertain any differences between students enrolled in different engineering streams. Table 2 reveals interesting information, which is:

1. The good news was that overwhelming majority of students enrolled in engineering at VU placed a high priority in choosing engineering as their preferred course of study when still in high school. This is not surprising given the growth of interest in the study of engineering [4].

2. The marketing of PBL pedagogy has also has taken a purchase in the awareness of engineering education at VU. Around half of respondents indicated that PBL pedagogy would be influential in choosing engineering study at VU, though the net positive influence which is the difference between positive and negative attitudes varied from 63 to 22 percent. Thus the introduction of PBL pedagogy would positively influence between 10 and 30 percent of the student cohort in their choice of engineering at VU. Survey results conducted among second and some third year mechanical engineering students showed anomaly in the results where 50 percent of all the mechanical students were negatively pre-disposed to PBL pedagogy.
3. A majority of students preferred the traditional instruction-based subject delivery and this preference prevailed even among students who were positively pre-disposed towards PBL education. Many of these students felt the need for more class contact time which has been replaced by problem and project based activities.
4. A significant and rising proportion of students were dissatisfied with the choice of engineering discipline as a course of study. In 2009, 2010 and 2012 students' choice of engineering discipline bore no significant relation to their attitudes towards PBL pedagogy. In fact, students who had no particular attitudes to PBL were most satisfied with their choice of study.
5. No casual relationship could be established between students' likely-hood with continuance with engineering studies and their attitude to PBL.
6. High but falling proportion of students were considering transferring their studies to other universities. Evidence suggests that students' having negative attitude towards PBL delivery are more likely to transfer their studies to another university thus, in the long term, nullifying any positives from the introduction of PBL pedagogy to engineering curricula at VU.

TABLE 2. *Overall student student survey responses.*

Questions	Percentage of Respondents who Responded Yes				
	2008*	2009	2010	2011**	2012
Did you place engineering as a preferred course prior enrolling at VU? (Was engineering amongst your top two preferences?)	88.1	81.9	86.8	94.1	83.1
Was VU amongst your two preferences (before change of preferences) on your selection of university 6 months before enrolling at VU?	48.8	42.1	60.9	25.0	57.5
Were you aware of PBL course delivery prior to enrolling at VU?	16.3	22.1	36.6	15.9	27.2
PBL Pedagogy would be influential in my choice of preference.	69.8	50.0	52.5	50.0	51.9
Positively	80.0	81.6	71.9	0.0	62.1
Negatively	20.0	18.4	28.1	100	37.9
Do you prefer PBL subjects to subjects delivered in the traditional instructional mode of teaching; lectures and tutorials?	67.4	66.8	65.7	47.1	53.2
1.Students who were negatively predisposed to PBL delivery.	100	58.9	64.3	100.0	63.0
2.Students who were positively pre-disposed to PBL delivery.	54.2	71.5	67.4	0.0	45.0
Given another chance would you enrol into a different engineering discipline course?	11.6	18.7	13.3	17.6	25.9
1.Students who were negatively predisposed to PBL delivery.	8.3	19.8	19.5	25.0	33.3
2.Students who were positively pre-disposed to PBL delivery.	0.0	14.9	27.5	0.0	30.4
Are you considering transferring into another (other than engineering) course?	11.6	19.7	10.2	5.9	11.3
1.Students who were negatively predisposed to PBL delivery.	16.7	7.8	16.3	12.5	13.6
2.Students who were positively pre-disposed to PBL delivery.	16.7	19.3	18.9	0.0	9.3
Are you considering transferring to another university?	44.2	49.5	32.8	43.8	24.1
1.Students who were negatively predisposed to PBL delivery.	33.3	84.4	29.5	50.0	60.0
2.Students who were positively pre-disposed to PBL delivery.	54.2	40.8	30.9	0.0	19.0

*Predominatly Architectural Engineering students. **Mechanical Engineering students

Table 3 indicates that the proportion of students who placed high priority on engineering as the preferred course of study was very high across all engineering disciplines. There was a continuous increase in the awareness of PBL among students enrolling in mechanical engineering. However, in retrospect, it was this cohort that was most disenchanted with PBL pedagogy with very high intent to transfer their engineering studies at other universities.

TABLE 3. *Student student survey responses (%) according to engineering discipline.*

(Tick the appropriate column)	**2008**	**2009 %**			**2010**			**2011**	**2012**		
	Arch	Arch	Mch	Civ	Arch	Mch	Civ	Mch	Arch	Mch	Civ
Did you place engineering as a preferred course prior enrolling at VU?	88.1	80.9	76.5	88.9	71.4	91.5	90.6	94.1	76.3	90.0	86.7
Was VU amongst your two preferences (before change of preferences) on your selection of university 6 months before enrolling at VU?	48.8	46.7	47.1	33.3	71.4	61.4	53.1	25.0	66.7	55.1	60.0
Were you aware of PBL course delivery prior to enrolling at VU?	16.3	19.1	24.5	22.2	40.5	27.1	37.5	15.9	25.0	33.3	25.0
PBL Pedagogy would be influential in my choice of preference.	69.8	50.0	50.0	50.0	73.2	48.8	43.8	50.0	39.5	57.1	81.3
Positively	80.0	79.5	74.0	83.3	60.9	80.9	67.9	0.0	57.8	46.7	84.6
Negatively	20.0	20.5	26.0	16.7	39.1	19.1	32.1	100	42.2	53.3	15.4
Do you prefer PBL subjects to subjects delivered in the traditional instructional mode of teaching; lectures and tutorials.	67.4	67.4	66.0	69.4	66.7	65.7	63.6	47.1	48.6	59.3	46.7
1.Negatively predisposed to PBL delivery.	100	55.6	50.0	66.7	61.5	72.2	62.5	100.0	1000	45.5	50.0
2.Positively pre-disposed to PBL delivery.	54.2	71.4	70.0	73.3	50.0	75.0	68.4	0.0	25.0	68.8	36.4
Given another chance would you enrol into a different engineering discipline course?	11.6	20.2	24.5	13.9	22.2	5.8	17.9	17.6	21.6	41.4	13.3
1.Negatively predisposed to PBL delivery.	8.3	20.0	0.0	33.3	33.3	0.0	37.5	25.0	22.2	41.7	25.0
2.Positively pre-disposed to PBL delivery.	0.0	11.1	30.0	6.7	26.7	33.3	20.0	0.0	30.0	41.1	12.5
Are you considering transferring into another (other than engineering) course?	11.6	22.5	30.2	11.1	15.8	8.5	8.8	5.9	11.1	14.3	6.7
1.Negatively predisposed to PBL delivery.	16.7	11.1	16.6	0.0	18.8	0.0	37.5	12.5	16.7	16.7	0.0
2.Positively pre-disposed to PBL delivery.	16.7	22.9	35.0	6.7	20.0	10.5	30.0	0.0	17.1	12.5	10.0
Are you considering transferring to another university?	44.2	49.4	49.0	50.0	32.1	31.0	33.8	43.8	36.1	36.7	20.0
1.Negatively predisposed to PBL delivery.	33.3	77.8	66.7	100	60.0	0.0	50.0	50.0	57.1	58.3	50.0
2.Positively pre-disposed to PBL delivery.	54.2	42.9	50.0	33.3	20.0	36.8	30.0	0.0	14.3	22.2	10.0

4 CONCLUSION

The investment in introducing PBL pedagogy was fairly substantial. I t involved the acquisition and reformatting of teaching spaces, purchase of new laboratory equipment, computers and associated hardware peripherals, and new software. It also required more extensive marketing to support educational innovation.

The data collected has shown that some positives from the investment. Between 10 and 30 percent of secondary students are more likely to choose engineering at VU because of the new pedagogy rather than marketing. However retaining of these students can be a problematic issue that needs to be addressed by further refining the new pedagogy. The data shown in tables 2 and 3 fluctuates widely between engineering disciplines and year of collection. The background noise is too large to bed-down any conclusions.

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66 A CURRICULUM IMPROVEMENT OF MIS COURSE IN COLLEGE

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ABSTRACT

Most of the social science college graduates today will someday work in a computerized application environment. They just believe and utilize the computer application output in their real-world work. Although they have studied some computer business applications in college, they do not know how the applications were made. The problem is that college courses assume that students already know the real-world operations and how the computer software was made. Courses generally focus on how the computer system works and the concept of computer based decision-making without relating to a real-world operation. Therefore, students do not actually evaluate the output; and they only use it as if it is in a black box situation. To understand real-world operations, I have made a virtual company in the class room and have been teaching a business software system design using it. This paper will introduce the teaching method using a virtual company, and discuss the effectiveness of this teaching method compared with book learning, and concludes with a discussion on future research.

Keywords: Teaching method, Business system design, Virtual company, Hands-on exercise

1 INTRODUCTION

Since business software system development is a kind of engineering [1, 2], it has been said that real-world experience is essential for studying system analysis and design [3]. For many reasons, it is difficult to create such a course in a college curriculum. In order for students to prepare for real-world experience, they actually create quasi real-world projects as exercises [4], and teach the course with the help of an engineer from a company [5], and set up a partial operation of a department [6]. All of those ways of teaching are not enough to teach indescribable parts of real business operations, which are important requirements in a real-world system design.

The course consists of roughly four phases: 1) Hands-on exercises of business operations using the model; 2) Analysis of the business operations of the company; 3) System design for the business operation; and 4) Development of a real computer system. This paper will briefly describe four phases of the course and will compare the effectiveness of hands-on exercise against book-learning based on knowledge and skills. It then shows how knowledge from hands-on exercises is helpful to system design.

1.1 The first phase: Hands-on exercises of business operations using a company

In order to study business information analysis and design, the course needs a good model of a company. The model should be as concrete as possible so that students can experience operations that are as real as they can be. Therefore, the best teaching material is to put students in a real company [7]. It seems difficult to do so. One way to overcome this is to build a virtual company that would be very similar to a real one with as simple an organisation as possible. A food wholesaler business was selected as the model company since it has a lot of manual intensive operations; the management structure is also quite simple so that students can deal with it easily.

Branch offices of the virtual company are located in six big Japanese cities. Students operate a Tokyo branch having four sections. There are twelve customer companies, and nine supplies from where the company buys commodities. There are only twelve kinds of commodities. Three to seven students are usually assigned for each section, and three customer companies are assigned to each student; three students take care of all suppliers together. Around thirty students in total participate to perform the exercise.

The length of one cycle of the exercise is one week and will repeat four times in a month. The exercise will continue for a quarter of the year. Students, before starting the exercise, learn about the company and prepare such data as goods, starting inventory and accounting master files with one cycle for practice before starting real operations. A sales meeting is held every month to evaluate operational performance in which students present a P/L statement, a sales and inventory report and so forth; a discussion is held to talk any troubles that may have occurred. The meetings will repeat three times until the end. During the meeting, the instructor questions about the reports and advice for operations in the next cycle.

Throughout the exercise, the instructor plays an important role. Students are usually beginners in business operations so the instructor has to explain tasks in detail not only during the preparation period, but also whenever students have problems with their operations. Another important role of the instructor is to be a timekeeper. The time for a cycle is expected to be constant, but it is common that the starting cycles take a longer time because of poor operational experience. The starting operation may be slow for many reasons. The instructor has to continue monitoring in order to advise how to recover. For the purpose of studying all operations, it is recommended to change the students' role or the section they belong to; but this should not be often and never all members at one time.

