A Framework for Writing Learning Agreements

Tony Clear
School of Engineering, Computer & Mathematical Sciences.
Auckland University of Technology
Auckland, New Zealand
tony.clear@aut.ac.nz

Roger McDermott
Department of Computer Science
Robert Gordon University
Aberdeen, UK
roger.mcdermott@rgu.ac.uk

Elin Parsjö, Åsa Cajander, Mats Daniels, Nanna Lagerqvist
Department of Information technology
Uppsala University
Uppsala, Sweden
elin.parsjo@gmail.com, asa.cajander@it.uu.se, mats.daniels@it.uu.se, nansiken@hotmail

***Abstract*—Active learning is a popular concept for motivating learning. Learning agreements are one strategy towards this goal. They can be used to aid the students to take ownership of their learning and in becoming more active in a course. Learning Agreements are especially useful tools for scaffolding learning in courses with a focus on developing the professional competencies of students, such as in Open Ended Group Projects, Work Integrated Learning or other authentic learning contexts. Such educational contexts are complex and we have found it necessary to scaffold student learning using agreements based on professional competencies. This has led to a pedagogical framework, which has found successful application in a number of contexts. This framework has been built based on discussions with students, and has involved the development of a supporting wiki which contains descriptions of the different professional competencies involved in the learning agreement. The IT based framework has been iteratively developed together with the students taking the course in the fall of 2015. The development and assessment of this framework is contrasted in the context of two courses using learning agreements, one (in Sweden) with a focus on development of professional competencies and the other (in New Zealand) addressing a mix of professional competencies and subject knowledge in a work integrated learning setting.**

Keywords— Open Ended Group Projects; Global Collaboration, Distributed teams; Learning Agreements, Personas, Authentic learning

I. Introduction

Active learning techniques are seen as an important way towards improved learning outcomes [1-2]. This is in line with a constructivist view of how learning takes place where a learner is seen as actively constructing meaning rather than passively absorbing information [3-4]. The Open Ended Group Project (OEGP) pedagogy [5-7] is an example of a learning environment that builds on the idea of active learning. In literature it has been noted that in using an OEGP pedagogy, student 'motivation' can suffer due to the complex, messy and ambiguous setting [8]. More generally this is an issue for students who desire the comfort of tightly structured course designs and assignments and find themselves out of their comfort zones when dealing with more open ended tasks, as observed in [9-11]. In a database course context Connolly and Begg [12] phrase it in this way:

> "*students often have considerable difficulty comprehending implementation independent issues and analysing problems where there is no single simple, well known or correct solution. They have difficulty handling ambiguity and vagueness, which can arise during knowledge elicitation".*

The use of learning agreements is an example of how students can take ownership of their learning and become more active in these contexts. Learning agreements are especially useful when the pedagogical aims of the task concern the development of professional competencies such as communication skills, writing skills and intercultural communication, since this kind of learning is well suited for individual reflection and active learning. They can be seen as scaffolding towards the goal of becoming a reflective practitioner [13] as students become aware of issues to reflect on before, during, and after activities. This is especially the case if the learning agreement has a focus on personal development of professional competencies rather than being about learning aspects of a subject.

We see the learning agreement as being an essential tool for making students active learners and helping them make their learning both more explicit and more personal to themselves, thereby increasing their commitment to their educational development. Making the learning more explicit is an essential part, since a student cohort might otherwise give lower priority and appreciation to this kind of activity due to the difficulty and unfamiliarity with observing progress in this regard, when compared with acquiring "pure" subject knowledge [6, 14]. Furthermore, a more frequent use of learning agreements could lead to more independent activity among the students and thus address the "learning to learn" competency.

A framework was partly introduced in the 2015 instance of the IT in Society course in Sweden [15] to scaffold the students in the use of learning agreements. We explore the framework in the context of the Swedish course and then compare and contrast this with a similar course in New Zealand. The course

in Sweden has a focus on development of professional competencies while the one in New Zealand uses learning contracts to address a mix of professional competencies and subject knowledge in a work integrated learning setting.

The contributions of this paper are 1) presentation of a framework to facilitate the construction of learning agreements, and especially the novel use of personas in this context, and 2) the comparison of usage of learning agreements at two universities in courses based on Open Ended Group Project (OEGP) pedagogy.

II. Background

The background section of this paper contains a description of professional competencies, Open Ended Group Projects and Learning Agreements. This is followed by an overview of the persona method as well as a presentation of the two courses that are investigated in the paper.

A. Professional Competencies

Acuna and Juristo [16] have noted a set of capabilities/competencies considered useful for software developers, among which analysis, independence, decision making, perseverance and stress tolerance were demanded. These are clearly additional attributes to the purely technical skills that are also needed, but may not be apparent or seen as important by students.

So how do we help clarify/make explicit for students our desire to develop these competencies as desired forms of learning in a course setting?

B. Open Ended Group Project

The Open Ended Group Project (OEGP) framework is a pedagogical approach that we have found to be suitable for addressing learning of professional competencies [5-7]. The basic idea is that the educational setting is based on students working in groups, or teams, addressing an open ended issue. There are several challenges for the students in this setting, e.g. to reach a common view of what the issue is and to form a strategy for addressing it. A pedagogical aspect is that the students will develop competencies suitable for functioning in the work environment and gain confidence in their ability to deal with situations where there is no right way to deal with it.

One challenge for the faculty is to find a balance between where all students get an understanding of what is to be done and where they work on their own and gain ownership of the project. On the one hand, helping them too much will move the learning environment to a more traditional faculty specified assignment and where they lose motivation, while on the other hand, providing too little support could lead to students becoming confused and disillusioned, as noted by Mayer [17] in a critique of pure discovery learning.

C. Learning Agreements

Learning agreements [18-19], or learning contracts, can be set up in different forms and can refer to many aspects of learning. When introducing such a concept in an educational situation it is essential to make it clear what the purpose is and between which parties the agreement is meant to hold. Some institutions prefer to circumvent the word 'contract' when supporting work integrated modes of learning, to avoid employer expectations of guaranteed task delivery, without a focus on the student's own learning goals or those of the academic institution [18].

D. Personas

Within the field of Human Computer Interaction, the 'persona' method was originally introduced by Cooper [20], who argued for hypothetical archetypes of real users in order to avoid designing systems that become too generic and in the end do not fit anyone. A persona is typically a short text describing a person including an image and a text that is relevant for understanding the person's needs. According to Cooper, personas should be based on actual users and should be precise and specific since it is more difficult to ignore a detailed persona than aggregated user data. The idea is that numerous personas are initially created through an iterative process, and then these are condensed, according to their goals, into fewer but more precise, examples.

The persona method has become a frequently applied technique and is used extensively in both industry and in research as a user centred way of representing users in situations where direct interaction with them are not available. The idea is that the overall focus and awareness of the users in development projects are heightened when working with personas [21].

However, their use is not restricted to this activity. For example, personas are described both as a communication tool and as a design aid. Nevertheless, Eriksson [22] argues that trying to separate the different ways the method can be utilized will both help the practitioner to more skilfully use the personas, as well as make them more open to alternative application. However, there has been some criticism of the persona method in which it is suggested that their misuse leads to designers distancing themselves from real users [23]. In addition, there is some research on personas that are used outside the project in which they were developed [24]. In that case the educational department adopted the personas as a way to introduce new employees to different clusters of customers.

III. Learning Agreements in the BCIS/BBus Course

At Auckland University of Technology the model for the Bachelor of Computer and Information Sciences/Bachelor of Business (BCIS/BBus) Conjoint Cooperative Education course has borrowed heavily from that of the BCIS Capstone Project. But it contains the additional element that there is normally some level of work placement or project for a real client, which places the course in a work integrated learning continuum [25-26]. A student studying the BCIS/BBus conjoint course is expected to meet the outcomes of both courses of study. Therefore, an individual learning agreement is required in which students define and negotiate their planned project assignment, addressing the three key dimensions of the cooperative learning model:

- the academic requirements (for both programmes of study)
- a student's personal and professional goals
- a student's workplace/sponsor's goals.

Each BCIS/BBus conjoint course of study normally involves undertaking a Project in a domain relevant to the Business major, in order to meet the needs of both programmes. Confirming the academic expectations of the Business major would occur as part of negotiating the initial learning agreement. The learning agreement assessment rubric is shown in Table I as an illustration on issues negotiated.

