DEVELOPMENT AND ASSESSMENT OF GENERIC SKILLS BY CONCEPTUALIZING LEARNING IN LIFE SCIENCE - ENGINEERING EDUCATION

A. Laakkonen
Ph.D. student
University of Helsinki
Helsinki, Finland
Email: anni.laakkonen@helsinki.fi

I. Viksne
Head of RTU's Prototype Development Centre
Riga Technical University
Riga, Latvia
Email: ilmars.viksne@rtu.lv

A. François
EPICES & PLACIS global coordinator
Institut Supérieur de Mécanique de Paris – Supméca
Saint-Ouen, France
Email : alexis.francois@supmeca.fr

A. Lanthony
EPICES & PLACIS coordinator for international and industrial relations
Institut Supérieur de Mécanique de Paris – Supméca
Saint-Ouen, France
Email: antoine.lanthony@supmeca.fr

K. Nordström
Professor
Aalto University
Espoo, Finland
Email: katrina.nordstrom@aalto.fi

Background of the project

Societal and cultural changes are modifying the expectations of the job market, which puts pressure on leveraging the practices of higher education to meet needs of society and employers. As a result, traditional emphasis on core domain-specific skills is changing as the contextual skills applying the knowledge to benefit the employer are highlighted. Universities need to embrace the challenge

of transferring generic skills to students for them to become constant learners capable of critical thinking, problem solving and other work life requirements, such as project management, team work, presentation and digital learning skills. Students' opportunities to learn work life skills during university studies depend on the features of the learning environment and the education they receive (Lakkala et al. 2015). Improvement of education demands new learning methods including verbal, digital, visual or emotional tools to increase personal and group commitment to learning (Nordström and Korpelainen 2011). Student engagement and putting real effort have also proven to have an impact on the outcome of the learning process as learning is expected to improve when knowledge is constructed by the students rather than received via formal instruction (Leidner and Järvenpää 1995, Entwistle & Peterson 2005).

The focus of this study is on multidisciplinary life sciences within the engineering curriculum. Notably, we are interested in how the development of specialized knowledge and skills in non-engineering subjects can be better fitted into a flexible learning style in the often traditional engineering learning styles and curriculum. It is very typical for education in life sciences to rely heavily on facts and details which students are often expected to remember. Therefore, some studies consider memorizing to be a key part of developing an understanding of the subject (Asikainen et al. 2013). However, this is not in line with the aim of university education to offer 'quality learning' often related to inducing a deep approach to learning, thus enhancing high-quality learning outcomes and success in academic studies (Entwistle & Ramsden 1983, Watters and Watters 2007). Our approach therefore targets to find more suitable teaching methods to promote deep learning of scientific facts in conjunction with development of social and team work skills as focusing on group activities and development of the learning space allows students broader means for deeper learning. Importantly, we recognize that development of multidisciplinary skills needs to be enhanced when students are engaged in an engineering program, but are also acquiring disciplinary skills and knowledge which may be very specific, eg. combining electrical and mechanical or chemical engineering with biology. The element of creativity was also added to the approach to highlight conceptual understanding via continuous engagement.

Course design and goals for learning outcomes.
Cell- and Tissue Engineering CHEM E3225 is a 5cr course in the new Biotechnology M.Sc. major of the Chemical technology degree program, and which was designed from the very start as a new concept. Eighteen students from the Biotechnology and the Biosystems and materials major participated, from the chemical engineering and electrical engineering programs. The length of the course was five weeks and included compulsory lecture attendance, laboratory demonstrations, and a group project. The course was assessed by self- and peer-assessment, evaluation by the instructors and a home exam. The home exam was opened two weeks after the start of the course and closed 8 weeks later. There were a total of 17 questions and assignments, 500-700 words each.

