Developing tolerance for ambiguity and uncertainty by interdisciplinary intensive courses

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ABSTRACT

Engineers work in fast changing environments with rapid and constant technological advancements. The working environment is increasingly interconnected and global. Thus the engineers have to possess interdisciplinary and multicultural team working skills and the ability to cope with complex and uncertain situations [1]. Engineering education must train the students in skills which enable them to handle those uncertain situations. These soft skills are best being developed while using other instruction models than the standard classroom teaching.

In this empirical paper one instruction method, **international intensive course (IIC)**, will be described and results of two intensive courses developed and conducted in academic years 2018 and 2019 will be described and discussed. The topic of each IIC was chosen so that a multidisciplinary engineering student team was needed to solve the problem task presented in the course. Different types of student team composition models were being tested.

Students` feedback related to their learning and team work was collected and analyzed. The major challenges were caused by the communication issues and the biggest benefits of the courses were the improvement in cultural and team working skills. The internal coach model was causing better student satisfaction than the outside consulting model.

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1 INTRODUCTION

1.1 Need to develop tolerance for ambiguity in engineering education

Engineers work in fast changing environments with rapid and constant technological advancements. The working environment is increasingly interconnected and global. Thus the engineers have to possess interdisciplinary and multicultural team working skills and the ability to cope with complex and uncertain situations [1]. Engineering education must train the students in skills which enable them to handle those uncertain situations. These soft skills are best being developed while using other instruction models than the standard classroom teaching. In this paper one method, namely international intensive course, will be described.

1.2 Tolerance for ambiguity – what does it mean?

Tolerance of ambiguity (TOA) means the extent to which individuals are naturally comfortable with ambiguous situations. Tolerance of ambiguity has been defined as: ***"the tendency for an individual to perceive ambiguous situations as desirable"*** [2]. It can be said that a person with a high tolerance of ambiguity is comfortable with ambiguous situations and perceives them as desirable, interesting and challenging and he or she strives to resolve problems or situations that appear to be complex or novel.[3]

Cultivating curiosity is found to be a trait that people could focus on while trying to develop their TOA. These behaviours centre around interacting with others and include effectively communicating and listening to others; when problems arise, asking questions that encourage curiosity and if confronted with resistance from others, asking questions that lead to identifying possible solutions rather than dwelling on the past. Collaboration is also important and it includes behaviours such as encouraging participation from others, question posing, creating strong professional relationships and networks for diversity of thought, idea sharing and being open to connect the ideas of new different people. If we can develop engineering education toward methods that increase the students` curiosity, we are helping them to become more tolerant for ambiguity which in turn helps them in their future working careers.[3]

1.3 Tolerance for ambiguity – how to develop it?

In this paper we report our two pedagogical experiments in which we wanted to find out how to conduct an international intensive course (ICC) as an instruction method in such a way that it would develop students` soft skills related to TOA (communication, problem solving, curiosity, collaboration, idea sharing etc.) and cause good overall satisfaction among the course participants. The first research question was related to the team coaching model of the intensive course. What is the best tutoring model? The second research question was related to the skills and competences of the participating students. What skills and competences will the IIC produce and develop?

2. EMPIRICAL ANALYSIS

2.1 Description of the intensive course settings

Next, the planning and the settings of the two international intensive courses will be described. The first course was kept in Russia at TPU (Tomsk Polytechnic University) in May 2018 and the second one also in Russia at INRTU (Irkutsk National Research Technical University) in March 2019. In both courses BSc students with different engineering backgrounds participated.

Before the courses, intensive planning work took place. First the funding had to be applied as the courses were financed by the Finnish ministry of education. This stage took place in autumn 2017. A network of one Finnish partner university and two Russian partner universities was founded and a preliminary course content and a grant application were written by the partners in September 2017. In *Table 1*, the IIC settings are described for the year 2018 vs. year 2019.