Table I: Learning Agreement Assessment Rubric

CRITERIA
Contract includes all required elements: Work assignment (BBus project), Discipline and capability goals, Contact arrangements with academic supervisor(s), Summary against graduate profile, proposal and letter of acceptance appended. Work assignment and learning goals cover all components
The components of the learning contract are appropriately linked: For example outcomes appropriate to goals, strategies appropriate to outcomes or objectives, demonstration / evidence and assessment appropriate to outcomes and strategies. Learning contract consistent with project proposal
Each component appropriately described. That is: Outcomes appropriately worded – can be preceded by "by the end of the assignment I will be able to…". Outcomes that can be demonstrated. Objectives as described in the "SMART" tool in supplementary appendix J1 Strategies are workable and give detail and depth about how the outcomes will be achieved. Demonstration/evidence and assessment is specific.
Overall contract provides a **course of study appropriate for full duration at** **level 7 and provides a sufficient level of critical analysis.** Most outcomes at the higher level of Blooms taxonomy.
Relationship of theory to practice is addressed in the agreement
Overall contract gives clear direction and guidance for the Coop assignment and addresses the needs of all three parties (workplace, student and AUT). The work to be undertaken is clear The discipline and capability goals are clearly expressed The focus for the semester is clear
Clear communication, presentation and format

An example of a specific capability [1]goal as expressed within such a learning agreement is given below:

Capability Goal 1

Objective

The objective of capability goal one is to improve my negotiation skills

The outcome

The ability to advise people when negotiating for functionality with clients will be provided.

Apply negotiation skills in different situations.

Strategy

To improve my negotiation skills I will observe and learn from workplace supervisors.

I will read up on negotiation skills.

Practice during different phases in the project like the user requirements phase where I can negotiate the amount of functionality within the available time.

Evidence

The workplace project manager will give feedback on my negotiation skills. I will also comment on this in my log book.

Assessment

Discussion of how I negotiated user requirements and functionality will be included in my Reflective report and will be assessed by AUT supervisors.

The learning agreement is a reasonably substantial document, typically in the order of 15 A4 pages in length, and is a summatively assessed item, with the rubric in table I above being applied. Assessment of the learning agreement is not a heavily weighted item, as the focus of the course is more on achievement of the goals committed in the agreement.

IV. Learning Agreements in the IT in Society Course

The IT in Society course at Uppsala University is open to students with a Bachelor degree. It runs during our fall semester and accounts for half the study time expected of the students during the semester. The course is a collaboration with students from two American sites; Rose Hulman Institute of Technology, Terre Haute, Indiana and Gannon University, Erie, Pennsylvania. The American students are enrolled in courses that only account for roughly a fifth of their expected study time during the period. We will focus here on the course at the Swedish site, since the changes are made by the Swedish faculty and primarily are intended for the Swedish students.

The course is based on an Open Ended Group Project [5-7] and conducted in collaboration with a real customer, who for more than ten years has been in the health sector in the County Council. The students have substantial freedom in defining what the project actually will encompass, although faculty give some restrictions and their plans have to be presented for, and approved by, the client.

This setting, with an open ended project typically involving over twenty students from different countries and also residing in different time zones, offers a rich environment in which each student is able to find some aspect of professional competence development on which to focus. The learning agreement in the course at Uppsala University is intended to help the students meet the specific learning objective of developing professional competencies, by ensuring that the students get an explicit emphasis on relevant aspects of learning for that goal. In the document each student identifies the professional competencies on which to focus. The students chose three professional competencies from the nine graduate attributes promoted at Curtin University, Perth, Australia and presented in Table II [27].

[1] a 'capability' can be viewed as synonymous with the term 'competency' in this paper.

Table II: Curtin University Graduate Attributes

	Graduate Attribute	Descriptor
	1. Discipline knowledge	Apply discipline knowledge, understand its theoretical underpinnings, and ways of thinking; Extend the boundaries of knowledge through research.
	2. Thinking skills	Apply logical and rational processes to analyze the components of an issue; Think creatively to generate innovative solutions.
	3. Information skills	Decide what information is needed and where it might be found using appropriate technologies; Make valid judgments and synthesize information from a range of sources.
	4. Communication skills	Communicate in ways appropriate to the discipline, audience and purpose.
	5. Technology skills	Use appropriate technologies recognizing their advantages and limitations.
	6. Learning how to learn	Use a range of learning strategies; Take responsibility for one's own learning and development; Sustain intellectual curiosity; know how to continue to learn as a graduate.
	7. International perspective	Think globally and consider issues from a variety of perspectives; Apply international standards and practices within a discipline or professional area.
	8. Cultural understanding	Respect individual human rights; Recognize the importance of cultural diversity particularly the perspective of Indigenous Australians; Value diversity of language.
	9. Professional skills	Work independently and in teams; Demonstrate leadership, professional behavior and ethical practices.

The learning agreement consists of three parts and is typically a few pages long, incorporating:

- Identification and description of the chosen professional competencies
- Description of how the student will act (in the project) to develop the chosen professional competencies.
- Description of how the student and faculty will know that development has occurred.

The students are thus encouraged to reflect on their own knowledge, skills and abilities, and commit to the development of personally chosen competencies, which will suit their personal needs as exercised in the context of the course. This is in line with our vision that a good strategy to develop professional competencies is to build a reflective mind-set [28]. The notions of "reflection in action" and "reflection on action" as metacognitive activities [Schön, 1987], are powerful in helping build the conscious and unconscious professional competencies typified by Schön's "reflective practitioner".

Over the years, students have shown considerable difficulties in writing their learning agreements. In our individual meetings with the students to discuss their learning agreement and progression, we have observed that the students were highly dependent on teacher guidance and that they had difficulties in reflecting on their learning and in defining their own educational goals. Also, the students seem to have difficulties accepting that there is no clear definition for the different professional competencies. We have thus identified a need to scaffold the students in writing these agreements although this very strategy was intended to scaffold them in developing professional competencies [29]. This has been done in lectures and workshops, but unfortunately without the desired outcome. We have thus, in refining the process, developed a framework for helping students to create meaningful learning agreements.

V. A Framework for Writing Learning Agreements

The framework developed to support the students in writing learning agreements in the IT in Society course has been built on past experiences and based on discussions with students. The idea is to build an IT based system for this framework, something that is currently being done using a course Wiki [30] set of pages. These pages contain: 1) General information about the assignment of writing a learning agreement, 2) Descriptions of the different professional competencies involved in the learning agreement (the nine graduate attributes from Curtin University), 3) A template for writing learning agreements, 4) Resources for developing different aspects of professional competencies, 5) A reflection section with specific questions related to what has been developed for each of the professional competencies, and 6) A set of personas and scenarios.

The first three items are quite straight forward, but nevertheless seen as useful in giving the students some understanding of what to do when setting up their learning agreement. The fourth and fifth items are where we envision participation from the students, in a "contributing student pedagogy" model [31]. The fourth item allows new resources to be added and comments on existing material can be made. The fifth item allows new questions to be added and comments can be made on old ones. The idea is to make the framework something that evolves over time. Resources are intended to be anything that can support a student to develop a specific professional competence. The resources are currently listed in the following categories: 1) books, 2) articles, 3) TED talks, 4) video clips, 5) courses, and 6) web pages. Some examples of reflection questions associated with each professional competency are "How did you adapt your written communication for the audience and purpose?" with regard to the written communication competency or "Have you learned new or developed techniques for visualization of data?" for the visual communication competency.

The sixth item, the set of personas and scenarios, is taken from the human computer interaction field and is intended to aid students in identifying themselves with regard to the international collaboration project and with potential professional competencies involved. The intention with this is to help students identify with different roles in the project and understand which professional competencies might be relevant for those roles. Another goal is to introduce the students to challenging scenarios that might arise in the project and the professional competencies that might be valuable in such scenarios.

A. *Focus Group Sessions*

Towards the end of the 2015 course instance two focus group sessions were conducted, one with five students (one

from Uppsala and the other four from the US) and the other with six students (three from Uppsala and three from the US). The sessions were led by a guest researcher not involved in the course together with a former student.

These two sessions were intended to explore the design of the Wiki as a collaborative technology platform. The students were asked to give input into the needs for the platform, how it might best be designed to support student learning and the role of mechanisms such as templates, personas, and scenarios. All students present in Uppsala at the time, (some of the students from Rose Hulman Institute of Technology were still in the US), were involved in the sessions.