For the projects, four groups were formed with four to five students. Each group was allowed to choose a topic from a selection of topics in the course reading material. The selected book chapter was the primary source for projects, but other resources could be used. The groups worked on their projects at the Design Factory of Aalto University, where students can use many different tools, materials and dimensions for building and visualizing scientific issues and concepts, such as drawing, LEGOs, modeling clay, videos, 3D-printing etc. (Björklund, Nordström and Clavert

2013) The objective of the projects was not to arrive at a predetermined 'correct' answer, but to explain a scientifically challenging subject to peer students without conventional presentation tradition, PowerPoint or similar written presentations. Students were free to choose their modes of final presentation. The documentation of the group projects pages focused on group work and a learning process in Wiki. As the present study also extends into an Aalto pilot "Biology Meets Mechatronics" during 2016-2019, students in the Cell and Tissue Engineering were required to reflect also on ongoing projects in Mechatronics exercises at the Aalto School of Engineering also documented in Wiki's.

Results

Students chose the following topics for projects; 1) three-dimensional liver construct, 2) tissue-engineering of intervertebral disc, 3) jaw bone and dental transplants and 4) tissue-engineered food. The groups created explanatory videos, prototypes, drawings, a quiz, a board game and a play to help them explain the scientific content. Self-assessment was collected at the middle and at the completion of the whole course. 17 students filled the form at the middle (94%), and 16 at the end (88%).

The self-assessment of individual students were combined with other members of the project group to compare the results and form a perception of the learning processes in the group. Overall, students estimated that their skills developed in a positive manner (Figures 1-4) during the course, however, it was evident that the one group that had problems with the scientific contents of the project, also gave themselves lower grades for development of skills during their work (Figure 4). The evaluation of all group's learning process were in line with the assessment by the instructors.

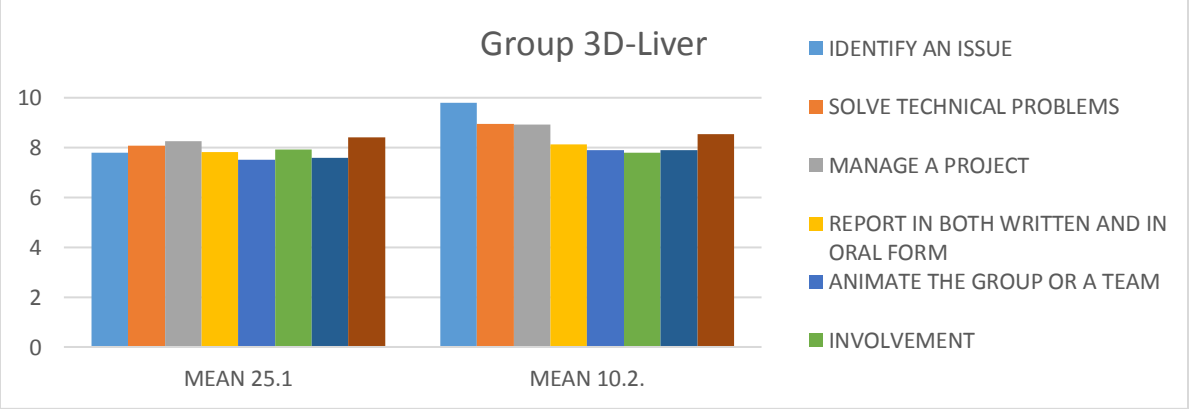

Figure 1. Scores of self-assessment on 25.1. and on 10.2.2016. The general trend for all development areas was positive and the group members seemed to be confident in their assessment. The means have been calculated from the self-assessment of 1-10, that each group member has given to themselves.