1.2 The second phase: Analysis of the business operations of a company

The second phase is a preparation stage designed to follow the system design phase. The thing required here is to analyze current business operations to find problems, and propose revised operations. The target for the analysis is the noncomputerized jobs for which they worked. There could be several jobs in a section, but the selected job for analysis should have a clear job boundary. If the job is very complicated or big, the job has to be divided into smaller ones. There are several analysis methods, but the analysis rule should be simple; if possible, the analysis tasks could be computerized as it will be easier to evaluate [8]. For educational purposes, the evaluation process is crucial not only for assessing the documents, but also for communicating with students. There are two steps for students to document the operation: 1) draw a current operation as precise as possible, and 2) discuss the problems to be revised or computerized, and then draw the revised operational flowchart. If the operation is simple or students can draw the revised flow without drawing the current operations, the above two steps can be combined into just drawing a revised operation flow using a Data Flow Diagram [9].

1.3 The third phase: System design for business operation

Here, students design computerized business operation based upon the revised operation plan. As stated in section 1.2, the revised operation does not mean it is completely new, but could be computerized current operations. Therefore, the instructor should explain the precondition of how a computerized operation should be. If the new operation requires real time operation or on-line data processing, advanced programming techniques are required in the next phase. If the revised operation is only to computerize current operations, a simplified database management system such as Access by Microsoft Co. is good enough for educational use.

1.4 The fourth phase: Development of a real computer system

Lastly, students develop computer programs based on the system design created in the previous phase. As it was stated in the previous section, before starting the development, the preconditions of a system should be clarified. The development procedure will follow that of the Access database system.

The first is to create all master 'Tables' and define the items according to the file format and write the properties of each item. Once all master 'Tables' are prepared, 'Forms' for the each 'Table' are designed in order to be used for typing master data into the 'Tables'. Next is to define input files and its 'Form' for inputting. Students define input files and properties. When input files are prepared with test data, the next task is to define transaction files for holding intermediate data of the process, using the 'Query' function. The 'Query' creating process is a key operation of system development. Students should practice all functions of 'Query' operations. The last task is to print all documents, of which process 'Query' was also necessary. 'Query' is a process which defines all necessary files, to create an output file where all items for printing are included. Then the 'Report' function of Access will create a crude layout and this helps the layout to be modified as the designer intends. There is another powerful function in Access system. All functions or processes created in the system can be connected to run as a stream of tasks, so that the process does not have to be individually run. A set of tasks for a stream run is defined in 'Macro' function, where the first process gets started, and the whole process is executed automatically.

2 HANDS ON EXERCISE ON A VIRTUAL COMPANY

One way to compare the effectiveness of the hands-on exercise against book-learning is, firstly, to itemize knowledge and skills which are expected to be gained by doing their hands-on operations, and then compare them with the book-learning operations. There is a variety of knowledge and skills involved in doing the operations, so these should be categorized in terms of the management level of tasks. They also should be categorized in a knowledge dimension which defines the type of knowledge and skills. The knowledge dimension comes from a revision of Bloom's Taxonomy of Educational Objectives [10]. The purpose is to classify knowledge and skills. In this way a teacher can focus on what and how to teach, so that students can learn well and effectively. The taxonomy classifies knowledge and skills into four kinds: Factual, Conceptual, Procedural, and Meta-cognitive. It also differentiates the cognitive process into six types: Remember, Understand, Apply, Analyse, Evaluate, and Create. These classified knowledge and cognitive processes are categorized in much detail in the book. The knowledge and skills are classified into one of the twenty-four (four x six) cross sections according to the things which a teacher wants to teach in his/her class. The topic in a section will be articulated in a sentence which has a specific object to teach and describes how the object should be studied in terms of Bloom's cognitive process.

Another classification of knowledge and skills is the level of the tasks: 'Top' level, 'Management' level, and operational level. In order to understand the company operations correctly, this classification is important in recognizing the task features of each level and the characteristics of command structure and information flow. Since the exercise is not a typical management game, students spend the majority of their time on operational tasks. Because of a page limit, the operation of knowledge and skills are only shown in Table 2.1.

The left half side of Table 2.1 shows required knowledge and skills, and the required cognitive process with respect to hands-on exercises and book learning. All knowledge and skills for doing tasks is evaluated in terms of the category of cognitive process of Blooms taxonomy which, for sample, indicates as #2 the category of Understand. The #2 means that the knowledge that is expected to do the task is simply an Understand dimension. The cognitive process interval of the two are shown in the next column under the symbol of'DIF', which indicates 'X' as no differences, '△' as minor differences, '○' as clear; and'◎' as remarkable differences. The right half of Table 2.1 also shows the required knowledge and skills for performing MIS design [11]. These are located in the same row of the corresponding required knowledge and skills on the left side. The required knowledge and skills are also evaluated in terms of Revised Bloom's cognitive dimension.

2.1 Knowledge and skills of operational level tasks

Table 2.1 shows the required knowledge and skills only for operational level tasks. This knowledge is considered to be all the tasks that students be well acquainted with. The results of the cognitive process for all knowledge and skills of the three types of the exercise are evaluated and listed under the title of (I), (II), and (III) in the Table.

2.1.1 Factual Knowledge

Knowledge and skills in this category is classified as factual knowledge, which is the basic knowledge necessary for this discipline. This is neither a procedure nor theory. In the Factual knowledge column of Table 2.1, there are, for example, two mentally heavy tasks in the practical training exercise. One is 'Detecting details of items written on documents' This knowledge requires students to learn about details of items in the document that they use. Students must detect inconsistencies among all data. The exercise will help to define properties of the data-base design. The other task is 'Organizing data for later use' This exercise allows students to determine how to organize data for filing so that he/she can deal correctly with the data later. This exercise will also help to define properties of the data-base design. In the business system design (Column III of the right side in Table 2.1), an important skill is how to define input files and access methods. The skill is called 'Designing input file and access method,' but it should be recognized that these techniques are not obtained either through practical training or book learning, but through data-base design exercise. A weakness of book learning is that students do not deal with real products, so they do not realize the problems which could occur when real products are involved.

2.1.2 Conceptual Knowledge

Knowledge and skills about a theory or a commonly recognized method is defined as conceptual knowledge. As shown in Table 2.1, four types of general knowledge and skills are identified as conceptual knowledge. Students learn this theoretical knowledge more efficiently in practical training, but there are only minor interval differences between the two types of training exercise. Applying a theory to a real situation is a good way to understand it. Take inventory control theory, for example, deciding an order quantity is not theoretically difficult to understand, but in order to carrying out in a real situation, students must begin with gathering necessary data from outside of his/her section and preparing that data for computation. Students must not only know about own tasks, but also the tasks other sections. It is safe to say that theoretical knowledge is effectively learned through hand-on exercise.

2.1.3 Procedural knowledge

The procedural knowledge is defined as the knowledge and skills which consists of a certain length of procedural and computational processes. Therefore, students need to get used to the procedure in order to use it. There are many of the kind of tasks in operational level, as it is sometimes called a routine work, which is composed of predefined methods and procedures, and will repeat regularly. As it is shown under 'DIF' column in Table 2.1, there are clear cognitive differences between the two exercises. Students in practical training do not use complicated cognitive processes, but they mainly use Apply process. Instead, in book learning exercise, students tend to Memorize or Understand the procedures. In Understand learning of procedural knowledge, students also show minor cognitive differences between the two exercises. As it can be seen from the system design column that many concrete design knowledge and skills appear, and they require not just Understand cognitive dimension but higher cognitive level such as Create. It means that procedural knowledge through practical trainings is quite helpful in doing system design. Beside, in a real system design, students need to know advanced software techniques such as on-line data-base design skills.

2.1.4 Meta-cognitive Knowledge

Meta-cognitive knowledge is none of the above kinds of knowledge but exists and works as a guide or watcher when the above knowledge is at work. Meta-cognitive knowledge can exist by itself as knowledge of cognition in general or as knowledge of one's own cognition. It would be hard for students to identify this kind of knowledge while doing training, but much material knowledge and many skills for system design can be obtained through the exercise. Knowledge and skills might be called implicit knowledge, which can be effectively obtained through the experience of human interaction. In this sense, the practical training for system design education could play an important role such as a hands-on design project course in mechanical engineering education. One characteristic of the cognitive process dimension is that the learning of Meta-cognitive knowledge needs a higher degree of cognitive processes such as Analysis or Evaluate since in order to recognize the knowledge; students need to determine the value of information in order to use it within a general concept. For example, this often occurs in the situation of human interaction such as 'Coordinating skills with co-workers'.

TABLE 2.1 *Operational level of knowledge and skills of business information system design, DIF[1)]: Interval Differences of cognitive process[2)]*

Knowledge Dimension	Expected Knowledge and Skills of (I) Practical training and (II) Book learning.	(I)	(II)	DIF	Required Knowledge and Skills of (III) Business system design.	(III)
Factual	1. Clarifying detailed information from and to customers.	#2	#1	△	1. Defining design information regarding input and output.	#4
	2. Detecting details of documented items.	#5	#2	◎	2. Defining the detailed property of items.	#6
	3. Clarifying the meaning of words by contrasting with goods.	#2	Not app.	○	3. Clarifying the meaning of written words on a product.	#2
	4. Organizing data for later use.	#4	#2	○	4. Designing a data file and accessing them properly.	#6
	5. Detecting a delay for data processing.	#2	#1	△	5. Designing input files and accessing methods to stored data.	#6
Conceptual	1. Using theoretical and computational methods to get a specific result.	#3	#2	△	1. Organizing appropriate data and method to determine detail specification.	#4
	2. Constructing theoretical background of operational decision-making.	#2	#2	X	2. Constructing computational procedure for operational procedure.	#2
	3. Carrying out computation to get indexes for decision-making.	#3	#2	△	3. Using computational procedure to get indexes.	#3
	4. Clarifying labour saving and computerization.	#2	#2	△	4. Structuring computerization boundary of a job.	#4
	1. Finding essential data by carrying out real work.	#3	#1	○	1. Finding I/O information required to complete a task.	#4
Procedural	2. Finding a set of tasks to complete by carrying out a real procedure.	#3	#2	△	2. Generating an entire job process and design information process flow and I/O layout.	#6
	3. Clarifying how work relates to that of other sections or companies.	#2	#1	△	3. Detecting works influenced by computerization.	#5
	4 Clarifying complexity of work procedure.	#2	#1	△	4. Organizing how to transfer a job to a computer system.	#4
	5. Using inventory control rules to real products.	#3	#1	○	5. Translating inventory rules for computer system.	#2
	6. Clarifying operational procedure by carrying out real operations.	#3	#2	△	6. Understanding operational procedure.	#2
	7. Carrying out accounting procedure to real money.	#3	#1	○	7. Paraphrasing accounting procedure into information processing.	#2

Meta-Cognitive	1. Identifying things to be discussed with co-workers.	#1	#1	△	1. Drawing a conclusion that the same data is used in multiple places.	#2
	2. Detecting differences between jobs described and practiced.	#2	Not app.	○	2. Illustrating the necessity and sufficiency of data to practice a task.	#2
	3. Recognizing confidence with one's work by practicing actual operations.	#1	Not app.	△	3. Detecting the value of a computer system.	#2
	4. Detecting information features between management and operational level.	#5	#4	△	4. Differentiating a report of management and operational work.	#4
	5. Coordinating skills with people outside of section or company.	#5	#2	◎	5. Detecting skills of proper information from outside people.	#5
	6. Coordinating skills with co-workers.	#5	#2	◎	6. Coordinating skills in order to get appropriate information.	#5
	7. Creating skills of formal documents.	#6	#6	X	7. Creating skills of formal documents.	#6
	8. Distinguishing relevant from irrelevant work for humans.	#4	#2	○	8. Differentiating a boundary of computerization.	#4

1) Interval Differences X: No; △: Minor; ○: Clear; ◎: Remarkable. 2) Cognitive Process Categories #1:Remember（Recognizing, Recalling）; #2:Understand（Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, Explaining）; #3:Apply（Executing, Implementing）; #4:Analyze（Differentiating, Organizing, Attributing）; #5:Evaluate（Checking, Critiquing）; #6:Create（Generating, Planning, Producing）

2.2 Assessmets of interval differences

To do an experiment in the course is a big burden in a small institute, and to measure the numerical value of the expected knowledge and skills is very hard. Although it is not scientifically rigorous [12], one way of measurement is to identify the expected knowledge and skills of the exercise, and then self-evaluate [13] them in terms of Bloom's taxonomy of cognitive processes. The differences of the cognitive category between the two exercises can be compared, with results written under the title of 'DIF' in Table 2.1. The Table states that in the Meta-cognitive process, there are knowledge and skills, which shows remarkable differences between the two exercises. It is safe to say that the knowledge and skills in the practical training could be effectively learned by real human interactions. There are also clear differences in the procedural dimension. It could be said that students in practical training can learn procedural knowledge very effectively. There are not remarkable differences in types of conceptual knowledge, but students in practical training may learn much effectively factual knowledge such as the details of documents that are used in the exercise. Lastly, the evaluation results for management and the top level of tasks are not shown here. The 'DIF' of all knowledge on both levels do not show significant differences between the two exercises.