An example of the information the students were sent before the sessions is the following:

> "As the usability expert Jakob Nielsen has observed in his Article on "The Use and Misuse of Focus Groups" [32]
>
> > *Focus groups are a somewhat informal technique that can help you assess user needs and feelings both before interface design and long after implementation. In a focus group, you bring together from six to nine users to discuss issues and concerns about the features of a user interface. The group typically lasts about two hours and is run by a moderator who maintains the group's focus.*
>
> In these focus groups, which will run for one hour only, the participants will introduce themselves and be guided through a series of questions and scenarios to gain feedback on the needs for the technology platform, and how it may best be designed to support student learning, including the role of mechanisms such as templates and personas. It is intended that your responses to the sequence of questions will help engender a group discussion about the merits or otherwise of suggestions made. A focus group does not have the intention of reaching a consensus so all views are equally valid. We will work through the feedback received and hope that your ideas and suggestions will help us design a better system and set of learning experiences."

Four areas were discussed in the sessions: experience with the learning environment, improvements to the system, issues concerning the Wiki, and use of personas and scenarios.

1) Experience with learning agreement

The responses were varied with some comments on how the learning agreements ere viewed at different collaborating institutions, due partly to how thoroughly these were explained compared to that which took place at the Uppsala site.

> *The student was really confused with the personal learning agreement and did not know what competencies were.*
>
> *A Swedish student says he has different thoughts than the American students. He passed the assignment the first time. He thought it was clear which competencies to choose and motivating them was easy.*

There were also comments about how students would know whether goals had been achieved.

> *Dependent on each competency there should be a way to know if you have achieved or improved the competency, like a task completed or question. "How will you know that this competence has developed during the course?" Is too vague.*

The students also asked for a greater justification for doing the learning agreement and also to have the professional competencies better explained. About half of the students did not really follow up on the learning agreement, but some did.

> *The student used the personal learning agreement to reflect on collaborating with people, also in a professional setting outside of the course, an internship.*
>
> *Two of the students used the personal learning agreement as a guide, others struggled.*
>
> *They need to know why the personal learning agreement is important and want more discussion.*
>
> *It was a long process to write it for the Swedish student, but it has been very giving/helpful.*
>
> *The personal learning agreement makes you self aware.*
>
> *One student used the personal learning agreement to pick assignments throughout the course that fit with the contract.*

2) Improvements

Suggestions for improvements came up at various stages of the sessions. Here are some examples of what was noted from the sessions.

> *A student found it difficult to write the personal learning agreement. You have to look at yourself to know what to choose. The student would have changed some competencies now that he is more experienced of the personal learning agreement.*
>
> *One student, others agree, think you should be able to change the personal learning agreement. There should be a feedback sessions about the personal learning agreement, maybe halfway through the course.*
>
> *There does not need to be more than three competencies. Would be possible to focus only on one competency, but with several aspects of it.*

3) The Wiki in General

The responses were in general positive, e.g. one student pointed out the reflection part as looking really helpful. There were some suggestions for improvement, like adding more information about the competencies and "success" stories from previous year's students.

They also suggested adding some sort of "self quiz" where they could learn more about themselves in relation to the competencies.

4) Personas and Scenarios

An introductory slide (figure 1) was used to frame the focus group discussion about personas and scenarios:

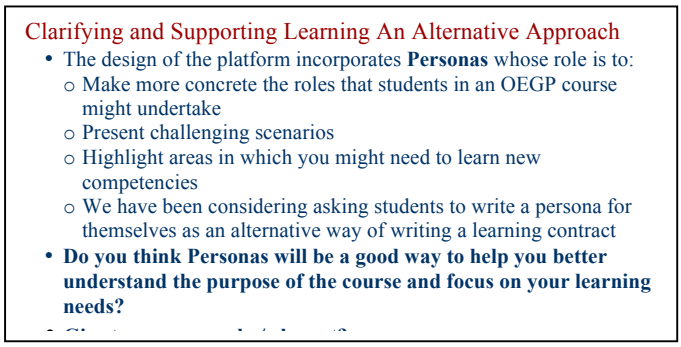

Figure 1: Slide for Focus Group on Personas and Scenarios

Two further slides, see figures 2 and 3, were used to introduce the idea of personas and scenarios:

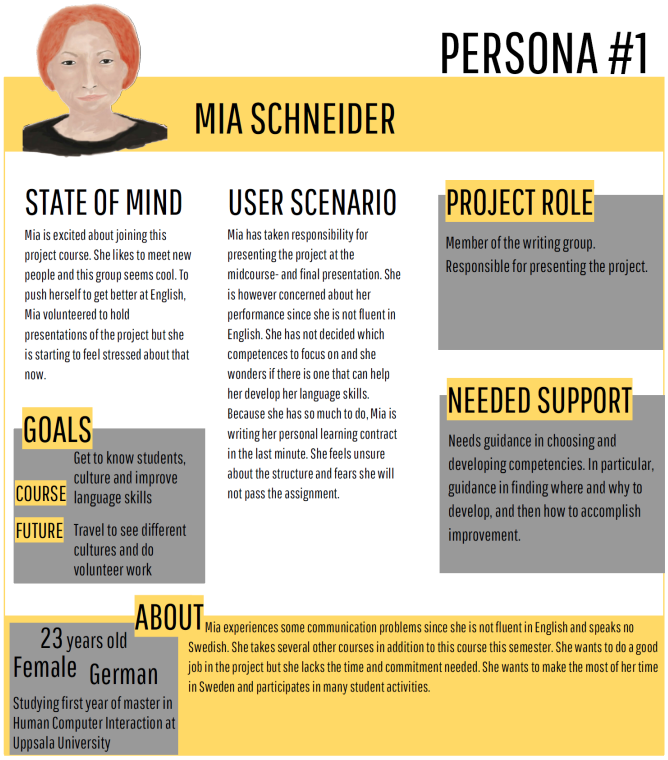

Figure 2: Persona #1

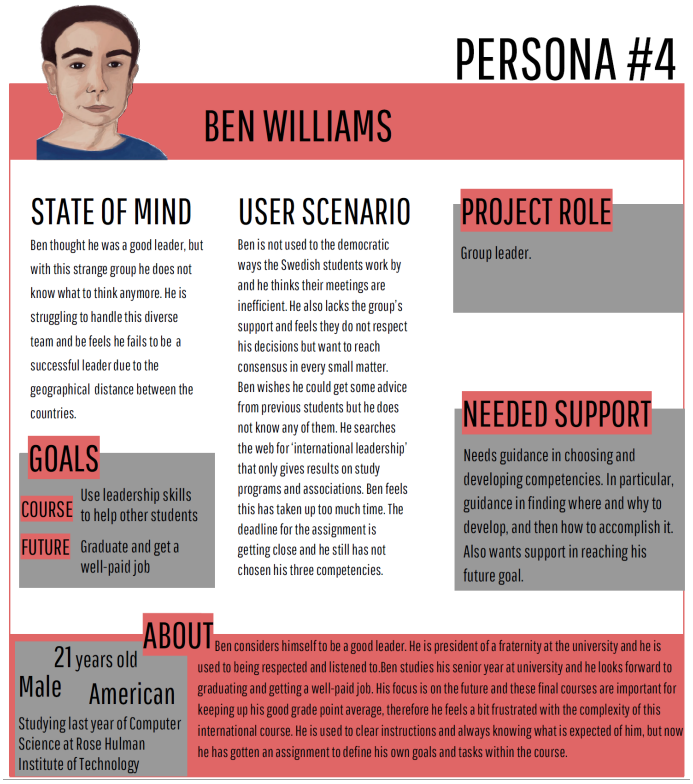

Figure 3: Persona #4

Most students were new to the idea of personas and scenarios, but the discussions were still fruitful. The two personas presented for them were built by personal experiences of two students from two different previous instances. It was interesting that the students said that they could identify persons being like the two personas. The students were in general hesitant about writing their own personas and scenarios. Some pointed out that writing personas and scenarios could be something to do over a period of time, e.g.:

> *They think you would know enough to write a persona by the end of the first week of the project. Would be better to write them, or revise them, midcourse. Would be good for reflection.*
>
> *Some pieces of the persona can be done early and some later.*
>
> *They think the personas would be very different in the start compared to the end.*

Several had thoughts along the line of writing personas for each other, but they saw more drawbacks than advantages with that.