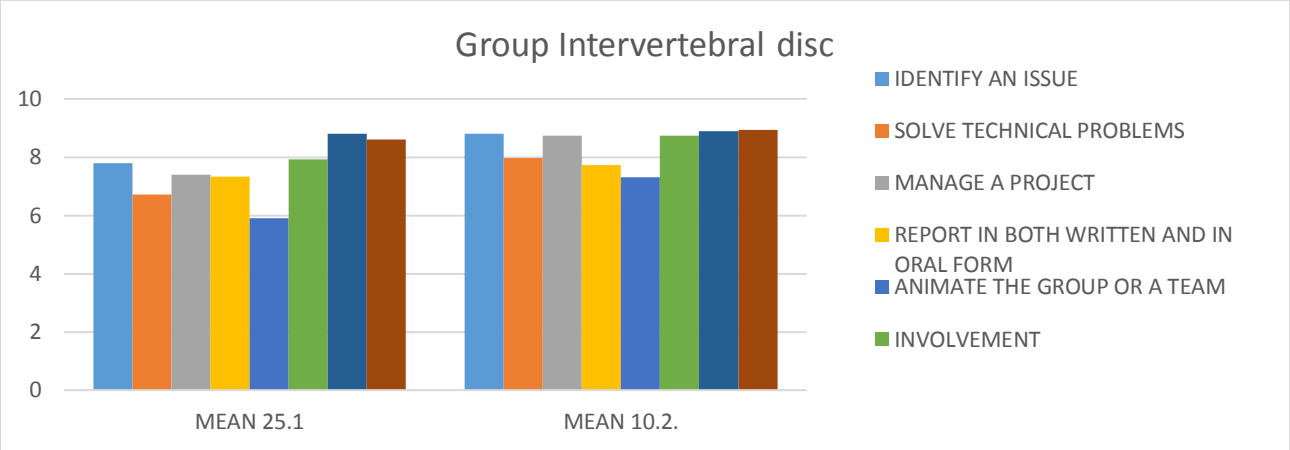

Figure 2. Scores of self-assessment on 25.1. and on 10.2.2016. The general trend for all development areas was positive, though the group members did not seem to be that confident in their first assessment. The means have been calculated from the self-assessment of 1-10, that each group member has given to themselves.

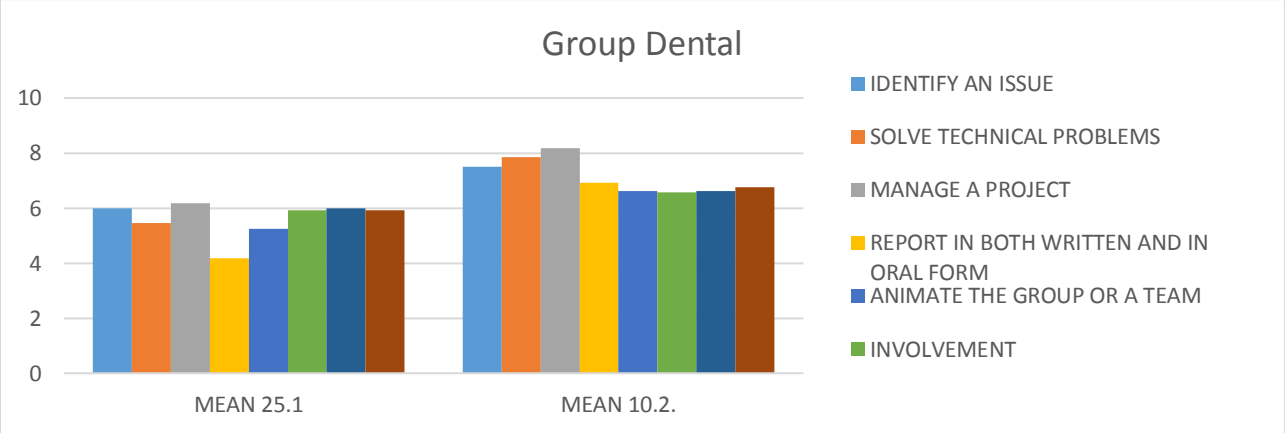

Figure 3. Scores of self-assessment on 25.1. and on 10.2.2016. The general trend for all development areas was positive, though the group was stricter on their scores compared to other groups. The means have been calculated from the self-assessment of 1-10, that each group member has given to themselves.