3 CONCLUSION

The results are not scientifically driven by a teaching experiment, but the self-assessment closely follows my own teaching experience. In order to get full confidence for these results, proof by a scientific experiment may be required.

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67 ENHANCING STUDENT MOTIVATION BY MEANS OF SOFTWARE PROGRAMMING PROJECTS

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ABSTRACT

Degree Programme in Information Technology in Turku University of Applied Sciences is a 4-year study. We have arranged interesting software projects for the second year students. The aim of the projects has been to improve motivation for programming and real-life business. Here we present four examples about projects that have helped students to achieve confidence in team working. First we discuss the importance of iterative models. It follows experiences of four students concerning the employment after the project and the cooperation between our students and companies. The positive results of projects enhanced motivation to learning and working. Besides, one student participated in a project with students of Health Care department. It turned out that the interdisciplinary project was encouraging. The analysis of this paper is qualitative.

Keywords: Engineering education, Software project, Iterative models, Motivation.

1 INTRODUCTION

We in Turku University of Applied Sciences have several basic programming courses for our students. The students belong to the Degree Programme in Information Technology. Many of them consider that these courses are difficult. There are many reasons for that.

Usually our students have very different backgrounds concerning programming skills. A heterogeneous student material requires individual teaching. This is not, however, easy to realize because of the lack of teaching resources. We have got a good support from the interactive system ViLLE [1]. The system works in the web page and hence the students can use it at their home. ViLLE runs a program step by step and asks questions from a student. The questions are multiple choice tasks. The system gives points of each module and shows the total points of the module. A teacher has also possibility to look at the total points of the whole course.

Some students are of the opinion that also mathematics courses are difficult. The skills of mathematics and programming are related to each other. A study in Coimbra gives some evidence about this relation [2]. They found a correlation between the programming results and mathematics grades in secondary education. They conclude that most students do not understand basic mathematical concepts and it is reflected on their abilities to solve problems and possibly also on their programming skills.

One problem in basic programming courses is that it may be difficult to give interesting programming exercises. That is largely due to the fact that many interesting programs are complicated and take a lot of time to design and realize. Some people suggest using games [3], but again creating graphics and animation can be a time consuming process. One solution may be games like ones in the Microsoft's XNA Game environment. It includes a ready-made framework for graphics, sounds and animation. A student can make a small game with moderate efforts. For mathematically talented students there exists Project Euler [4]. It is a series of challenging mathematical and computer programming problems. New concepts are given in the context, which are intended to be fun for curious mind. Many low-grade students maybe should try short programming exercises as in the web page [5].

However, many problems remain. That is why the aim of this paper is to describe, how the courses that are based on projects can improve motivation to software programming. Besides, these projects often connect students and software companies and offer opportunities for entrepreneurship.

2 THE IMPORTANCE OF ITERATION IN PROJECTS

A repetition of a process is an iteration, if

- it has a default value that is a starting point of the first iteration
- the result of the iteration is a starting point of the next iteration
- the process of iterations stops, when the result of an iteration is near enough the target value

In mathematics the iteration methods are used, when it is difficult or impossible to get the exact value. However, a simple division algorithm can be understood also as an iterative process. Usually each iteration produces the more precise result. The iterations are very common in programming. Then the iteration is a repetition process and the number of iterations is a finite integer.

The corresponding concept in Problem Based Learning (PBL) is a PBL cycle. We refine and expand our ideas in each cycle.

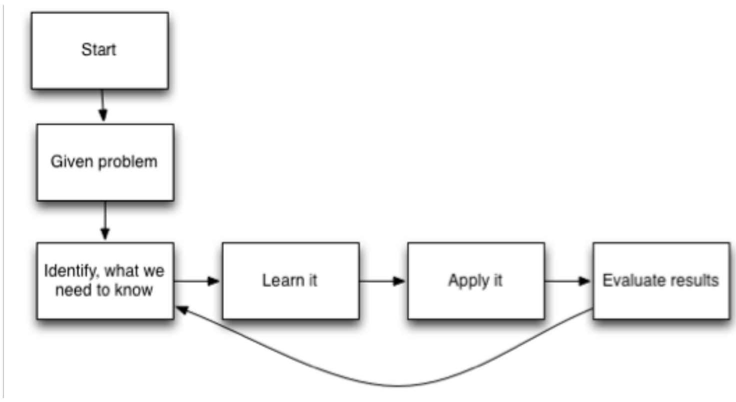

FIGURE 1. *PBL cycle.*

Waterfall models were used earlier in projects. It is a model, where the transition to the following phase takes place only, when the current phase is completed. The design process is sequential.

The more modern software management models emphasize iteration. These kinds of models are for example Rational Unified Process (RUP) [6], Extreme Programming (XP) [7] and other agile methods. These were developed because of weaknesses of the waterfall model. The agile methods use short cycles and utilize earlier iterations. Usually the team starts with a basic subsystem of the requirements. They analyze, design and implement it. Testing and evaluation are continuously present. After the first iteration they have a small prototype. Subsequent iterations cultivate ideas and add functionality. Thus the software becomes more mature version by version, when new things are added to the software in the iteration. Therefore the term incremental development is often mentioned with iterative development.

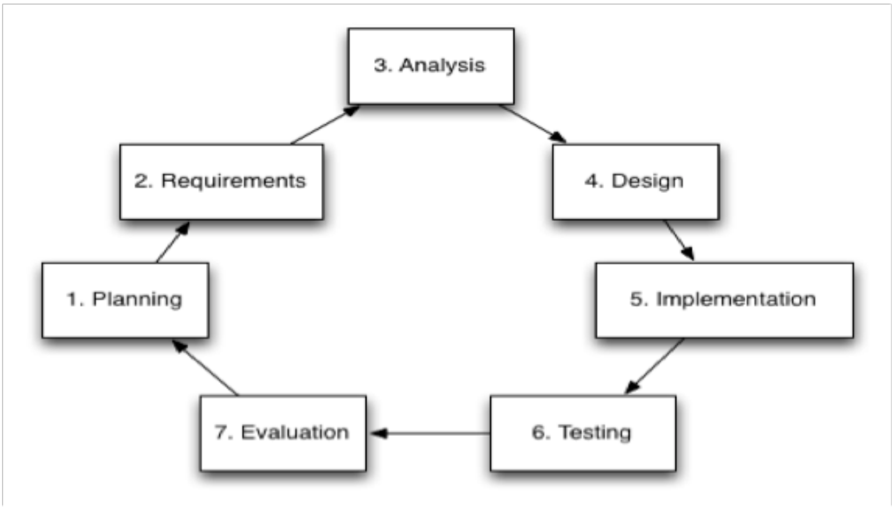

FIGURE 2. *An iterative model.*

RUP has also named different phases. The first phase Inception takes care of the scope of the project, requirements and risks. In Elaboration architecture is designed. Construction phase includes analysis, design, implementation and testing incrementally in iterations. In Transition the system is delivered. RUP uses also Unified Modeling Language (UML) diagrams in every phase of the project. [6]

The characteristic properties of XP include intensive code testing and social impact. The code is tested with unit tests and acceptance tests. These tests may be automatized to the high level. XP favors pair programming and communication with a customer. Feedback from customers, team members and the system has a high value. [7]

3 SIMILARITIES OF ITERATIVE METHODS AND CDIO

The engineering education framework CDIO started from MIT's new kind of course in the Department of Aeronautics and Astronautics. Crawley and Waitz wanted to bring real-world engineering to their students. New courses were based on design-and-build projects. The name CDIO came from the words conceive, design, implement and operate. [8]

Conceive defines customer needs and conceptual, technical and business plans. Compare this to figure 2, phases 1 and 2.

Design "focuses on creating the plans, drawings and algorithms that describe the product, process or system that will be implemented" [9]. This is presented in the phase 4 in figure 2.

Implement takes a design and produces software or other product. It contains manufacturing, testing and validation. Essentially they are the same things as phases 5, 6 and 7.

In the Operate phase the product is ready to be delivered. Normally the process does not stop here. On the contrary, the product has to be maintained, training and servicing to the customer has to be arranged and somewhere in the future the life cycle of the product is bound to come to the end. In iterative models the used word is deployment. According to the report [10] deployment includes the activities related to the release, installation, activation, deactivation, update, and removal of components.

Of course CDIO is a comprehensive framework and contains many other aspects. For example social skills in-group working, assessment and evaluation of processes, and contacts to companies are distinguished features.

As a summary we see that many product making models have a lot of common. Some models stress certain things more than the other models. Modern society requires fast changes and a rapid product development, which leads to faster cycles. Iterative models find their niche in this environment.

4 LOW MOTIVATION OF STUDENTS

Motivation is a multifaceted term and is connected to many problems in engineering education. We have met many students with low grades. Often the same students have a poor attendance and they are in danger of quitting their studies. The research [11] shows that participation in school gives positive results and also on the contrary. This leads to better grades, too.

Why students drop out, is discussed in the paper [12]. According to this research there are push effects, it is situations or experiences within the school environment, and pull effects, it is external factors. One interesting point is that we may affect to better participation by involvement in co-curricular activities (CCA). The ministry of education of Singapore informs that every student takes part in one of the following CCAs:

- Sports and Games
- Uniformed Groups
- Performing Arts Groups
- Clubs and Societies

[13]

We have a tutoring system, but is it enough? Should we do something similar as in Singapore?

5 STUDENT PROJECTS

Basic programming courses in Turku University of Applied Sciences contain concepts of procedural and object-oriented programming. Besides, we have programming with Lego Mindstorms for freshmen.

When the students have passed basic courses, they should have experience of designing and coding small programs. In the end of the second year students get a bigger challenge, a real project from the customer. The leap from basic courses to projects can be quite big for some students. The ideal customer is a company, but sometimes the customer is a person from our administration or a lecturer of the other department or school. Here it follows some opinions of four students. Of course the students are amongst the most talented ones.

We take first some common notions. The motivation of the programming groups grew as the project advanced, because this was the real work for the real use. Every project participated to ICT Showroom, which is an exhibition and a competition for students. Thus the project had a clear endpoint. Both the public exhibition and the competition raised motivation to do the work ready on time. Generally, the feedback of projects from students has been positive. It has been arranged as a written report or as an interview. No statistical research of feedbacks has been done yet.