> *One student does not think they would note everything well about themselves in a persona. It would also be hard to write about someone else, do not want to bash them.*

It was generally seen that personas and scenarios, such as those presented, could help them in writing their learning agreements.

> *Personas could help writing the personal learning agreement.*
>
> *Personas should not replace the personal learning agreement. The personal learning agreement helped compare an international project vs a local.*
>
> *The personas could help if you are struggling.*
>
> *Could be good with examples like the given ones. Some think they would have no idea what to write with just a blank space.*

There was a discussion about the value of seeing personas from previous course instances, although the opinions were divided about the value.

> *Would be good to see personas from previous years.*
>
> *Having past students' personas would make it difficult to think freely, but that is different for everyone as some think it can also help.*
>
> *Can be hard to write a persona because others perceive you differently. With help from other people it would help one to see which competencies to improve.*

Much of the discussion of personas and scenarios diverged from being a support for writing learning agreement towards being something in addition, like being a scaffolding of its own.

VI. Comparison Between the Two Uses of Learning Agreement

There are some major differences in how learning agreements are used in the two courses. The assessment is perhaps the most obvious difference, where in the Swedish instance it is writing the learning agreement that is assessed, whereas in the New Zealand instance it is especially the

fulfillment of the agreement that is evaluated. Another difference is that the client is involved in New Zealand whereas the learning agreement in Sweden does not involve the client at all. The content of the learning agreements are also different, where the one in Sweden only focuses on the learning of professional competencies and the one in New Zealand also covers the work assignment and concrete knowledge components. The freedom in how to write the learning agreement is higher in Sweden and both sites have seen the need to actively scaffold the students in writing them.

The differences stem to some part from the courses having different learning objectives, but there are substantial similarities and thus fertile ground for learning from each other. Things to consider on the Swedish side are to also include a clearer assessment regarding fulfilling the learning agreement at the end of the course. At the moment students are only assessed about their learning agreement in their final reflection assignment and there it is ok to come up with thoughts about what happened without a demand for living up to the agreement.

Raising the bar with regard to fulfilling their learning agreements would probably lead to students taking them more seriously than they do today. The counter argument is the question of scalability and the extent to which an instructor can actively work with multiple students in a mentoring role actively iterating drafts of the learning agreement at the busy start of semester period.

An assessment at the end of the project could involve use of a grading rubric which would increase transparency with regard to what is assessed, but also most likely restrain the students' freedom to be inventive in how they think they should show that they have developed with regard to their chosen professional competencies. Involving the client is another route to increase the seriousness of the learning agreement, but this is a rather big step away from the current version. A smaller step would be to include negotiations with other students in writing their learning agreements. We are currently considering which of these options to include in the next iteration of the course, and how far to spread that practice across sites.

VII. Conclusions

There are many different ways to use learning agreements in courses and they can be quite powerful tools in directing students learning. We have found that using them to scaffold, and assess, students development of professional skills is complex and have thus developed a framework for supporting the students. The support is intended both for writing the learning agreement and to function as a guide throughout the course.

We have developed a prototype of a Wiki based tool to support such a framework in collaboration with students and evaluated it through focus group sessions as well as observing and interacting with the students in the international student collaboration project. The results are positive, but have raised issues that we can only investigate through active experimentation with the framework in the field. Therefore we will continue our efforts in order to provide the students in the 2016 instance with a fuller version of the framework based on the Wiki platform. We will include the personas and scenarios, based on the balance of positive comments in the focus group sessions.

The use of learning agreements will be influenced by the comparison with the use of learning agreements in the New Zealand course in that a clearer follow-up of the development will be undertaken toward the end of the course. We will also probably introduce some form of negotiation with other students in the process of writing individual learning agreements.

Overall we believe the learning agreements have value for students and have the potential to contribute strongly to student motivation and in building both their awareness of and commitment to developing professional competencies. However their format and the types of support for their inclusion in a course is clearly an ongoing process for us. The introduction of the wiki and the personas as reviewed in this report, present one scaffolding strategy towards the more effective contribution of learning agreements in Open Ended Group Project courses.

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The Archetype Learning Method - Scaffolding Teamwork Competences in the Engineering Classroom

Arnold Pears, Mats Daniels and Åsa Cajander
Department of Information Technology
Uppsala University
Box 325, 751 05 Uppsala, SWEDEN
Ph: +46 18 4711066, FAX: +46 18 55 02 25
Arnold.Pears@it.uu.se

***Abstract*— Globalisation of both the workplace and higher education is a fact for many Universities and Industries. For the universities the challenge lies both in identifying the needs and developing pedagogies suitable for preparing their students to become a workforce that can contribute in a global economy. Thus, a central issue is how to provide an appropriate level of background knowledge and skills which contribute to the success of the individual in the workplace, and to the success of their employers.**

Helping students develop the skills required for success in global software development teams provides a number of unique challenges and opportunities for the designers of engineering degree programmes. A central issue is that students bring with them local cultural norms, different native languages, and rhetorical traditions, which place an additional burden to the already difficult task of working effectively in a student engineering team.

The contribution of this paper is the presentation of two learning activities; 1) structured role-play and 2) hypothetical archetypes, used within a method we call the "Archetype Learning Method" (ALM). The activities are geared towards enhancing the students' awareness of the underlying complexities inherent in participating in global software engineering and through that provide scaffolding to the development of teamwork skills.

Our method provides students with strategies for engaging more productively in teamwork in a global context, hence contributing to the systematic development of one of the critical professional skills identified in the CHAOS report.

I. Introduction

Globalisation of both the workplace and higher education is a fact for many universities and industries [1]. For the universities the challenge lies both in identifying the necessary work place competences and developing suitable pedagogies which prepare their students to contribute as a productive workforce in a global economy. A central issue is how to provide graduates with an appropriate level of background knowledge and skills [2], [3], which contribute to the success of the individual in the work place, and to the success of their employers. Helping students develop the skills required for success in global software development teams provides a number of unique challenges and opportunities for the designers of engineering degree programmes.

The complexities involved in functioning in a global software engineering team are considerable. Among them the reality that students bring with them local cultural norms, different native languages, and rhetorical traditions, which place an additional burden to the already difficult task of working effectively in a team. The contribution of this study is the presentation and evaluation of a method to address some of these educational issues, with a focus on scaffolding the development of teamwork skills.

Critical awareness in global software engineering naturally concern purely technical complexities, but also of high importance and the focus of this paper is the many aspects of diversity in global teams. Compelling evidence of the need to more comprehensively address this issue can be gleaned from the CHAOS report produced by the Standish group

annually since 1995 [4]. The 2015 CHAOS report is a systematic meta-analysis of 50 000 software engineering projects for success and threat factors. One of the conclusions of that report was that emotional maturity is one of the four most important factors of success for software engineering projects. The Standish group defines emotional maturity as "the collection of basic behaviors of how people work together. In any group, organization, or company it is both the sum of their skills and the weakest link that determine the level of emotional maturity".

In our project courses the main educational goal is to provide students (our future engineers) with strategies for engaging more productively in teamwork in a global context, developing the professional skill identified as a key success factor in the CHAOS report. This paper focuses on global teamwork skills, since this is one of the most important aspects of running successful projects.

As a part of this effort we developed the "Archetypes Learning Method" (ALM). This paper explores how two learning activities 1) structured role-play and 2) hypothetical archetypes of students can be used to enhance awareness of the underlying complexities inherent in participating in global software engineering. These methods are applied in structured reflection activities in a two course sequence in our Information Technology Engineering programme at Uppsala University, Sweden.

Our method provides students with strategies for engaging more productively in teamwork in a global context, hence contributing to the systematic development of one of the critical professional skills identified in the CHAOS report. The remainder of the paper is structured as follows. Section II describes the background, and challenges which were the drivers in developing the ALM approach. Section IV provides an overview of the activities included in the method, explores staff and student perspectives on the use of the method in teaching, and discusses the evaluation data we have collected. Section V provides recommendations and outlines future work.

II. The 21ST Century Challenge

Over the last decade project and problem based learning has emerged as an important component of much of engineering education [5]. Project and problem based learning environments have also been the focus of much research in higher education [6], and are widely claimed to contribute to development of both professional competences such as teamwork and communication [7], [8] and twenty-first century skills [9].