Table 1. Description of the IIC settings

Time period and place	2.5- 11.5.2018 Tomsk	2.3 -12.3.2019 Irkutsk
Course title and duration and credits	International and Interdisciplinary Workshop in Big Data Analysis for Smart City 10 days intensive work including 2 travel days plus pre- tasks and a learning diary credits: 5 ECTS points	Sustainable Design for Smart Regions - Blockchain Application for Sustainable Energy Systems 10 days intensive work including 2 travel days plus pre- tasks and a learning diary credits: 5 ECTS points
Main responsible lecturers and coaches	A team of Finnish and Russian engineering lecturers 4 MSc students as moderators/tutors	A team of Finnish and Russian engineering lecturers 2 PhD students as co teachers/tutors
Learners	3rd year Finnish mechanical engineering BSc students 3rd and 4th year Russian transport, urban sustainable development and IT BSc and MSc students 20 students, of which 8 Finns, 12 Russian students	3rd year Finnish energy and environment BSc students 3rd and 4th year Russian electrical and IT BSc students and two PhD IT students 19 students, of which 9 Finns, 10 Russian students
Learners' backgrounds	Heterogeneous group with different engineering	Heterogeneous group with different engineering

	backgrounds, 3 different nationalities	backgrounds, 4 different nationalities
Task in the course	Big data analysis to solve a transport problem in Tomsk	Develop a blockchain application for sustainable energy system for Olkhon island
Team selection and size	Teams pre-selected by teachers Multicultural and - disciplinary teams of 5-6 persons, a MSc student acting as an expert moderator team member inside each team	Teams pre-selected by teachers Multicultural and – disciplinary teams of 4 to 5 persons. Two expert PhD students coaching BSc student teams as outside experts
Data collection	Open-ended questionnaire in the end of the workshop	Open-ended questionnaire in the end of the workshop

It should be noticed that the major part of the network was founded at the SEFI conference in Orleans in 2015.

Both intensive courses consisted of daily lectures and some excursions related to the students` team task which they had to solve during the intensive one week time. Time was also reserved for the team work itself and for some social activities in order to develop the team spirit. The team tasks of the both intensive courses were quite challenging for the BSc students and there was also a time pressure in order to develop the students` time management skills as well as their tolerance for ambiguity. The team task could not be solved without active sharing of the knowledge between the team members. Before the team task was started some lectures about team development and cultural differences were given to the students and some teaming activities were also performed. The students were also asked to do online- meetings and video-sharing with their teams before the workshop.

The students were tutored by the lectures. As the first research question was related to the team coaching model of IIC:s, two different coaching models were being tested. In Tomsk IIC an **internal coach model** was tried. This meant that the expert moderator student (who was an IT MSc student) was part of the student team and thus the coach student became himself a member of the student team. In Irkutsk another model (**outside consulting model**) was being tested. In this model the two student tutors (who were IT PhD students) were located outside the student teams acting as outside expert consultants, they were not located inside the student teams and thus they were not actual student team members as the MSc students in the Tomsk setting were.

2.2 Analysis and findings from students' feedback – tutoring model

In both courses open-ended feedback questionnaires were used to get students´ opinions and ideas for further development. The students were asked to give an overall grade (from 1= worst to 5= best) for the whole IIC as well as for their team task. The Tomsk IIC got an overall grade of **4,3**. They also gave a grade for the team task and it was **4,2** so it can be concluded that the student satisfaction was quite high here even this was the very first time this kind of intensive course was implemented within this network. The Irkutsk IIC on the other hand got an overall grade of **3,6** and **3,3** for the team task so it can be concluded that the student satisfaction was lower in the latter course than in the previous course even the latter course was planned and developed based on the feedback of the previous course and the latter course included even more interesting excursions etc. than the first one. So this raises the question why this difference exists in the students` satisfaction levels as the settings of the both courses were in general almost the same.

After studying the course feedback in more detail it can be noticed that in the latter Irkutsk intensive course the teaming between the student team and the expert coach student was not very strong and deep (as it was in the first Tomsk course where the expert moderator student was one member of the student team) and this caused some stress inside the teams as the team task was (on purpose) quite challenging but the students did not interact actively with the expert student anyway. As a result, **9** out of **19** students in the Irkutsk IIC claimed teaming and international communication as the area that could be improved; there was no consensus among Irkutsk students on what went well in the whole course (in contrast, **12** out of **20** students gave recognition to international communication and teamwork in the Tomsk IIC).

This happened because the student team members and the expert PhD student did not become very familiar with each other during the Irkutsk course as the PhD students seemed to operate as outside consultants, unlike the Tomsk course, where the moderator (MSc) students were themselves team members. The BSc students were not asking so much questions and help from the PhD students in Irkutsk. This was noticed also by the teachers but no interference into the learning activities of the teams were made by the teachers as the tutoring model was being tested here.