5.1 Group 1

One group made an educational game to help students of dental hygiene to deepen their knowledge. At the same time they cooperated with four students of dental hygiene, who prepared their bachelor's thesis about games in education. The interdisciplinary project was very valuable for each group. The result arouse such interest that one student was invited to ITK 2012, which is a conference of Interactive Technology in Education.

This group has following opinions. The project was near the working life project and therefore an interesting task. Tutoring was continuous and supporting. The group had, however, a lot of learning, for example, how to divide project design and coding between the members. Every member showed enthusiasm about the topic of the project, which they considered useful. They also told that the combination of a game and learning is appealing for students.

5.2 Group 2

The requirements of this project were demanding. One company had some protocols related to mobile synchronization. The group realized this system. The group succeeded so well that the company wanted one student to continue this challenging project.

The student is working nowadays in the same company. He has worked in many areas with open source systems. We can mention only a few of them: monitoring synchronization servers, realization of Symbian and iOS device management protocols and some multicast communication in clustered servers.

This student said that the project was necessary to his employment. In this case the most motivated thing was to transform the design to the working software product. In case of difficulties the real experts of the company were available. It is not easy to arrange the same development environment in the classroom with such expertize.

5.3 Group 3

This group had many capable students. They contacted a local game company, which had developed a hit product for iOS. The group transformed the game to Android system. In project they got acquainted with a new cell phone technology, which boosted them to do a lot of work. Students are usually very keen on multimedia and here they had a possibility to apply graphics, sound and video.

After the project the employment of the students has been good. The same company took one student to do his work experience. The other student saw his own capabilities of programming. The company atmosphere turned him to establish a small company, which is making games to some Finnish schools for learning mathematics.

5.4 Group 4

The second year project was crucial for the students of this group. They had an idea for the project. Because they knew, what they wanted, they chose some virtual courses freely for supporting their project. The topics they were interested were available only in virtual courses. After winning the competition in our ICT Showroom they went on the Imagine Cup competition of Microsoft with great success. They highlighted the following things for motivation:

- to have their own idea that they can design and implement
- a competition, to which they can bring this idea
- external courses that support their vision
- contacts to other competitors opened their eyes for larger insight

The employment situation of the students of the group is excellent. One member got contacts to Microsoft; one established an advertising company and the others received interesting jobs.

6 CONCLUSION

These few examples are typical ones, when our students have got a real life project. Thus the connection to companies is a remarkable factor to receive interesting topics with modern technology. At the moment it seems that a cell phone game is the most attractive area in technology. Our challenge is to get these elements moved to classes and hence increase student motivation. Iterative models have become very important in projects. Hence our question is: How much they can help us in our classrooms?

7 ACKNOWLEDGEMENTS

The acknowledgements go for my colleagues and students, who have participated to these projects. This paper would not either be possible without the support of our organization.

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70 ENTREPRENEURSHIP IN A CURRICULUM REDESIGN OF COMPUTER ENGINEERING

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ABSTRACT

Brazilian educational system does not favour entrepreneurship and only a small percentage of the population has formal training in entrepreneurship. The computer engineering course at the State University of Feira de Santana started in 2003 and among its objectives it was stated that it would encourage the creation of new technology-based businesses. Although former students declared that they were interest in opening a new business, most of them did not start up a business. During the curriculum redesign processes, a couple of new components were proposed to address entrepreneurship training. In Entrepreneurship I, the student will build business plan from an business idea proposed by them. Entrepreneurship II focus on early development of the product defined by the students in their business plan developed in Entrepreneurship I. As a final goal, it is expected changes in the local scenario with the start up of new IT business in local region by former student of computer engineering.

Keywords: Engineering Education, Entrepreneurship, Computer Engineering, Brazilian Education, Innovation.

1 INTRODUCTION

According to a report from Global Entrepreneurship Monitor [1], Brazilian educational system does not favour entrepreneurship, and is considered focused in educating employees. Particularly, university education does not address entrepreneurship and only 9% of Brazilian population had start-up training, with a much smaller percentage having formal training at universities [2].

The Computer Engineering course at the State University of Feira de Santana (CE-UEFS) was the first course in Information and Communication Technologies at UEFS and is the only biased IT course in a university at Feira de Santana. Feira de Santana is the second largest city in Bahia State with almost 600 thousand inhabitants and a Gross Domestic Product of more than 3 billion dollars [3]. The main economic activities are based in Service Industries, Manufacturing Industry and agriculture. Even so, businesses in Information and Communication Technologies remain incipient in the city, and it was hoped that a new computer engineering course could aid in changing this scenario.

Therefore, among the objectives of the CE-UEFS, it was stated that it should stimulate the start-up of new technology-based business. Nevertheless, until now, almost none of the graduated students have not got involved in new business start-up. And among the reasons stated by former students for the lack of interest in constituting new business is the lack of information on the subject.

The curriculum of the CE-UEFS was redesigned in 2011, and with support from the university's Office of Technology Innovation, new courses were included to address issues related to entrepreneurship in order to improve the our students' profile in these areas. Technological innovation and associated themes, such as entrepreneurship and university-industry collaboration, were only recently included as an important topic in Brazilian government agenda. The Innovation Law, approved in 2004, stimulates the transfer of know-how from university to industry. It also allows the creation of the Offices of Technology Innovation (OTI) at public universities, which are in charge for managing the relationship between the academy and the industry, with the start up of new business as a possible path to integrate university with the industry.

In the next section, the computer engineering course is described, together with its innovative problem-based learning methodology and the curriculum redesign process. In section 3, an approach for two courses in entrepreneurship and new business start up is proposed. In the last section, final remarks and expected outcomes are elaborated.

2 THE COMPUTER ENGINEERING COURSE OF THE UEFS

The CE-UEFS followed the national curriculum guidelines defined by the Ministry of Education. The first curriculum was proposed in 2002 and went through small changes until 2010, when the curriculum redesign process started.

The course has an innovative pedagogical project, mainly for the use of Problem Based Learning (PBL) as a methodology in many core course. In Brazil, CE-UEFS was the first undergraduate course in the IT area to use PBL and, as far as we know, stays as the only course in computer engineering to employ such methodology in Brazil.

The Problem-Based Learning approach is an active, adult-oriented, problem-centered, student centered, small-group (groups of eight to ten students) method [4]. Problem-based learning is defined as a process of teaching that uses concrete problems to motivate students and that is focused on student-centered activities. Instead of the emphasis being on teaching, greater significance is given to the learning process [5]. Thus, students are introduced to the subject matter through related practical problems, together with the underlying theory, after which they work independently, individually, or in groups, to arrive at suitable solutions. The students decide what they study and take full responsibility for the learning process.

The decision to adopt PBL in the course was made because this methodology has been recognized as one that could to reinforce the interaction between theory and practice. Another important characteristic of the course is the integration of some curriculum components by grouping courses with related content in the same semester, sharing studies, works, challenges and learning opportunities (for more details, see [6]). Nowadays, the use of PBL allows us to easily integrate several components of the curriculum in order to face the continuous increasing in the volume of technical and scientific knowledge required by the engineers, as long as help the students to develop independent and lifelong learning skills.

2.1 The First Curriculum

The pedagogical proposal of the course had several features that distinguished it from traditional curricula. The course was designed in order to achieve curricular flexibility, allowing faster curriculum update, focus on student education, possibility for integrating basic studies with professional studies and use of diverse academic activities.

The course was divided into basic core (math, physics, etc.), professional core (basic fundamentals and techniques of computation) and specific core (technology computing and multidisciplinary applications). The core specific, that involves knowledge and technology very specific and/or volatile, was covered by a set of optional components curricular.

The composition of the optional components curricular offered to computer engineering course can be changed by the Board of the Computer Engineering Course, which can create new optional components curricular, change or exclude existing optional components , according to the composition and qualification of its faculty and demands of local society and market.

Another characteristic of the course's pedagogical project was humanistic and complementary education for the computer engineer, focusing on wide education and other aspects that are not only technical formation. These aspects involved knowledge that allowed students to better understand the reality around them, to perceive the moral, ethical and philosophical aspects involved in living in society and to understand the role of humans as a producer and multiplier of knowledge and culture, in other words, the students gain a wide cultural background. The complementary formation aims to give the student the capacity for teamwork, ability in verbal and written communication and capacity of business management.

At the end of the course, in order to improve students' investigative and scientific profile, they should write a monograph describing results of a research project performed under the supervision of a faculty member. Also at the end of the course, students must perform the obligatory internship in a business company.

A innovation of the first curriculum was the creation of thematic projects of computer engineering. This component was created with the goal of bringing the practice of realistic projects into the course. A traditional course usually has not enough time to conduct long-term projects, so common in day-to-day organizations. Moreover, a traditional course does not allow satisfactory integration of knowledge with other courses. The first attempt to solve such problems, in the first curriculum, was the creation of curricular components called Annual Projects. The Annual Projects were performed by a group of students under the orientation of a faculty member, who defined the proposal to be developed, simulating a real-world project. However, the implementation of these components had many disabilities and operational difficulties. Annual Project was not able to reproduce a real-world project development, because teachers generally proposed more academic themes and there was not business plan or customer need analysis. Also students felt frustrated for not being able to propose a project of their own.

2.2 Curriculum Redesign

Since the start of the computer engineering course at UEFS, the initial curriculum have gone through small changes aiming at improving it, based on experience and results in implementation of the course. Nevertheless, as new faculty members got engaged with the course and more experience was accumulated with the curriculum components, the need for a curriculum resign process started in order to cope with bigger changes and rethinking the curriculum as a whole. In 2010, a commission with a large number of faculty members started the curriculum redesign process and, in 2011, a project with this aim was presented and approved by the university's higher councils. It was not proposed a completely new curriculum, but rather a set of small and big changes to be made to curriculum components, such as in syllabus, components order, sequence and integration, as well as creation and exclusion of components.

One aspect in the curriculum proposal that motivated the need for change was one objective proposed for the computer engineering course that could not be achieved. It was proposed as an objective that the course should encourage the creation of technology-based companies in the local region through training students with pro-active and entrepreneurial attitude and through technology transfer of hardware and software for these companies. Nevertheless, only a few graduated students considered starting a new business.

To better diagnose the professional career track and business start-up interest by former students that graduated in computer engineering, a form was sent to them with questions regarding these aspects. From 53 graduates, 28 answered the questionnaire, about 52%. Analysing the answers, it was noted that almost all of them have become employees or go into public service, mostly in other cities. Only two business were started by former students: a groups of graduates started one but closed after a few years and another graduate started another one and it is still developing its product. But almost 40% of the graduates were interested in starting a new business during/after their computer engineering course. Reasons for this interest included the possibility of solving technological challenges, guiding their own directions, working on something of personal interest and better earnings. But the ones that were interested in starting a new business and did not do so, stated that the lack of an idea for a business and also the feeling of not being prepared to do so, prevented them from becoming an entrepreneur.

Based on this analysis, the commission for curriculum redesign decided that entrepreneurship training should be an obligatory course in computer engineering at UEFS. It would help achieving the objective of stimulating new business start up by former students and also technology transfer for the close relationship of these new businesses with the university. As Annual Project in the first curriculum did not fulfil their intended proposal, but it was important for students to experience real-world project, it was decided that Annual Project should change into an Entrepreneurial Project. Students should be able to propose their own projects in Information and Communication Technologies, but in the form of a business plan. And, afterwards, since it is an engineering course, they should execute what they proposed and develop their product/service, thus also becoming an opportunity to integrate knowledge from various subjects.