The initial data which forms the background to the current paper was collected in 2008 [10] and revealed a strong tendency among students to focus on utilising existing strengths in teamwork situations. This indicated that students were choosing to sacrifice many learning opportunities in student teamwork in order to optimise the quality of the desired project result or artefact, rather than taking the opportunity provided by the project to develop new skills and competencies. This behaviour was also linked to student's concerns about optimising their time usage in the course, and a desire to complete projects as quickly as possible and often with the minimum effort required to pass.

As a result of the insights we gained in this research we commenced a series of reforms in our degree programme curricula [11]–[14]. The implementation of these reforms included restructuring several courses to provide a clearer focus on developing skills that had previously been under emphasised. We also changed our assessment approach to focus more on rewarding students who exploited opportunities for professional development and and reducing the rewards associated with the technical sophistication of the final product [15].

Peters [16] reports results from a critical incident analysis focused on understanding why students in a project course expressed a strong conviction that spending time on understanding a complex problem set in a societal context was a waste of time. A number of the students in the class reasoned that their task as professionals was to solve well defined problems that someone else had specified for them. Spending time on working out how to collaborate in a semester-long international student collaboration project was also seen, albeit not as strongly phrased, as wasteful, where, again, it was seen as someone else's problem to sort out. They were also of the initial view that the main challenges with project work in a team environment were technical rather than social and cultural.

Further data collected in the subsequent year in

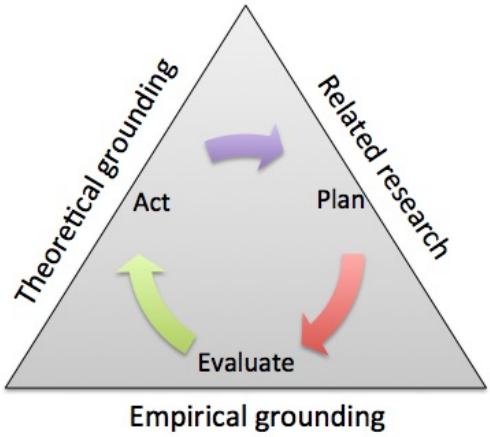

Fig. 1. The ALM Development Process

15 minute individual teamwork debriefings indicated that many students failed to appreciate some types of workplace skills that would likely serve them well outside the academy. In particular students evinced a very strong belief that their future work would consist of well defined technical tasks for which a single optimal solution could be devised, and where their employers would know the ”proper” way to arrive at this ”correct” solution. Albert is an excellent example of this type of view.

> Albert: ”It was a very interesting project, really fun, but very unrealistic!”
> Interviewer:”Really? In what way unrealistic?”
> Albert: ”Well, you know [pause] well, like when you are working in a company your boss will know exactly what needs to be solved technically. I mean this whole fuzzy problem thing, it isn’t really something that a real company can tolerate. They know what is to be done and exactly how to do it. So I don’t see why we wasted time with you pretending that you didn’t know the exact problem to be solved.”

III. The Archetypes Learning Method (ALM)

A. Developing the ALM

To address the specific challenges posed by culture and background on teamwork and software systems design we developed the Archetype Learning Method (ALM) and devised a series of associated learning activities which were incrementally introduced into a two course sequence in a five year engineering programme in information technology engineering Uppsala University, Sweden.

The ALM was developed iteratively and evolved from classroom interventions and observations. The personas element draws heavily on related research in human computer interaction [17]. While the scenarios are drawn from our work on project team dynamics and, related theories from computer science education from our action research context. The elements of the design process are depicted in Figure 1. Our empirical data consists of a detailed case study and also analyses of reflections gathered during several instances of two global software engineering [11], [14], [18] courses that have been offered at our institution over the past decade.

B. The ALM Structure

To help students focus on the design challenges inherent in working as an IT professional the ALM method provides two separate, but interrelated, modules. The structure is shown in Figure 2. Fictive student archetypes (implemented through our student persona sheets) provide a mechanism to facilitate awareness of others, and other cultures and norms. The role-play sheets provide scenarios that leverage these norms to simulate situations that place students in roles they might otherwise never encounter. These theatrical situations are used to stimulate reflection on key areas which are challenging in teamwork.

The process involves a period of role-play, which is then followed by a period of staff facilitated and guided reflection. This provides the staff with an opportunity to introduce relevant theories and leadership and teamwork concepts. For instance the leadership scenarios can be used to explore tacit and explicit power, delegated power and informal leadership approaches. Passive resistance strategies and other teamwork strategies can also be explored in this way.

C. Applying the ALM in Instruction

The ALM role-play module targets cultural norms for communication and negotiation in teams by defining archetypes with which students interact in role-play.

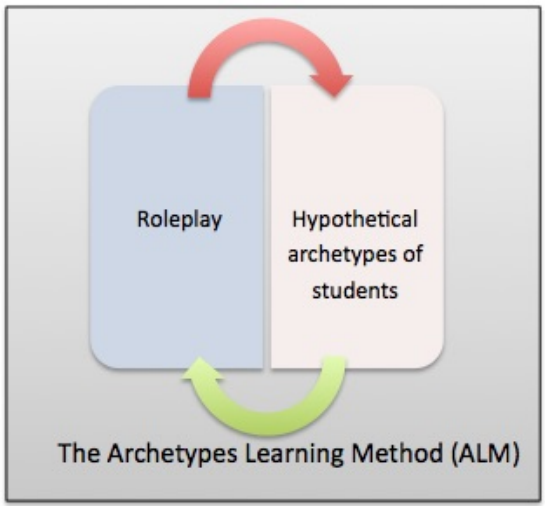

Fig. 2. ALM Structure.

The 1DT092 - Global Software Product Development (Runestone) course at Uppsala University is a collaboration between Uppsala University, Turku University of Technology, Finland, and the Hanoi University of Science and Technology (HUST), in Vietnam[1]. The course has been running since 1997 and has involved a number of other universities over its lifetime, including Rose Hulman Institute of Technology and Grand Valley State University in the USA and Tongji University in China. The course is 10 ECTS credits and runs for approximately 11 weeks. In this course development teams are allocated 3-4 students from two of the participating sites. Each team thus consists of 6-8 students who are asked to produce a prototype of a distributed system which is capable of steering a remote robot in real time both autonomously and under direct human control. More information about the course can be found in our publications that describe aspects of the course [11], [19], as well as on the course web site, which is hosted in the project management tool RedMine at `www.runestone.it.uu.se`.

The role-play exercise in the Runestone course was introduced in 2014 as a result of student feedback on the annual course evaluation. Students observed that they felt a need for more scaffolding in terms of dealing with challenges stemming from the course demands on competence in leadership, collaboration and inter-cultural communication.

To address this we introduced a course presentation dealing with formal and informal power and leadership strategies. The formal instructional session on leadership is complemented by the role-play exercise presented here. The scenario provides a staged exploration of intra-team dynamics from team formation and goal negotiation, through to internal conflict resolution and challenges associated with failure of some members to pull their weight.

To emphasise the cultural components and to help students gain awareness of the power and limitation of cultural stereotypes each student in the role-play exercise is given a fictitious character to play. The characters are simplified student characters which combine both student and cultural stereotypes. These characters are included for reference in Appendix B.

The scenario sheet presented in Appendix A provides the overall structure of the 90 minute classroom role-play session. Student are briefed on the purpose of the exercise and the intended aims for about 10 minutes at the start of the session. The remainder of the session consists of alternating periods of role-play and scaffolded reflection. Each role-play element is played out in the student groups for between 15 and 20 minutes. This is followed by a series of reflection questions from the facilitating staff member which draws on the different experiences of the groups. These sessions are typically conducted in an active learning space with group table setup. The facilitator gathers input on what happened in the role play from each group, and uses that to discuss strategies for dealing with the range of situations that can arise.

The archetype method is used in the subsequent course, 1DT012 - IT and Society[2], and it utilises character sheets developed based on persona stereotypes [14], [20]. The IT and Society course is a collaboration between Uppsala University, Sweden and Gannon University and Rose Hulman Institute of Technology, both in the USA. The course is a large scale international project course in collaboration with the Uppsala Academic Hospital, one of the largest medical training and research

[1] `http://www.uu.se/en/admissions/master/selma/kursplan/?kpid=31373&type=1`

[2] `http://www.uu.se/en/admissions/master/selma/kursplan/?kpid=31021&lasar=17\%2F18&typ=1`

hospitals in Sweden. The focus of the project is on understanding the challenges of IT deployments in the health-care sector and working directly with personnel from the Academic Hospital in current IT deployment projects.