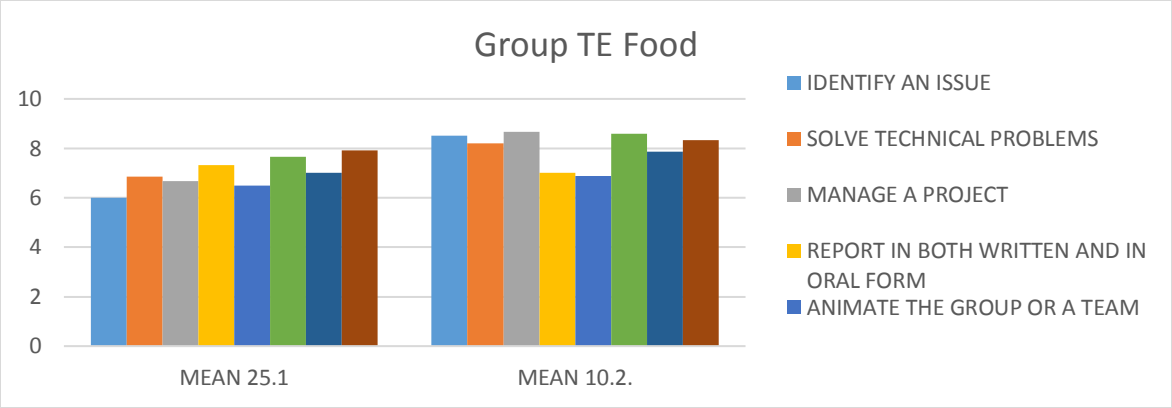

Figure 4. Scores of self-assessment on 25.1. and on 10.2.2016. The general trend for most development areas was positive, with exception for the scores for reporting and animating the group or a team. These observations are noted to be true and honest, as the group had some problems with their final presentation. The means have been calculated from the self-assessment of 1-10, that each group member has given to themselves.

The questions in the assessment form were based on work done in the Erasmus plus project European Platform for Innovation and Collaboration between Engineer Students (EPICES) 2014-1-FR01-KA203-008560 (Figure 5). The assessment tool was adjusted at certain points to form relevant assessment issues which reflected the nature of the course. The tool was found to be very convenient to use and objective. Deciding on the weight coefficient was found to be most challenging, however, it proved to be most straightforward to assign weights that differed clearly, eg. 10, 5 and 2.

Cell and Tissue Engineering 5 cr Group Assessment

Note: C3225 in bold text explains the modifications that were made for the present course in order for the assessment to be relevant

nr.	Skills	Relevant to the course	Weight coefficients (1..10)	Weight coefficients in %
			Adjustment of the test weight coefficient by test workload (0...+10) --->	
			Weight coefficients by tests in % --->	
	METHODOLOGICAL AND TECHNICAL SKILLS			
	Identify an issue, figure out the stakes			
1	Understand an issue (from a third person, a customer, a service...), reformulate it, stand back, with a global and critical view of the context: **C3225 understand the scientific content**	**Y**	10	8,26 %
2	Build and write a book of specifications	**N**		0,00 %
	Solve technical problems			
3	Conceptualize an idea: **C3225 1) Build or demonstrate your assigment 2) in home exam ability to give examples**	**Y**	10	8,26 %
4	Model and develop technical solutions with creativity and innovation	**N**		0,00 %
5	Check the work and pay attention to the details	**Y**	5	4,13 %
6	Learn by yourself and use computer tools. **C3225 : Computing tools not assessed**	**Y**	5	4,13 %
7	Choose a solution	**Y**	5	4,13 %
	Manage a project			
8	Define objectively the deadlines and milestones in the project and keep to deadlines	**Y**	5	4,13 %
9	Grasp quality, costs, risks, and react to differences relating to the life of a project	**N**		0,00 %
10	Plan and manage the project during its lifetime **C3225 : Be able to keep to goals and timetable**	**Y**	5	4,13 %
11	Adapt his / her attitude and accuracy of deliverables taking into account the requirements **:C3225: applies both to assigments and home exam - for the latter pay attention to what is asked in the question, when is the home exam due etc.**	**Y**	5	4,13 %
	MANAGEMENT AND COMMUNICATION SKILLS			
	Report in both written and oral form			
12	Synthesize, structure and present information in a clear and precise manner	**Y**	5	4,13 %
13	Communicate in both written and oral form in a foreign language	**Y**	2	1,65 %
14	Use new ICT	**N**		0,00 %
15	Present and argue a solution or an idea to all kinds of public: **C3225: applies to assigments - presentation skills and innovativeness**	**Y**	5	4,13 %
	Find the necesary ressources			
16	Identify the necessary skills and resources, both internally and externally	**N**		0,00 %
17	Negotiate / motivate and call upon his / her resources and skills	**N**		0,00 %
	Animate a working group or a team			
18	Drive, unite and mobilize a team and delegate (leadership)	**Y**	2	1,65 %
19	Take responsibility of decisions and be pro-active (maturity)	**Y**	2	1,65 %
	BEHAVIORAL AND CULTURAL SKILLS			
	Involvement			
20	Make commitments (punctuality, deliverables, ...) and respect people	**Y**	5	4,13 %
21	Be autonomous, persistent and take initiatives	**Y**	5	4,13 %
22	Be curious and open-minded	**Y**	5	4,13 %
	Adaptability			
23	Get organized and manage complexity, unpredictable situations and stress	**Y**	5	4,13 %
24	Adapt to a new environment (professional and / or academic and / or cultural and / or linguistic) **C3225: eg. Working with new people, in new spaces etc.**	**Y**	5	4,13 %
	Values and ethics			
25	Show honesty, ethics and exemplary	**Y**	10	8,26 %
26	Follow the procedures in place in institutions (companies and / or academic)	**Y**	5	4,13 %
27	Respect the constraints of intellectual property and confidentiality	**Y**	5	4,13 %
	Maturity			
28	Self-assess**: C3225 Self assessment will be included in group work assigments and the written home exam**	**Y**	5	4,13 %
29	Assess the team work	**Y**	5	4,13 %
		Total	**121**	**100 %**