3 THE PROPOSAL OF ENTREPRENEURSHIP

Entrepreneurship has been claimed as a cornerstone to the improvement of the actual economic scenario, mainly after the blast of the recent economic crisis the world is facing, and the newly graduated students in Brazil are been more and more demanded about their entrepreneurship' skills.

In order to prepare our students for facing this new scenario, we included entrepreneurship as two formal obligatory courses in the curriculum of Computer Engineering. In such courses, we intend to initiate our students in the entrepreneurship universe and help them to develop their skills in this area inside a safe environment. Furthermore, we will use the courses as an opportunity to discuss more deeply many aspects of product development, such as marketing, financing, taxes, which are not treated in the technical courses. Entrepreneurship training includes divided into two sequential courses, Entrepreneurship I and Entrepreneurship II, each one taking one semester.

3.1 Entrepreneurship I

Entrepreneurship I takes 60 hours (15 weeks) and has two main goals: a) to stimulate students to think about how they can create and drive their own business, even before they conclude their graduation, and b) to help students to learning the steps involved in planning of new technology-based enterprises.

This course focuses on preparing students to create their own business by aligning the technological and scientific concepts acquired in other courses. The students have two weekly meeting of two hours each in which they receive information about technical concepts about entrepreneurship, intellectual property, innovation, marketing, finance, human resources, administration and other topics related to how to start and maintain a business.

The idea is to introduce these concepts to students so they can open their minds to the complexity and peculiarities of driving a business, so these concepts are discussed in a easy way in order to not overwhelm the students with many technical aspects of these areas. We intend to encourage the students to think about creating a business instead of scaring them with the huge amount of information related to each theme.

Special attention will be dedicated to show the students that to create their own business, instead of being a possibility only for students in developed countries, is also possible to them and that it may be a path they can follow in order to reach their professional success. One of the major difficulties we are facing, in our course, is that the students are not used with the idea of have their own business. Instead, they are used with the idea of getting a job in a company or in public service, and the majority of them have to leave the city to achieve this, because we do not have opportunities in Feira de Santana region.

Another important part of this course is to teach the students how to create a business plan. For this, the students will have to choose a business idea related to the IT market, local or worldwide, and, using this idea, they will have to prepare a complete business plan. Several models of business plans will be discussed by analysing real business plans. The students will be guided through the several parts of a business plan while they build their own plan. At the end of the course, the students will present their business plan to a board of evaluators, who will assess the quality of the plan according to the economical and technical viability.

3.2 Entrepreneurship II

Entrepreneurship II takes 90 hours (15 weeks) and has focus on the initial development of the product defined by the students in their business plan developed in Entrepreneurship I. It is a practical course in which the students will have two hours weekly meetings with a faculty member, called Coordinator, who will follow them in the implementation of their business plan. This weekly meeting can also be used for activities related to the start-up of the business, like contact with potential customers or implementation of the product.

Besides the Coordinator, students will be assisted by other faculty member, the Advisers, who are experts in the subject area of the product proposed by the student and help with technical issues that arise during the development of the proposed product. Four weekly hours, at minimum, can be used by students to meet their Advisers or perform specific tasks related to developing their product.

At the end of the course, the students will present a report about the implementation of their business, detailing the product and describing their experience along the process and how they intend to continue their activities with it.

4 FINAL REMARKS

In this paper we presented an approach to include the entrepreneurship training in the Computer Engineering Course at State University of Feira de Santana. We presented the context in which the course was conceived and also how it evolved into the idea to give our students skills to face the challenges presented by the current economic scenario in the world.

Our first major difficulty is the lack of experience in such activity because very few faculty members have practical experience in starting up and managing business. Furthermore, the students are used to think about themselves as employees instead of driving their own business, and such behavior demands an additional effort in order to help them to change their point of view.

Since the new entrepreneurship courses are in its initial phase, we are still learning about how to better perform it. So far, during Entrepreneurship I course, we have received a positive feedback from the students, which are excited with the new possibilities they can achieve as entrepreneurs. It is hoped that the development of entrepreneurial skills by students can motivate graduates to undertake new businesses, encouraging the creation of new technology-based companies, contributing to development of the Feira de Santana's region, Bahia. This experience in bringing entrepreneurship training to an engineering course may also serve as a starting point for other similar initiatives in other Brazilian universities.

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71 CHEMICAL ANALYSIS SERVICE: LEARNING IN PROJECTS

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ABSTRACT

The pedagogical philosophy of the Turku University of Applied Sciences emphasises fostering innovation through work-based learning, i.e. close collaboration with businesses and working life through R&D projects. Chemical Analysis Service first began as a project in the Degree Programme of Laboratory Technology. The need for this project was a response to increasing requests from industry partners to various chemical analyses, analytical methods and quality control. The Chemical Analysis Service has expanded into a learning environment, offering students an opportunity to improve their skills in the fields of chemical analyses and quality. The topics have included e.g. testing natural water field analyzers, waste water analyses, antimicrobial active substance analyses, water purification resin testing and heat capacity testing of bioenergy. Chemical Analysis Service has been a successful project especially developing the students' skills in laboratory technology. Pedagogically it has been significant importance applying project work and innovation pedagogy to the real-life cases.

Keywords: Project learning, Integration of RDI and teaching, Student motivation

1 INTRODUCTION

In 2007, Chemical Analysis Service began as a project in the Degree Programme of Laboratory Technology which was integrated into the Degree Programme of Biotechnology and Food Technology in 2008. The number of students in Laboratory Technology programme varies annually from 10 to 15. The need for this project was a response to increasing requests from industry partners to various chemical analyses, analytical methods and quality control. After running for several years the Chemical Analysis Service has expanded into a learning environment, offering students an opportunity to improve their skills in the fields of chemical analyses and quality. The topics have included e.g. testing the natural water field analyzers, waste water analyses, antimicrobial active substance analyses, water purification resin testing and heat capacity testing of bioenergy as well as method development for chromatographic and spectrometric analyses.

Chemical Analysis Service was established when one of our clients from a small chemical company needed the product quality control. The major problem was that the client didn't even know which critical process parameters to analyze. The conclusion from the consultation was that one of our students made the bachelors thesis about the quality control in the company having a chemistry lecturer as the instructor and expert of the subject. The problem was solved and excellent feedback was given by the client. Later, it was noticed that the case was a good example of the CDIO-chain: Conceiving -Designing-Implementing-Operating. The beginning was to consider and discuss the problem with the client. The second step was to investigate the process and the product to find the critical points. After that there was implementing and finally the execution and operation. The task included plenty of disciplinary knowledge integrated into professional skills and practice. The chain of CDIO matches well with innovation pedagogy which is pedagogic strategy of Turku University of Applied Sciences. [1]

2 THE PROGRESS OF CHEMICAL ANALYSIS SERVICE

During the first years only few students were involved in the projects of Chemical Analysis Service. This led into the situation where only few and carefully chosen students could accomplish their studies in the project. The rest of the student group had to settle for the traditional laboratory work. However, the advantage gained was that the critical parts of the Chemical Analysis Service project were spotted to make the required changes.

Before participating the Chemical Analysis Service, the students have performed the first year of their studies with basic knowledge on chemistry, analytical methods and laboratory practices. There are several possibilities for participating the Chemical Analysis Service. The student can cover a part of a course by participating a project. Some students have completed their practical training in a project. All this requires flexibility and interpretation of the curriculum as well as good will and flexibility from teachers.

One of the critical issues was to assure that the measurements and analytical methods were reliable. Before testing of the real samples it is essential to investigate a method of analysis, test it, find the limits of the measurements and prove the validity of the method. The solution has been the integration of the project with Quality and Metrology course which obviously connects the RDI and teaching in innovative manner. Moreover, the students perform the method development in courses of Analytical Techniques, Instrumental Analysis, Environmental Chemistry or in Physical Chemistry depending on the subject of the project. However, the combination of a project and the curriculum can be inconvenient because the needs of the clients are not connected to students' schedules. It is possible that there is no appropriate course going on to adopt a new project to be a part of the course. For this kind of situation we have established a course called "Project" where the students can implement the client requests.

2.1 Phases

In the first phase The Chemical Analysis Service was started on the basis of the clients need for analyses. The project needed only one student to solve the problem and finish the assignment. Benefits were mutual: the client's problem was solved and the student achieved valuable professional skills and knowledge about process and quality control. Moreover the student made her bachelors thesis on the case.

The second phase started a year later when the co-operation with the degree programme of Sustainable Development was beginning. The task was to test some environment field analyzers. In the project two students performed their practical training as well as some project studies and optional studies. The same students continued their studies in project by participating to the next and remarkably bigger project concerning domestic sewage disposal. It was an EU project which needed waste water analyses. The amount of laboratory work increased and finally there were five students who accomplished the series of hundreds of waste water analyses.

The third phase in the developing the Chemical Analysis Service was to integrate the RDI projects to teaching to involve the whole group of students into the RDI projects. This started in 2010 when the whole group of students in Laboratory Technology did their first method development, sample treatment and method testing in variety of RDI projects.

Table 1 shows the development of Chemical Analysis Service learning environment beginning from the single student project to a RDI-integrated, the whole class employing study method. Some students have worked as student assistants and they earned some wages instead of getting credits.

TABLE 1. *Development of Chemical Analysis Service.*

Academic year	Task	Number of ECT credits	BSc Thesis	Students
2007-2008	Quality control project for customer	18	1	1
2008-2009	Environmental field analyzer	45	0	2
2009-2010	Environmental project	20	0	5
	RDI-projects in Analytical Techniques course (e.g. prel. tests of biodiesel, AAS, FAME, sports drink)	32	0	16
	Practical training (Ag)	24	0	2
2010-2011	Projects for Susbio (e.g. GC)	20	0	10
	Bioenergy: heat capacity measurements	0	0	1(paid)
	Practical training (GC for VFA)	24	0	2
	Projects (etheric oils GC-MS, FIA, etc)	20	0	10
2011-2012	Quality in laboratory	63	2	7
	RDI-projects in Analytical Techniques course (e.g. KF, Iodine number, AAS)	26	0	13
	RDI projects integrated in other laboratory courses (e.g. validation, qualification, method development)	38	0	10
	pH project	0	0	1 (paid)
	Chloride in water	4	0	4
	Project work	21	0	3

The progress of learning in projects is shown in Figure 1: the total number of the students involved and the credits achieved. The growth of project activities has resulted in a situation where many new aspects and procedures have to be reconsidered.

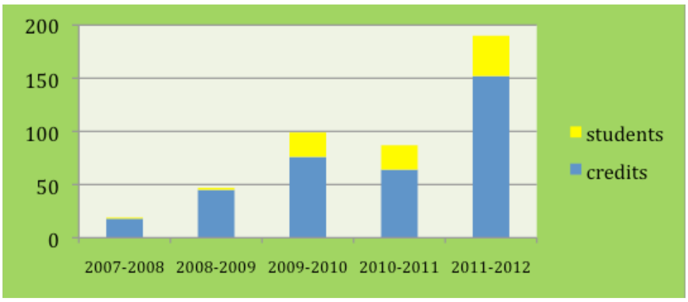

FIGURE 1. *The progress: number of students and credits in Chemical Analysis Service projects.*

In 2010, the whole class of students participated Analytical Techniques course integrating RDI-projects. The experiences from this first trial were so promising that we have continued to integrate RDI to teaching ever since. In order to fully understand the entire objective the students are themselves in contact with the client. Most students have been highly motivated. They have reported that they had learned much more in a project than in a traditional learning situation arranged in the laboratory. A connection to the "real world" and a deep concentration on the chosen topic has been reported rewarding and the learning results are clearly better. Furthermore, the student experiences the entire project cycle from the first contact with the client to objective definition, reporting and feedback.