Appendix A shows a sample sheet used in the course. These personas are derived from the researchers' many years of observation of students taking the course. A subsequent pedagogical development project took an action research approach to developing and evaluating these sheets, and involved students in the process of creating personas. The archetypes represented by the personas were developed to make cultural differences, and differences in level of ambition, more visible to course participants, with the intention of facilitating better teamwork in the course project. These characters have subsequently been used to develop and prepare students in two offerings of the course. Related research relevant for this work is the personas method in human-computer interaction [17] as well as our earlier research on the development of global software engineering skills [14].

The archetype method has been used in two course instances of the IT in Society course, which follows the Runestone course described above. In the IT in Society course Archetypes, and the student's earlier experiences collaborating with students from abroad in Runestone, are used as a base for discussion of barriers and enablers for teamwork in global software engineering. In these course instances the archetype personas was presented to a small group of students who discussed the following questions.

- What do you think of this persona? Is it realistic?
- What can the project group do to motivate this person?
- What can the leader do to motivate this person?
- What can this person do himself/herself to be more motivated?

During the seminar each of the personas was discussed separately at the same time as the faculty summarised the suggestions into mind maps with possible actions to take for each persona.

D. Evaluating the ALM

There are two separate results of this research. The first, and most concrete, result is the archetype learning method (ALM) itself. ALM provides structure and guidance for creating learning environments suitable for developing skills in global software engineering at the same time as it functions as a framework for development and refinement.

The second result is the insights reached in the process of developing ALM. These insights are based on our analysis of observational data from student role-play sessions, and reflective texts produced during the courses. We contextualise these results and frame them within the scope of our current experience with scaffolding global software engineering competencies to provide insight into both the strengths and shortcomings of our approach. A valuable "side-effect" of our research is a characterisation of the manner in which students respond to challenges in global engineering teamwork based on our analysis of student insights and examples of the types of strengthened capabilities that can be developed.

We asked the students about the value of the archetype personas exercise in our anonymous midterm course evaluation. On a scale from 1 (not valuable at all) to 5 (very valuable) the exercise got a medium of 3,7, with 22% stating that it was very valuable. The following comment identifies one of the major weaknesses with the approach; "It was nice to do, but lacks follow-up or concrete action plans for when this happens.". While this is true, there is seldom a single manner in which to handle these types of situations, and exact concrete advice with universal applicability is hard to provide. One other interpretation of this type of statement might be that it results from a student desire for the staff to handle these type of problems for them. The student perspective varies however, depending on the type of team role the student finds themselves in. Our staff have observed that the interaction with the students, especially the project and group leaders, is often at a higher level. This has allowed a more nuanced discussion about for instance teamwork and issues stemming from cultural differences

Each student in the Runestone course writes a weekly reflection about the course activities, and

their perspectives on the project as a whole. Henrik's reflection provides a direct student perspective on the role-play exercise.

> "In this lecture we did two interesting role plays. In different groups each of us got a different character and we had to play this character in two different team meetings. In the first virtual team meeting we discussed about a project leader and project goals, while the second virtual team meeting was about a free-loader, where we discussed about one team member that doesn't work that much and we are supposed to find a solution. It was quite interesting to play such a role and see how the other students react. In addition, it was nice to guess what was written on the other role instructions. I think such role play helps for solving problems later, since it trains to feel and think how another character thinks and what problems they might have. Since it is necessary to get often a compromise between different opinions."

IV. Conclusions

This paper provides guidelines for helping students to develop successful strategies for global software engineering teamwork. The role-play exercises and an example of the archetype cards we have developed are provided in the appendices. Full materials for the ALM are available from the authors.

Our research suggests that role-play and archetype exercises contribute to enhanced teamwork competence and students (and engineers) ability to negotiate the challenge of global software engineering. The evaluation data confirms that students gain value from the model, though not all students find it a comfortable exercise to engage with. While learning based on discussions of scenarios might not be as efficient as experiencing the scenarios as lived experiences, they still provide an effective avenue for learning and understanding.

It is crucial to note that learning activities, such as the ones presented in ALM, need to be both accepted and appreciated by both students and faculty in order for them to be sustainable. Staff in our project courses appreciate the ALM, especially since the learning activities were easily carried through and were perceived as creating a positive and active learning environment for the students. Students are not universally positive to the approach, but in many cases students, such as Henrik above, also clearly appreciate the model and associated exercises and reflect on them in a constructive manner.

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V. Appendix A

Background

Your team consists of between four and six participants for the teamwork role-play exercise. The objective of the session is to attempt to understand and act out some team scenarios and reflect on what strategies can be used to deal with situations that arise in teamwork.

Scenarios

Scenario 1 - Team Goals

Your team has just formed, and during the first meeting you have been asked to elect a team leader, and discuss initial plans and work schedules for the project. As the discussion about the project progresses the topic shifts from discussing the technical aspects of the project, to who will be the team leader, and what final grade the team should aim for.

Reflection

What happened in the discussion?
What power strategies were used?
Did any character dominate, or influence the outcome? How?
What grade did the team decide to aim for? Why? How did you reach that decision?

Scenario 2 - Project progress

After about four weeks of the project things are starting to feel very disorganised. No-one really knows what anyone else is doing, and project progress is hard to measure. The team leader (see scenario 1) has called everyone to a meeting to discuss the situation, and to sort out how to solve the problems the team is experiencing.

Reflection

What decisions were reached?
What were the hardest aspects of the situation to deal with?
What might have been done differently?

Scenario 3 - Freeloader

The team is now more than half way through the development cycle, and it appears that some of the team members are hardly ever present on campus. The members who have not been present are out of contact and unsynchronised with the rest of the team.

Spend a few minutes role-playing around this question using the roles and characters you have been given.

Reflection

What did you discuss?
What strategies were suggested in order to deal with the problem?
Was consensus reached?
To what extent do you believe the suggested strategies will really work and result in change?

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VI. Appendix B

Characters

Josephine

Josephine is a Swedish student from the Engineering programme in Information Technology. She is living close to campus, and is very keen on programming and technical aspects of computing. She doesn't feel comfortable in long discussions, and would rather get down to the real work as soon as possible in order to make rapid progress. Discussion is usually a waste of working time according to Josephine, and she tries to participate to a minimum in meetings. She is an ambitious student with very good grades, and sees this course as a way to show off her technical competence and get a high grade.

Jonas

Jonas is interested in systems design and human computer interaction. He has chosen the course because it seems to involve aspects of understanding how systems will be used, including requirements analysis and interface design. He is a little unsure about how good a programmer he is, though he has received top grades in all his programming courses. After reading about the course he thinks that some of the teamwork and coordination aspects of the course seems very interesting and would quite like to have a role like team leader, or meeting coordinator during the project. The final grade is not so important to Jonas, gaining useful experience to prepare for working life in his startup company is his major goal.

Yuen

Yuen is on exchange studies from China. He is a top student from his home university, where only the most outstanding students (those with the best grades and overall academic merit) are chosen for exchange studies. Yuen is unsure of his English, and speaks as little as possible. He is also unsure how he measures up to the Swedish students in terms of competence and management skills. He would not question authority, such as a group leader, and does not want to let the team down, even when he is not sure of what to do. When he does not understand what is happening he just says, "Yes, Yes, definitely!" and smiles politely.

Mona

Mona is not sure that this is the right course for her. She is a perfectionist, and likes to master all the details of every situation in order to work out what the optimal solution should be. She feels that most difficulties are best solved through meeting and discussing at length what to do. However, once a plan is made she becomes very angry if someone disrupts the plan, or an event she was unable to foresee changes the situation. Her plans are perfect, and everyone should follow them to the letter. If she decides that this is an interesting course she will engage very actively and try to plan the entire project. If she concludes that things are not working out, she will first try to make everyone in the team work harder to fix the plan, and if that does not seem to work become disinterested in the project and stop contributing. For her the final grade to aim for will depend on her engagement.