2.3 Analysis and findings from students' feedback – learning outcomes

The students were also asked what they learned in the course. Skills and competences named by students after the Tomsk and Irkutsk courses are shown in Figure 1 and Figure 2 respectively. In the bar charts subject competences are given in blue and soft skills in grey colours. The number of students that stated progress in each skill is given along the x-axis.

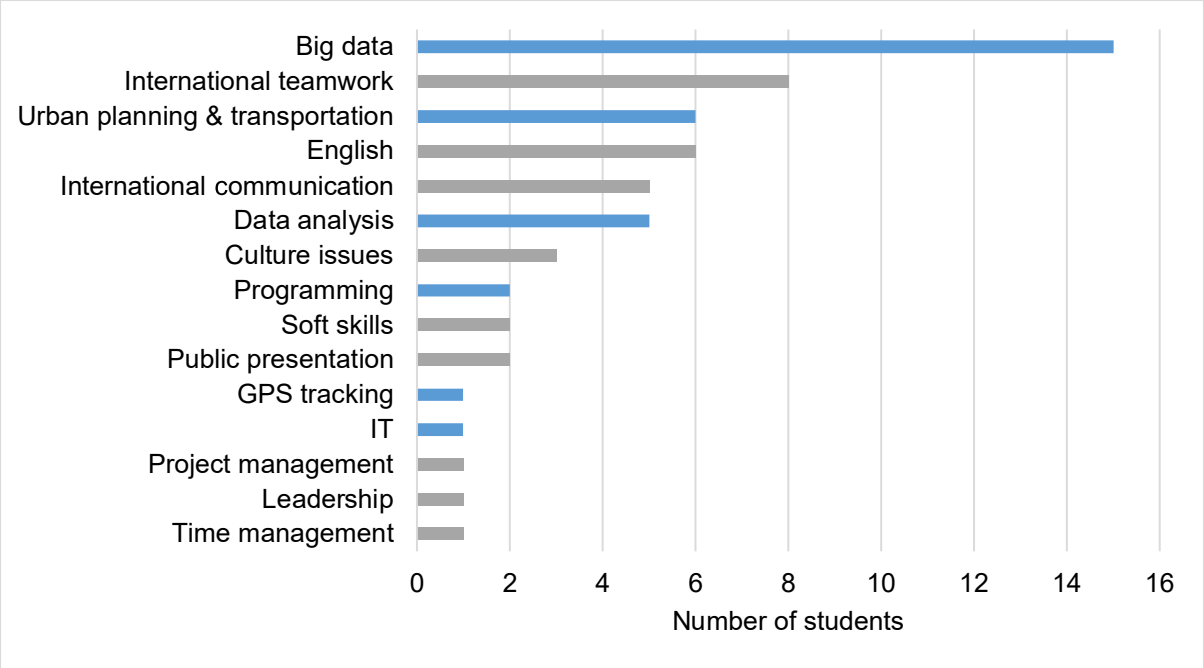

Fig. 1. Soft skills and subject competences developed during Tomsk intensive course