The integration of teaching and RDI has extended to quality issues including new quality projects in the Quality and Metrology course. Furthermore, new courses are adopting RDI parts at least in some extent. E.g. Physical Chemistry lab and theory as well as Environmental Chemistry can easily be integrated to RDI projects.

The proceeding has not always been successful. For example, in a case of chromatographic method development the project was integrated to a traditional laboratory course. The idea was to make an on-going method development: the student was supposed to pass the results and knowledge of the project to the next one who continued the method development. This didn't work because of the lack of time for supervision. The rest of the group needed too much of lecturer's time which led to inadequate guidance.

The most challenging projects have been the ones with a tight schedule. One of our projects suffered from the changing schedules of a client. This caused difficult situations when the students in the project tried to reschedule their work and at the same time take care of their other studies. Work in project always requires a plenty of scheduling and coordination between several factors and it is essential that everyone involved is obeying the arrangement.

2.2 Quality

The connection of Chemical Analysis Service learning environment to RDI projects has awakened our laboratories to meet a new challenge. The laboratory which is used both in basic studies and in RDI projects is a challenge from quality assurance perspective. In the traditional laboratory work the students perform the measurements according to the instructions and there is no mandatory need to assure that the outcome of methods, measurements and equipment actually is right.

During the Chemical Analysis Service it became obvious that the quality of the measurements is absolutely important to assure because the clients made significant conclusions and decisions based on the measurement results. Chemical Analysis Service has the responsibility of improving the quality in the laboratory.

From RDI's point of view it is essential that instruments work as they are supposed to work and that they are always left in good condition to the next user. The large number of users who are in different stages of education and orientation cause some inconvenience in the laboratory. A simple example of this subject is the treatment of an analytical balance. Everyone knows that the balance needs to be cleaned after use. Still dirty balances are constantly found in the laboratory. This problem was solved by locating the traceably calibrated balance separated from the other balances to assure the appropriate and careful use.

The laboratory quality is developed in a Quality Project where all the important equipments for RDI projects will be qualified. Qualification includes the inspection of present documentation (IQ), operational qualification (OQ) and planning the tests for performance qualification (PQ). Moreover it is essential to make a maintenance program for the equipments. The additional aim of the Quality Project is to validate the most important methods.

All the qualification and validation assignment are executed by students in projects. A part of the projects are included in degree programme courses, some parts are accomplished as the bachelor's thesis and the rest in other project studies. The quality development work has required much more supervision than the traditional laboratory work. However the quality project has been very interesting and motivating for all the participants. This working method has offered both the students and the lecturers as well as to other personal a great opportunity to learn new aspects of quality and to enhance the professional expertise.

2.3 Pedagogical Aspects

"Innovative behaviour means the ability to recognize new possibilities in new situations when the operational environment has changed causing absolutely new needs and new kinds of attitudes and connections." [2]

Ten years ago teaching in Degree Programme of Laboratory Technology consisted of traditional disciplinary theory lessons and problem solving in the classroom. Practical part was laboratory work where the students used written procedures with artificial samples having no connection to the real world. At that time, the assessment of students' learning were traditional tests that measured mostly how well the students had studied teacher's material. The real quality of learning was almost impossible to assess. It is well known that students can pass exams without understanding the issues and without reaching the learning outcomes.

Year by year the real world problems have been increasingly integrated into laboratory practise as was shown in the table 1. The changing situation has given requirements to change the pedagogical strategy from disciplinary method to problem-led and practise-led learning. Good combination of disciplinary learning and practise-led learning is required to accomplish better learning outcomes. [3] Practise-led, working life oriented learning environment give students better motivation and consequently better learning outcomes. Recent pedagogical challenges are connected to defining the learning outcomes: what should the students be able to do after the course. The learning outcomes should be the basis of the course. The activities in the course give the students the desired skills and knowledge: what kind of work should students do to achieve the learning outcomes. The great challenge is the assessment: how do the students demonstrate that they have reached the learning outcomes.

The pedagogical development during the Chemical Analysis Service project has been leading more and more towards the principals of CDIO. The chain of Conceiving-Designing-Implementing-Operating procedure has realized in the projects. The aim is to execute the whole CDIO chain but occasionally only certain parts of it were fulfilled. However, in Laboratory

Technology studies all the CDIO-components has been taken to practice in somewhat and the procedure is progressing.

Pedagogical strategy in Turku University of Applied Sciences is innovation pedagogy. The principles of CDIO match perfectly with innovation pedagogy strategy having hands-on project studies in co-operation with working life and RDI.

3 CONCLUSION

Chemical Analysis Service is quite popular among the Laboratory Technology students. It encourages learning by doing and the accumulation of both wider and deeper knowledge on the subject. A major challenge in Chemical Analysis Service is a need for supervision and control by a lecturer. An individual student needs much more lectures time and conducting compared with traditional laboratory lessons.

As a summary it can be considerate that Chemical Analysis Service has been a successful project especially developing the students' skills in laboratory technology studies. There are many new partners from both industry and TUAS projects and it has been possible to develop the laboratory instrumentation and methods and furthermore the skills and knowhow of both students and personnel of TUAS. Pedagogically it has been significant importance applying project work and innovation pedagogy to the real-life cases. In the future, the challenge is to concentrate on developing the curriculum more flexible to accept projects as a part of the implementation. An active client acquisition enables more and more students to take part of the Chemical Analysis Service project and therefore improves the expertise of the students.

The Degree Programme of Biotechnology and Food Technology is going through remarkable changes in both curriculum (syllabus) and pedagogical methods. The Degree Programme is adopting the principals of CDIO, which means a new way of implementation and studying. However, it has been quite obvious that there have already been Conceiving-Designing-Implementing-Operating workshops included in Chemical Analysis Service's learning environment. The faculty is definitely able to use the experiences and practices which have been successful in the project. It is utmost important not to separate the disciplinary knowledge from practice-led, hands-on learning. The strategy of CDIO is integrated learning of knowledge and skills. Skills cannot be separated from knowledge, because skills are context dependent. The teaching of personal skills, interpersonal skills as well as professional skills has improved through the Chemical Analysis Service learning environment.

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76 THE AGE OF INFORMATION AND DE FACTO ETHICS

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ABSTRACT

This paper discusses cyber ethics, e.g. how ethic norms are realized in virtual environments, and in particular how this happens in the Internet. Authors argue, that there exists a conflict between pragmatic, and general justice. The definitions of cyber ethics are discussed through the lenses of pragmatic ethics, while at the same time challenging dominating values in the contemporary society. Authors suggest that prevailing values are pragmatic by nature, following the ideology of de facto ethics, but they also question the legitimacy of this dominant approach. Used research approach in this study is phenomenology, where conceptual analysis on cyber ethics is based on comparison. Based on this analysis, new openings on the cyber ethics research will be presented, and discussion about the reasons for present situation takes place.

Keywords: Cyber Ethics, Information Society, IT Profession, Phenomenology.

1 INTRODUCTION

This paper discusses cyber ethics, e.g. how ethic norms are realized in virtual environments [1], and in particular how this happens in the Internet [2]. As such, the discussion concerning cyber ethics is essential for engineering profession, as well as for engineering education. Authors argue, that there exists a conflict between pragmatic, and general justice. The definitions of cyber ethics are discussed through the lenses of pragmatic ethics, while at the same time challenging dominating values in the contemporary society [3]. Authors suggest that prevailing values are pragmatic by nature, following the ideology of de facto ethics, but they also question the legitimacy of this dominant approach. Used research approach in this study is phenomenology, where conceptual analysis on cyber ethics is based on comparison [3,4]. Based on this analysis, new openings on the cyber ethics research will be presented, and discussion about the reasons for present situation takes place. In addition, authors will also discuss what really makes us active members of a reality that is determined by de facto ethics, and what we can, and cannot do about it. While the speed of technological advances is very fast, ethical discussion concerning these issues seems to be lagging in behind [5,6].

It appears that while used technology has already established itself as a part of normal everyday routines, it is still unclear what is right or wrong. Is this a discussion, that engineers should take care of — or is this a general discussion that should take place every time new, ground breaking innovations emerge? Ideological discussion concerning de facto ethics is essential opening for enhancing ethical awareness among those working in the field of information technology.

Every branch of science has to define its ethical foundations; otherwise it is doomed to stagnation and destruction. The ethical foundations can be specified only by self-reflection and critical evaluation. Academic discipline of IS, for instance, has many names, such as Information Systems, Management Information Systems, Information Management, Management of Information Systems or Informatics [7]. In spite of the pragmatic nature of IS and engineering in general, it is important that the values, ethics and moral related to these are constantly evaluated and developed. In this sense, this particular branch of science has matured from plain professional engineering skills to a scientific discipline, where discussion concerning the very foundations of this discipline will take place. Behind the ethics are the values that reflect a person's, a group's or a profession's sense of right and wrong or what "ought" to be. Values can be seen as goals but they also regulate our course of action.

Moral emerges from the fact that when we act, we need to consider other persons and, in fact, the whole world – because our actions will affect them. Information ethics is only one many-sided area or ethics. Today, we also speak a great deal of environmental ethics, or ethical standards for juristic persons, business enterprises, and communities. Sport ethics is a fairly topical issue at the moment. We are never completely free in an ethical sense. On the contrary, we must constantly take individuals, norms of the society, values, and of course legislation, into consideration [8].

von Wright defined in his pioneering study of ethics the moral so that he divided the moral good (goodness) into 6 classes or categories: The instrumental and technical goodness, utilitarian and medical goodness and hedonic good are all good in instrumental sense – they can be treated as means. He also discerns moral goodness that is good as such, good for no particular reason. With this he means for instance that good for somebody is intended for its own sake. von Wright's typology of the varieties of goodness helps us to discern and evaluate different kind of goodness, or things or matters that are valuable. [9]

Medical goodness is connected with health and well-being. It can be said that our time favours everything that has with health to do. We should eat healthy food, do physical exercises regularly and look young forever. On the other side we are hysterical when the swine flu is approaching or the first wrinkles or lines appear on our faces. [10] Utilitarian good means good that is distributed fairly. Taxation policy, for instance, is a means of achieving utilitarian goodness. The basic idea behind hedonistic thought is that pleasure is the only thing that is good for a person. What is pleasure is difficult to explain but usually we think that all kinds of physical enjoyment like alcohol and delicacy are hedonistic pleasures.[11]

Instrumental goodness is mainly attributed to implements, instruments, and tools – such as knives, watches, cars, mobile phones, lap tops and so on [12]. The goodness called technical relates to ability or skill. Somebody, we say, is good at (doing) this or that. [13] If we examine the Internet it can be evaluated from different kind of goodness, different points of view. It is quite sure that the Internet is good in a utilitarian way: although we can talk about digital divide, the Internet is an excellent tool in spreading information all over the world. [14]

According to Habermas there is a communicative void in the society. Habermas also says that communication is the most important barometer of democracy. According to his theory of discourse ethics, the more the people and institutions communicate in a society, the more efficiently democracy works. We could draw a conclusion from this and say that the Internet is good in a utilitarian sense. [15] [16]

It can be said that the Internet represents pluralism, competition between different opinions and genuine free public debate. And most important of all, the Internet offers a foundation to interactivity. This may be the most important democratic value of the Internet. On the other side, digitalization has improved the possibilities of mass communication and entertainment [17]. According to critical theory – and Habermas – virtual entertainment alienates people from real feelings. And there is no doubt that the Internet is good in instrumental way too, because it is so effective. But here resides one contradiction. The Internet is also very effective when spreading bad influences.