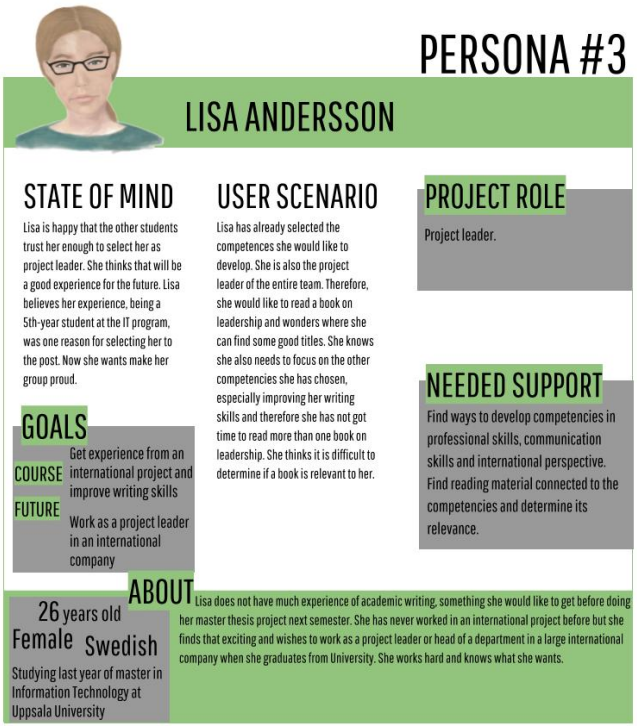
Sverker

Sverker lives in Stockholm and works part time with his own games software company. He is very sure of himself, and has selected the course because it seems possible to participate via the Internet pretty much for the whole course. There are few scheduled classes in Uppsala, and most of those don't look like they will be very interesting, so he plans to skip most of them. Perhaps he might go to the first one to meet the lecturer and the other people taking the course this semester. The plan is to spend as little time as possible on the course, and to make the minimum effort needed in order to pass.

Tapio

Tapio is a Finnish student taking the course as part of his degree in Finland. He is a good communicator, and keen to be a part of the project. He is concerned that the collaboration from a distance will present challenges, since he is the only Finnish member of the team, the other four members are from Sweden. His technical skills are quite strong, but he is quiet, and only contributes to discussions if he feels that he has something really important to say. He would quite like to be team leader, but wonders if that would be possible, when all the rest of the team are in Sweden.

VII. Appendix C



Unexpected Student Behaviour and Learning Opportunities: Using the Theory of Planned Behaviour to Analyse a Critical Incident

Åsa Cajander, Mats Daniels, Diane Golay, Jonas Moll, Aletta Nylén, Arnold Pears, Anne-Kathrin Peters
Department of Information Technology
Uppsala University
Uppsala, Sweden
Email: asa.cajander@it.uu.se

Roger McDermott
School of Computer Science and Digital Media
Robert Gordon University
Aberdeen, UK
Email: roger.mcdermott@rgu.ac.uk

***Abstract*—One of the challenges in being a teacher is to set up an educational setting where the students receive relevant learning opportunities for the specific course, the students' education in general, and for their future. However, efforts to create such educational settings do not always work in the way that faculty has intended. In this paper we investigate one such effort seen from a critical incident perspective. Central to the analysis in this paper is how the Theory of Planned Behaviour (TPB) can provide explanations for the incident. The critical incident can be summarised as students refusing to take part in a non-compulsory, but from the faculty perspective highly educational, activity. We describe the incident in depth, give the background for the educational intervention, and analyse the incident from the perspective of TPB. This paper makes two major contributions to engineering education research. The first is the development of a method for analysing critical teaching and learning incidents using the TPB. The critical incident analysis illustrates how the method is used to analyse and reason about the students' behaviour. Another contribution is the development of a range of insights which deal with challenges raised by learning interventions, especially those involved with acquiring hidden or "invisible skills" not usually seen or acknowledged by students to belong to core subject area of a degree program.**

I. Introduction

One of the challenges in being a teacher is to set up an educational setting where the students receive relevant learning opportunities for the specific course, the students' education in general, and for their future. It is especially challenging to create learning environments involved with acquiring hidden or "invisible skills" (defined by for example [1]) not usually seen or acknowledged by students to belong to the core subject area of a degree program. Moreover, efforts to create such learning opportunities do not always work in the way that faculty has intended. One example of such an effort is described by Peters et al. [2] where a critical incident reveals that many students taking a project course aimed at preparing them for being global software engineers do not see the value of the course as it clashes with their perception of being software engineers, and are hence not motivated to put effort into the course. The critical incident presented in the paper by Peters is within the context of an Open Ended Group Project educational setting, which aims at developing professional skills relevant for software engineering. In a paper by [3], the evolving use of this learning environment is presented together with the challenges it has faced. Other related studies have investigated the effects of educational settings called service-learning which combines community service with instruction and student reflection [4]. In the book by [5] such learning environments are explored and challenges and solutions are presented in relation to community service as a part of teaching in learning in higher education.

A number of studies have investigated the effects of teacher and student motivation on behaviours and the quality of student experience and performance. For example, [6] establishes that students' interest in the topic and achievement motivation predict both their experience of the learning situation and their achievement, independently of their ability. [7] show that students that are motivated to process the learning material perform better than less motivated students, regardless of clarity of instructions. [8] investigates how teachers' enthusiasm correlates to choice of instructional methods and students' perception of the learning situation. [9] developed a model where teacher interest is described as consisting of subject, didactic and educational interest. The model is then used to investigate the effects on student motivation [10]. The study finds that teachers' educational interest is a strong predictor of classroom management, which in turn shows strong effects on student motivation.

Inspired by a similar, very successful course at another university, a course in human-computer interaction was re-designed with an element of gamification [11] as well as presentations in front of a jury. Such elements are known to increase motivation in a very similar setting. The teachers planned the course based on the rationales presented above to create a more student-centric learning environment. To their surprise, many students seemed not to be motivated to engage in the setting, and the gamification component in particular did not seem to have a positive effect on motivation. As such, the learning activities introduced by the teachers had not the

outcome they expected. We will describe this in terms of a critical incident and use the Theory of Planned Behaviour to analyze the incident. The focus is on understanding the gap in alignment between the teachers' intentions regarding student activities and the students' actual behaviour.

This paper addresses the following research questions:

- Q1: Which differences and similarities between the intended behaviour (by teachers) and the actual student behaviour can be identified in the particular critical incident?
- Q2: How can the Theory of Planned Behaviour be used when analysing and understanding the critical incident?

Understanding the student behaviour in the context of a particular incident is the focus of this paper, but the methods applied in the analysis can inform the analysis of incidents and educational settings more generally. One key contribution of this paper is to investigate the application of the theory of planned behaviour (TPB) to yield insights into factors that contribute to understanding student behaviour in teaching and learning settings in higher education. This is particularly relevant for studies in higher education where a much higher degree of learner autonomy is expected of all students, in comparison to the more tightly controlled environment typical of K-12 education.

In the paper we will first give a theoretical background by giving a summary of the Theory of Planned Behaviour (TPB) and briefly mention some aspects of the Critical Incident Analysis. This is followed by a description of the context, i.e. the course and the intentions behind changes, for the critical incident being studied. We continue by presenting the method used and some aspects of the data collected and a description. The actual incident is then described before we use the proposed method to analyse the event and trace reasons behind student behaviour using the TPB. This is followed by a discussion of the method and the results.

II. Theory of Planned Behaviour

The Learning Sciences have a long history of re-deploying models from the wider social sciences to describe aspects of educational theory. Thus, for example, Tinto's model of student retention [12] is based on Durkheim's model of Suicide [13], while models of classroom management [14] have been based on self-actualisation theory [15].

Social Psychology models have, historically, started their analysis of behaviour by considering attitudes as important predictors of behaviour, although the relationship may well be an indirect one. The main approach has been to develop integrated models of behaviour which account for the variation in observed action, while controlling for sociodemographic factors. Of these models, those based on social cognitive theory [16] have received a great deal of interest and they now constitute some of the most frequently used models of human behaviour employed in behavioural change research [17] [18]. They have been applied to such diverse fields as health-related behaviours [19], criminology [20] and education, where they form the basis of the Technology Acceptance Model (TAM) [21]. This has resulted in the inclusion of additional determinants such as social norms or intentions which mediate the effects of attitude on behaviour.

An early example of such a social cognitive theory is the Theory of Reasoned Action developed by [22]. This sought to model volitional behaviour and proposed that intentions to perform a particular act are predicted by two variables: attitudes, which reflect a person's evaluation of his/her behaviour performance, and subjective norms, which reflect a person's perceptions of important others' approval for behaviour performance, and the person's perceived level of behavioural control. Hence, rather than attitudes being related directly to action, they serve rather to direct behaviour by influencing the intentions of the agent. In addition to personal attitudes, subjective norms, that is, an individual's perceptions of general social pressure to perform or not to perform the behaviour also contributes to intention. If individuals perceive that other individuals who they deem significant either endorse or disapprove of the behaviour, they are more or less likely to intend to perform it. In general, the more favourable the attitude towards the behaviour, the stronger should be the individuals intention to perform it.