Figure : Assessment tool, developed in the project European Platform for Innovation and Collaboration between Engineer Students (EPICES) 2014-1-FR01-KA203-008560. Modified to suit the assessment goals of the present course (text in bold)

Official feedback was also collected, but only six students (33%) gave official feedback, and the overall opinion for the course was positive. The students also felt that group work enhanced learning. The home exam was opened two weeks into the course and the deadline was 4 weeks after the ending of the course. However, it became evident that students felt that the workload was too heavy, and the deadline for the exam was extended for another four weeks. Overall the home exam was considered to enhance learning, and students felt that it drove them to really get familiar with the textbook and the contents of the course. However, there were several overlapping courses with heavy homework assignments, which made the home exam in this course seem to heavy. It was evident, that even if the students had the opportunity to start doing the home exam already during the course, they all delayed starting it until the end of the course. In our experience, this type of procrastination is quite often encountered, and therefore raises concerns about the ability of students to understand the importance of keeping to agreed schedules. In working life, such skills are very critical, and therefore we need to look into means of enhancing student awareness of such skills.

In conclusion, the development of generic skills was supported by the conceptualizing of scientific data, and students felt that the projects contributed to their understanding of the topics, that had been presented in the lectures. The assessment of skills by using the tool developed in the Erasmus plus project gave a very objective means for grading the course, for which 25% of the grade was dependent of the work done in groups and 75% on the an individual home exam result.

References

Asikainen, A.et al., 2013. IJER Res 62, p. 36-42.
Björklund, T. et al. 2013. EJEE 38:5, p. 567-577
Entwistle, N. & Ramsden, P. 1983. Understanding student learning. London: Croom Helm.
Entwistle, N., & Peterson, E. 2005. IJER 41, p. 407–428.
Lakkala, M. et al. 2015. Aust. J. Educ. Tech 31:5, p. 521-536.
Leidner, D.E., and S.L. Jarvenpaa. 1995. Mng.Inf.Syst.Quart.19, p. 265-291.
Nordstrom, K. & Korpelainen, P. 2011. Teaching in Higher Education, 16:4, p. 439-450.
Watters, D., & Watters, J. 2007. Int. J. Sci. Educ. 29, p. 19–43.