2 DE FACTO ETHICS

Authors argue, that the Internet belongs to the practical, pragmatic or functional part of the world. But is the pragmatism the best possible ethical theory suitable for cyberethics? Pragmatism emphasizes the importance of activity in human life. It explains technical development and progress with relation to moral, but when justice is taken into account, pragmatism is no longer the best possible explanatory model. Pihlström argues, that although the scientific worldview would not be the best possible (to the mankind), we can make the world a better place to live in through our active work [18]. In addition to optimism, James's and Dewey's pragmatism emphasized development and change, and because of this it suits well the world of information technology. According to pragmatism, values are being tested all the time with reality [19]. This is to say that pragmatism does not accept any permanent values, and therefore it is suitable for describing virtual ethics and reality. The norms exist in relation to the surroundings, they are context bound. The individual reactions against the value hierarchy can change it. Usually development in value hierarchies is slow, but sometimes it is surprisingly fast.

The moral action is not only the adaptation of moral rules, because the moral principles are suppositions or hypothesis, which have to be tested constantly. They must fulfill certain qualifications or requirements and they are open for changes. When we test moral rules we also interpret them. Legal system and legislation are good examples: The judges not only adapt the law but they also interpret it because they often have to deal with precedents without applications. Pragmatism accepts value hierarchy but this hierarchy is not a permanent one. Why don't we think likewise about the Internet? It is possible to measure the usefulness of the Internet and can call the result of the measurement the utility of the Internet? The pragmatic moral bound to consequences is an easy way to describe the Internet and the fast technological advance. Many of the traditional pragmatists agree on the idea that everything, also the moral arguments, can be measured.

According to Husserl [20] the highest ethical goal of the rational culture and civilization is its spontaneous and self-steered improvement. In the same way as a rational individual is able to evaluate and study his practical goals, so can a whole culture. European (or western) culture is therefore able to direct itself its future. Husserl notes that there are ideal absolute goals, as well as ethical, that can never be gained or fulfilled totally, but they are something worth reaching for. Here Husserl comes near Immanuel Kant's regulative principle. These aims and the relationship of the European civilization to these goals can be evaluated over and over again, and this is the strength of the rational European civilization. Husserl doesn't name precisely what these goals may be, but it is highly probable that the idea of equality could be among these definitive goals. [21]

As Miettinen [22] states, equality in a society can't be described quantitatively or geometrically. Nevertheless, we understand what it means. We are able to evaluate our activity in proportion to this goal even though we can never achieve it. Although it is out of our reach, it determines our activities and choices. [23] This means that we are trying to achieve equality, for instance, over and over again. The original Internet enterprise (ARPANET) in the 1970s was based on noble ideals (democracy, equality, non-commercialism, free speech and communication), but as Johnson stated, these pioneering dreams have been crushed. Control has taken over and because of commercialism there is no democracy, equality or area for free communication, to put it simply [24]. However, these goals or absolute ideals do still exist and are waiting for the new evaluation, as Husserl said. Husserl speaks about reappraisal and new beginning, but on a very universal level.

Pragmatism is based on so called de facto ethics, and it easily neglects values like democracy and equality. Profit, surplus, effective use of time, logistics, effectiveness, price and usefulness are some of the instrumental "values" typical of the de facto pragmatism. But it is not that simple. If pragmatists get an assignment that consists of the development of Internet democracy, they certainly accomplish it, without thinking of the meaning of the word democracy. De facto pragmatism can be defined by comparing it with de facto standards. As soon as a new technology is being introduced, everyone is eager to utilize it as soon as possible. There are no significant attempts to create standards that should be followed, but instead, the solutions created by one vendor will quite soon become "de facto standard". Application is being accepted by general public without being defined and accepted officially, because this would take too much time.

Similar de facto –practice appears to exist in moral issues related to the Internet. Moral codes are being molded and taken into use taking only pragmatic issues into account, while actors are everything but professional. A new moral is being created in the Internet all the time; new virtual communities are being born constantly, and these form rules and practices, which differ greatly from commonly accepted ethical codes in the society. From the ethical viewpoint this phenomenon is interesting – it appears that everything is happening faster in the Internet.

There are many causes behind this de facto practice. Husserl would say that it depends on the triumphal march of the applied sciences. Johnson would probably say that the American domination in the Internet is the main cause. Apparently there are other reasons, too. Moral education, inculcation of enlightened attitudes through education has certainly good possibilities to clarify the ethical background of the Internet. It is certainly necessary, because we all want to be sure that the Internet is going to be working smoothly in the future, and that a fair, righteous and democratic Internet is reality.

3 SELF-REGULATION AS A HOBBESIAN ENTERPRISE

European Union has started a project, where great emphasis is on the encouragement for self-regulation of the Internet. The Safer Internet plus programme aims at promoting safer use of the Internet and new online technologies, particularly for children, and at fighting against illegal contents and contents unwanted by the end-user, as part of a coherent approach by the European Union. [25]

Behind self-regulation is a desire to promote the functioning of the same set of values and professional ethics. Visala states that when the Internet crossed the borders of the scientific community and became a commercial and civic enterprise, the whole gamut of human activities and interests came along. Money, flaming, plagiarism, copying of data files etc. finished the well working self-regulation. [26]

A classic example of self-regulation is the Leviathan by Hobbes. Hobbes described the society that had plunged into anarchy. In such a society the inhabitants can't predict or make plans for the future. Unable to rely indefinitely on their individual powers in the effort to secure livelihood and contentment, Hobbes supposed that human beings join together in the formation of a commonwealth. Thus, the commonwealth as a whole embodies a network of associated contracts and provides for the highest form of social organization. On Hobbes's view, the formation of the commonwealth creates a new, artificial person (the Leviathan) to whom all responsibility for social order and public welfare is entrusted. [27]

Wallace has stated that the Internet and the co-operative groups work effectively and without quarrel or contradictions, if they are homogenous [28]. In this respect the Internet is full of paradoxes. Globalization shrinks the world and spreads the Internet, but simultaneously the amount of potential troublemakers increases [29].

The Safer Internet project has listed ways to increase the functioning of the Internet with the help of self-regulation. There are certainly many technical devices. But the most important way to improve the working of the net is to increase education and enlightenment. This will also improve self-regulation [30].

Educational tools can be seen as a part of called information literacy which means "the set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Information literacy is increasingly important in the contemporary environment of rapid technological change and proliferating information resources." According to Information Literacy Competency Standards for Higher Education information literacy is related to information technology skills, but has broader implications for the individual, the educational system, and for society. [31]

4 CONCLUSION

It is obvious that the principles of virtual ethics (cyberethics) can be drawn from traditional ethics. There are some special features which are typical for the Internet, which may inhibit the development of solid sustainable ethical code. One of these characteristics is the fast growth and the hectic nature of the Internet. This is why the concept of de facto ethics is so well suited to describe the real ethical meaning of cyberethics – or is it better to call it a non-ethical theory (a theory that describes practical activity) that defines only technical, goal-oriented activity or goal rationality.

According to Beck [32], the social production of wealth systematically goes hand in hand with the social production of risks. According to him [33], risks and the potential of self-threat have been unleashed on a hitherto unprecedented scale as a consequence of the exponential growth in the forces of production as the process of modernization continues. This is a place for a well-founded question: How can ethical discussion take place, when the consequences of possible risks are well beyond comprehension?

Husserl explains convincingly how the ethical principles in a community "ought" to work. Husserl's idea that we have to redeem our ethical goals over and over again can be seen as a well-defined comment against pragmatism and de facto ethics. De facto ethics and pragmatism don't operate on the same level with traditional ethics or ethical code. There are no distinct and unquestionable principles in pragmatism; efficiency, usability and fastness can be seen as one of the main criteria to the activity of good quality (valuable). But it might be so that sometimes it would be useful to study the ethical foundations of all the activities in a society. Husserl's ideas bring ethical content to the non-ethical environments.

Husserl's idea about the revaluation of ethical code, goals that had to be evaluated over and over again, is based on the idea of western rationality, but it certainly conflicts with the ideas of freedom in the different sectors of the society. De facto ethics explains the factual situation in a society that is getting more and more technical all the time. Self-regulation on the other side is a typical way of trying to get the Internet function. Because of Internet's voluntarily character that has not always been very successful. Many of the different self-regulation projects have improved the functionality of at least some of the Internet environments. In self-regulation we can see some kind of eternal return to the times when the pioneer spirit of the Internet was dominant. De facto ethics makes it possible to describe the factual ethical situation in the Internet; traditional ethics tells us how it should or could be. If we give priority to values like freedom, democracy and equality, there is certainly a big difference between the factual situation and the absolute ideas (ideals, natural values, as described in traditional ethics).

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78 FROM THEORY TO PRACTICE: ADAPTING THE ENGINEERING APPROACH

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ABSTRACT

The relationship between engineering and cultural practices and worldviews is little studied. Engineering education is largely based on the assumption that engineering sciences are value-neutral and objective. However, technology is always applied in a particular societal setting, depending on the surrounding conditions. The aim of engineering education is to teach how to adapt theoretical knowledge to practical technical problems. The ability to connect theory and practice develops in varied degrees in primary and secondary schools in different parts of the world. Paradoxically, a school system that relies on theoretical instruction appears to produce concrete thinkers without pragmatic skills. This paper examines school backgrounds and learning approaches of an international group of engineering students. It presents an analysis of student writings on their learning experiences, which are compared with earlier observations and surveys. The effect of culture to adapting technology emerges as an important factor, which is discussed based on the hypothesis on re-engineering of cognition. The development of engineering expertise in a global context arises as a multifaceted challenge that increasingly calls for attention from educational institutions.

Keywords: Impacts of culture to engineering; multicultural education; engineering skills; globalization

1 INTRODUCTION

Engineering sciences are applied sciences with a practical aim. Engineers work to create state-of-the-art solutions to real life technical problems [1], [2]. Therefore, for engineering education to be successful, the adaptation of theoretical knowledge has to be strongly supported by providing skills for the application of theory to practice. Moreover, the application of technology needs to be appropriate in the particular social and environmental conditions [3].

Currently, engineering education has become a global market where students select their place of study comparing options worldwide [4]. Even small countries and language areas have entered the competition by offering degree programmes in English. For instance, Finland receives engineering students from Africa and Asia, partly owing to the reputation of the Finnish mobile technology companies, as well as due to the free university education. The international student body differs considerably from home students who have rather uniform backgrounds due to the equalitarian school system.

This paper examines the acquisition of practical skills and how the connection between theory and practice is formed in education. The student population that is investigated in this study represents over fifty nationalities, and it is highly diverse as regards to educational backgrounds, technical skills, and learning strategies.

Several earlier studies have pointed out the difficulties that emerge in multicultural engineering student groups, in particular relating to the practical orientation [5], and differences between teaching modes in Europe and North America compared to Asia and Africa [6], [7]. This paper aims at taking a closer look at the type of difficulties and reasons behind them. In addition to comparing instructional methods and epistemological views, the paper analyses the impact of culture and student experience to learning and relation to technology. First, the effect of culture to adapting technology is discussed. Secondly, the paper presents an analysis of self-reflective student writings at the university under consideration. Finally, the findings are discussed to formulate an enhanced view on the development of engineering expertise during education in a global context.

1.1 Culture and technology

The application of technology is influenced by society and culture, and uses of technology are embedded in cultural practices [8]. On the other hand, uses of tools and artefacts influence the way a person thinks and learns [3]. Technology changes the way people behave, shaping cultures, the most prominent current example being the influence of social media in forming new communities and generating political actions.