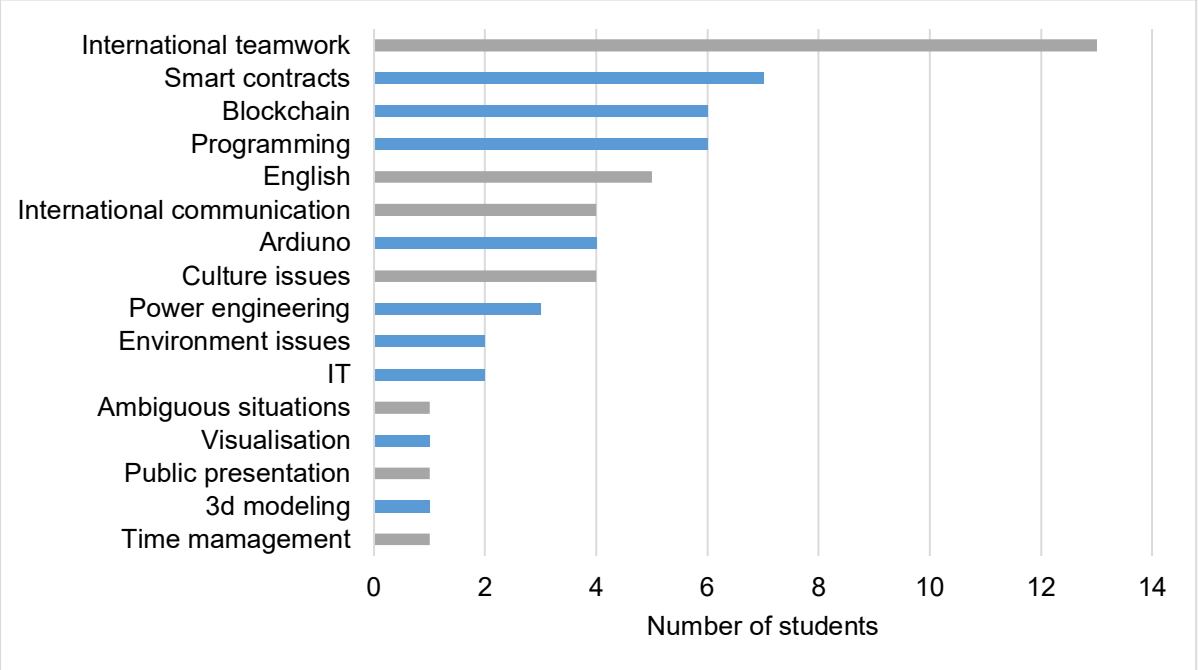

Fig. 2. Soft skills and subject competences developed during Irkutsk intensive course

It can be seen from Figures 1 and 2 above that this instruction method (IIC) develops the expected substance skills like big data analysis, urban planning, power engineering, programming and other IT related skills depending on the topic of the course and the team task. Besides, it also develops team working skills, communication skills, language skills, multicultural understanding skills, time management skills and other soft skills, although they were not explicitly announced

in the course programme. Students' feedback further demonstrates a fair distribution of responses between hard and soft skills (30/29 in Tomsk IIC and 32/29 in Irkutsk IIC respectively). Therefore, it can be concluded that the proposed instruction method can be successfully used to help students to achieve such competences which are required in their future working careers and in coping with ambiguity of the work environment.

The students` feedback also shows that the Russian students were more critical while evaluating the team task than the Finns and they wanted to have more exact guidelines for the team task than the Finns. This can indicate that the Russian students had lower tolerance for ambiguity than the Finns but this issue needs further research. Besides, Russian students were more focused on substantial skills rather than teamwork or commmunication skills in their responses, although they recognized the challenges and benefits of team work and communication in multidisiplinary and international teams. It can be assumed, that these two findings are interlinked, although this assumption requires further analysis and justification.

It was an interesting fact that almost all students said that the course could be improved by increasing the time for the team task but only some students reported that they had developed in their time management skills.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 How to develop tolerance for ambiguity?

Engineers working in the modern work environments have to cope with the increasing amount of task and environmental ambiguity so their tolerance for ambiguity should be increased and developed already during their education phase. In order to develop this important skill it is highly recommended to use also other instruction methods in engineering education than only the traditional classroom teaching in one´s own home university. International intensive courses have proved to be a successful method to teach both substantial knowledge and the soft skills expected by present-day employers. To organize an international intensive course the teacher needs a network of active colleagues abroad, willingness to take risks and to use some extra time in planning too. Of course an external funding source is also vital. But it all pays back in the end.

3.2 Coaching model and virtual teaming

As a conclusion it can be said that the internal coach model seems to be a better model in this instruction method for the team coaching than the outside consulting model, especially when the team is given a challenging task where they really need some deeper expert advice in order to succeed with their team task and to cope with the ambiguity. It can also be concluded that it is not easy to team up virtually. Most of the students did not want to upload any video of themselves before the course, so online teaming should not be counted too much on. Best teaming happens when people meet in real life ftf.

4 SUMMARY AND ACKNOWLEDGMENTS

Engineering students must be trained to face uncertain situations as the uncertainty increases in the working life all the time. To develop the students` tolerance for ambiguity new pedagogy and other instruction methods than the traditional classroom teaching must be taken into use. If universities want to develop radical and new pedagogical approaches they must give their staff possibilities to attend workshops, seminars and conferences even abroad where the staff members can hear about new pedagogical methods, meet other interested colleagues and create new networks. The institutions must also be prepared that sometimes mistakes can also happen so the organizational culture must support innovative ideas and encourage risk taking. Otherwise no new teaching approaches will be tried. We thank our home universities for the possibilities to make these trials (and sometimes even errors) with the new pedagogical methods such as multidisciplinary intensive courses. We also thank the Finnish ministry of education for the financial support for organizing the international intensive courses.

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