People learn throughout their lives, mostly outside formal learning institutions [9]. Children mainly learn by observing the behaviour of their parents and siblings and through the consequences of their own activity [10]. Similarly, learning about technology also begins in early childhood: children learn to avoid electric outlets, to switch on lights, to avoid moving vehicles, to jump on escalators, etc. When a child learns that she has to turn the flow of water off after washing, she adapts a set of cultural knowledge: water might be a scarce resource, or there might be no running hot water unless a boiler is first started. This knowledge and subsequent habits that are formed are part of the cultural apparatus that the child masters. Later, more complex technological systems are learned such as operation of remote control devices and washing machines. Children learn to control and maintain technical devices, thus developing a personal connection to technology.

Additionally, formal schooling introduces a number of technologies such as use of computers, laboratory equipment in science labs, household technologies, and woodworking. Young adults have acquired a large set of technical abilities that they can use in their lives and studies. Many of the abilities are unconscious, embodied skills: a person knows how to ride a bicycle, but cannot explain it [9]. Because most of the skills concerning technology are embedded in everyday cultural practices, they are often not even counted as skills, unless someone suddenly shows a lack of that skill [3].

In higher education, previously adapted cognitive styles and study practices affect the way students work with assignments, which becomes apparent in multicultural settings [6], [7]. Problems in multicultural engineering education have been discussed, for instance, by Stewart in Australia concerning Middle Eastern students [5]. Stewart mentions low English language proficiency, cultural adjustment and plagiarism as issues that concern international students.

In particular, his study highlights the unfamiliarity of international students with teaching methods requiring student activity, self-regulated learning, and problem based learning. However, the lack of practice is seldom discussed.

2 A STUDY OF STUDENTS' PRACTICAL EXPERIENCE

This research was conducted at the Helsinki Metropolia University of Applied sciences, in the School of ICT, which has two English medium Bachelor of Engineering programmes: Information technology and Media engineering. The student intake is around 80 students each year. Universities of applied sciences aim at educating engineers in close connection with local companies, aspiring to a practical orientation. The curriculum contains a high proportion of laboratory work and projects, as well as trainee periods in industry.

This study presents findings from an analysis of self-evaluation reports written by the students of one intake group in 2010 (34 responses). Additionally, data from two earlier surveys among international and home students (62 responses in one set of questionnaires and 180 in another questionnaire) is used [11]. Below, student quotes from their writings are replicated in their original format without spelling or other correction in order to avoid misinterpretations.

2.1 Results

Students of an international group wrote an evaluation report of their first semester of studies. They were asked to assess their study progress and write down any remarks they had on studying at our university. 34 reports were collected, out of which 5 by European, 17 by Asian, and 11 by African students. The African students were mainly from Ethiopia and Nigeria, Asian students comprised of Nepalese, Vietnamese, Chinese and Pakistani. The reports were analysed by the content areas and the comments were classified according to themes that arouse from them regularly. The coding and analysis were done manually. [12]

The most often occurring theme was the change that students had observed in modes of study. Many African and Asian students included a comparison of their previous study institutes and the current way of organizing studies. Many of them had already started university or college level studies in their own country or elsewhere in Finland. Those who came from Vietnamese, Nepalese or Ethiopian universities, regularly mentioned that studies by us are more practical (10 students), their previous studies were more theoretical (11 students) or even that the way of studying is totally different in Finland (7 students). Six students particularly commented on the modernity of laboratories and computer equipment. The CCNA in the quote below refers to network training for Cisco certification. Student statements:

"When I compare my previous school, in my come country, and Metropolia UAS, I can say that education in Metropolia is more of practical, laboratory based, while in my previous school education is less practical, more of theoretical. Let me take CCNA-1 course to compare these schools. … Here in Metropolia When we learn the CCNA course, we used to use the real physical devises like Router, Switch, Hubs and others. We used to practice the course on the real physically available devise. But in my previous school we used to study the course by simulation software, which used graphical representation of these devises on computer and we practice on that way. ..” An Ethiopian student

“In my country I was studying the physics and I studied only the course the related to physics and its application. The course here like Technical writing and presentation skill, introduction to studies and orientation project are the course that helps to build the extra skill and knowledge that is required to become the good engineer. This course help to build the confidence and helps to interact within the multicultural environment. Actually the Europeans are almost forward in the every sectors and today I came to know the reason behind it. The European systems of educated are considered to be the most advanced, because the course not only contain the subject’s related material but also the intellectual development subjects, presenting skills. This is why there is lack of confidence in the student of the my country though they are graduated they can’t deal their knowledge in the good way.” A Nepalese student

The educational institutions in developing countries are generally poorer and less well equipped than in Western countries. The laboratories are inexistent or very poorly equipped (see also [13]). The difference even between Northern European and Eastern and Southern European countries is considerable and reflects the economic situation of the country [14]. Students are therefore not exposed to practical laboratory work, and they lack experience with technical devices. However, all students strongly share the feelings that are quoted above that a chance to become engaged to laboratory practice is a great opportunity, which they eagerly embrace.

2.2 Findings

Students from Africa or Asia seldom have first-hand experiences with technology. They did not have home computers, they have not experimented with educational science kits, or been involved in any of those activities that are so common in Western science and technology classrooms. The reports quoted above reveal this lack of hands-on experience. Contrastingly, home students and other Western students often relate how they received their first computer, how they tried to assemble some device, or their first programming efforts as schoolchildren. Western students usually have a personal history with computer technology, making their current study a continuity of it.

The deficiency in practical skills among international students displays itself in many ways during the studies. First of all, students find it hard to get started with laboratory work, and it takes them much longer to complete their assignments than for home students. This is due to three separate factors: not being used to laboratory procedures, unfamiliarity with equipment, and last but not least the study language, which is not the native language of students or teaching staff either.

Conducting science studies without mastering the study language leads to superficial learning without a deep understanding of the subject. Thinking and communicating with deficient language knowledge results in rote learning and mechanical copying of texts. Moreover, the view that the formal layout of the report is more important than the contents of it, points towards epistemological differences in understanding knowledge.

The ability to follow instructions when working is basically a universal skill and Hutchins [8] even considers it as a part of basic human intelligence. However, the ability to follow instructions is dependent on the style of the instruction, which is learned separately for each type of task [11]. The lecturing – examination style of education teaches students to follow simple steps verbatim, and to repeat them mechanically. Laboratory work instructions, research process outline and essay writing process are higher level instructions that require certain application of skills according to the task, therefore, they are context dependent. In fact, they might require mastery of small implicit processes that are not explained in the instruction. One typical type of instruction is test taking, such as SAT and TOEFL. Students in the United States actually practice for years in order to perform that kind of tests fluently: not only for content but for the procedure. Metropolia's international students sometimes commence their studies with an inability to follow formal work instructions. As a consequence, they need to struggle hard with laboratory assignments.

3 DISCUSSION

Education at Anglo-Saxon and Northern European universities is based on certain practices such as team work and project work that rely on social cognition and extensive use of mediating artefacts, first of all ICT network tools. Moreover, the overall approach to learning is based on student independent knowledge acquisition and collaborative learning, and allows certain freedom in the planning and execution of studies. Despite of the variety of educational theories that are applied in Western institutions including constructionism and problem-based-learning, the practices seem to be more uniform than theories would indicate [15]. Because students need certain fluency in these methods to be fully able to benefit from them, many Asian and African students have to adapt a new set of study methods and practices. Their previous experience from home countries turns out to be useless.

In engineering thinking, much of the work is done through categorizing and drawing system descriptions such as charts, graphs of processes, flowcharts, algorithms, categorisations, structures, data base concept charts, entities, and object classes. The descriptions are part of the design and documentation and, moreover, they also act as tools in thinking [1-3]. In this respect, the shared and contextual nature of design work, its social processes, and mediating structures are essential parts of the cognitive process.

Engineering skills consist of a large set of competences, which are partially technical, and partially social and culturally produced. The figure 1 summarizes the engineering expertise that is influenced by culture.

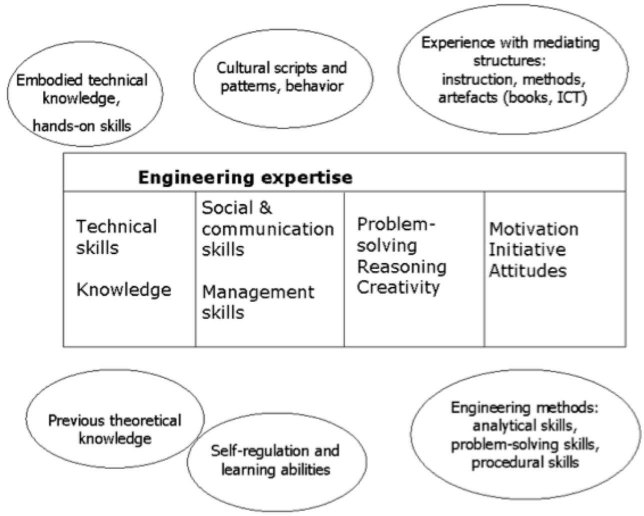

FIGURE 1. *Engineering expertise influenced by culture.*

On the other hand, the mode of studying in most Asian and African schools is based on theoretical lectures and examinations. Classrooms contain a large number of students who sit quietly and listen to the lectures. In the examinations, students are expected to reproduce the information that was lectured. Professors and lecturers are considered as authorities whose information is not questioned [16]. Discussion or questions in the classroom are not permitted, nor is independent problem-solving practiced. The mode of learning could be called a recipe approach that includes drilling, following models, and learning by heart, instead of aiming at a conceptual understanding. Arguably, this "mind as container" -model of teaching is not completely absent in Western engineering education either.

Manual hands-on work is not part of the curriculum in third world schools. The connection between theory and practice is fully absent from the school system, even more so as also the teachers have a background without any practical experience. Therefore, de-contextualization of knowledge is not achieved. Epistemologically, book knowledge is considered as a separate category from everyday knowledge, and its truth value is of different kind from everyday knowledge [17].

The knowledge of the development of brain would indicate that learning of motor skills and working patterns should take place in the childhood when the plasticity of the brain is highest, and new skills become "hardwired" in the brain [18]. Professional musicians, gymnasts, and dancers start at an early age to practice their specialty. On the other hand, the brain areas for complex decisions develop until the early twenties, and therefore most demanding design and planning tasks can be aptly performed only by an adult brain. Ideally, the education supports and takes advantage of the development phases of the brain on all levels.

4 CONCLUSION

The development of an engineering attitude and genuine interest in technology, as well as behavioural patterns that belong to engineering practice, is a process that starts early in the childhood. Several studies indicate that numerical and spatial skills start to develop already at preschool age, and early practice of numeracy skills predicts later success [19]. Students who have been deprived of early exposure to numbers and technology are at a disadvantage when they come to study engineering. They would need extra support in order to catch up with their peers. The differences in educational practices cause a wide gap in student practical and numerical skills, and its consequences are often ignored or underestimated in Western universities. Therefore, it would be crucial to offer tuition in hands-on skills and laboratory practices in the beginning of the studies for international students. An introductory project course in engineering practices such as suggested by Brockman [1] could serve this purpose.

Whether the lack of experience in technical practices during childhood and youth influences the performance of professional engineers and whether third world engineers really have a different pattern of working has not been addressed here, but it would be another interesting area of study. Do all engineers develop a loving and caring relationship to technology that compels them to maintain and look after technological devices?

Furthermore, Western engineering practices tend to emphasize only step-by-step analytical processes, which support design process, but not necessarily innovation and good leadership whereas holistic, organic approaches are based on divergent thinking that foster creativity. Therefore, engineering students with less technical backgrounds are not only a challenge in education but, on the other hand, they can contribute to a more versatile innovation environment. Educational institutions have not yet taken full advantage of the potential that diversity can offer.

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