This theory was relatively successful in accounting for behaviour which was dependent solely on personal agency, i.e. the ability of the subject to form an intention about a desired course of action and to be in a position to follow that through. However, it was less successful in accounting for behaviour in which lack of control over the implementation of the action was a significant factor.

The Theory of Planned Behaviour [23] sought to address this by positing that a person's plan or intention to act is indeed the primary predictor of subsequent behaviour and that personal attitude and social pressures and norms are determinants for an intention to act. Nevertheless, another significant contributory factor to intention is a person's perceived behavioural control, i.e. the extent to which they perceive they can control their behavioural performance. Perceived behavioural control influences both intention and behaviour and was introduced to allow the prediction of behaviours that were not under complete volitional control, i.e. the formation of an intention to do something was not sufficient to ensure that the action would follow since individuals perceive there are constraints which restrict their degree of choice and their ability to perform the action.

The inputs into attitudes, subjective norms and perceived behavioural controls are beliefs which link a given behaviour to a certain outcome, or some related attribute such as the cost of performing that behaviour. An individual may possess a large number of beliefs about a particular behaviour, but only those which are salient at a particular time will affect the outcome. Attitudes are underpinned by behavioural beliefs, subjective norms by normative beliefs and perceived behavioural controls by control beliefs. Each behavioural belief consists of two components: a belief about the likelihood of an outcome occurring and an evaluation which weights the importance of that outcome. Normative beliefs again consist

of two components: referent beliefs, i.e. the set of beliefs held by those who the subject refers to for guidance, and motivation to comply. The second component again moderates the first, because one is only likely to experience social pressure from particular referents if one is motivated to comply with those particular referents, i.e. those persons or external influences that are considered significant by the individual in the situation. Finally, the theory proposed that the beliefs underpinning perceived behavioural control are the perceived frequency of those factors that facilitate or inhibit the actions in question. These too are moderated by the relative power of those factors to inhibit/facilitate that behaviour. In all cases, the saliency or relevance of the beliefs to an individual promote or inhibit the corresponding factors.

The Theory of Planned Behaviour, as outlined above, has proved very appealing to researchers working in the field of behavioural change with meta-analyses reporting explanatory effects of 20% of the variance in prospective measures of objective reporting of behaviour, i.e. a medium to large effect size [24]. Nevertheless, there are questions about the extent of its scope within social psychology and its application to other domain areas [19]. Some researchers have speculated that the theory can be incorporated into a Dual Process Model in which behaviours arise in two different ways. Where motivation and opportunity permit, intentions may well mediate the influence of attitudes on behaviour. Alternatively, when either motivation or opportunity is lacking, the attitude toward the object may impact on behaviour in a more spontaneous manner, e.g. as described in the MODE model of [25]. In addition, [26] suggest that two additional variables have been shown to independently contribute to the prediction of intention, in addition to those mentioned above. The first of these is social identity which refers to that part of an actor's self which relates behaviour to societal goals and reflects the extent to which individuals see themselves as fulfilling a role within society. The second factor is a set of moral norms which are comprised of the individual's salient perception of the moral correctness or incorrectness of performing a behaviour, and so are concerned with personal feelings of obligation in the matter.

III. Critical Incident Analysis

The critical incident technique was originally developed by [27] to analyse critical incidents related to learning and student identity. Critical incidents detail "true-life events in professional activity which the member of a profession regard both as important and as factual evidence of good and bad practice" and the analysis of these are then used for professional education particularly relevant to practice [28]. Following Donald Schön's idea of the reflective practitioner [29], the critical incident technique is also part of the critical reflection model [30]. Here, critical incidents are used to reflect on practices, elicit embedded assumptions, and to help each other "derive changed practices and theories about practice that result from their reflections" [30]. In our study we apply the critical incident technique using it as a way of framing the analysis of a critical incident that occurred in an educational setting in an undergraduate course in a Swedish research university.

IV. The Course and the Intention of the Changes Made

The incident under study occurred in an introductory course in Human-Computer Interaction (HCI) given at Uppsala University to Computer Science Bachelor students in their third year. The course previously had problems with motivating students despite several attempts to reorganise and restructure its content. The overall structure of the course under focus was inherited from earlier course instances, and this particular course instance was the penultimate before another major reorganisation of the course.

There were around 50 students taking the course, of which 12 were women and 38 were men. In the end, 4% failed the course.

The set-up of the project-based course is illustrated in Figure 1 (see below). The faculty of the course had good contacts in health care so this became the focus of the students' respective projects. Students formed teams of 3-4 people and teams were then organized into bigger seminar groups (abbreviated SG in Figure 1) comprising four teams each. The projects comprised three phases, each corresponding to a specific aspect of the user-centered design cycle and including one or several assignments. There were both group and individual assignments (respectively abbreviated GA and IA in Figure 1). Each phase ended with a compulsory seminar (abbreviated S in Figure 1) where students had to present their work to the three other teams within their assigned seminar group.

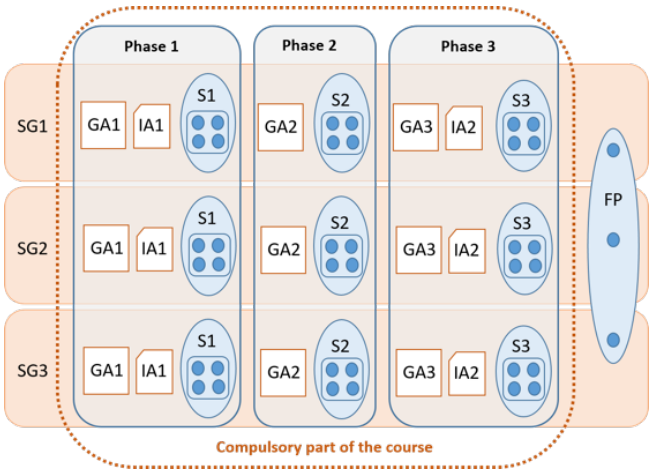


Fig. 1. The course set up: teams of students were organized into three bigger seminar groups (SG) throughout all three phases of the projects. In each phase, one or several assignments needed to be handed in. There were both group assignments (GA) and individual assignments (IA). Each phase ended in a compulsory seminar session. After the last compulsory seminar, one team from each seminar group was selected to do a non-compulsory presentation (FP) in front of a jury.

The main changes and additions made in preparation for this course instance were the following:

- A gamification component in the form of a competition between the different teams of students and a final presentation in front of a jury consisting of invited people representing different perspectives of the healthcare sector;
- An expanded project scope allowing students to freely choose from a wide range of health related apps on the market instead of between only two given redesign tasks;
- An increased focus on the content of the projects rather than on the form of the project reports;
- Continuous supervision / tutoring by the course faculty in the form of written feedback on each of the five main milestones of the course.

In the context of this paper, the gamification component is the most interesting modification made to the inherited course set up. It consisted of a competition between the different teams of students and was based on the teams' presentations of their work during the three mandatory seminars. As mentioned above and illustrated in Figure 1, the different teams of students were organized into three different seminar groups. The distribution of the teams between the three sessions was fixed and did not change throughout the course. This means that each team presented in front of the same audience, and always saw the presentations of the same classmates throughout the course. At the end of each presentation, the classmates in the audience were asked to rate the presenting team's project according to four pre-given criteria (the criteria were different for each seminar and based on the learning outcomes of the course) on a scale from 1 to 10. After the three seminar sessions, the course faculty rated in turn each presentation according to the same four criteria given to the students. Students and faculty ratings each made out 50% of the total amount of points obtainable for each seminar. At the end of the third and final mandatory seminar, the three teams ranking first in their respective seminar group were selected for the final, non-compulsory presentation before the jury. The students were informed at the start of the course that all team members from the team chosen by the jury would receive cinema gift cards as a reward.

At the end of the course three people were invited as members of the jury. The jury was chosen to fit the eHealth app redesign project task. The first member of the jury was the manager of the division in charge of eHealth at the eHealth Government Organisation at a national level in Sweden. The second member of the jury was a medical doctor now working with eHealth at the County Council of Uppsala. The third member was a full professor of human computer interaction with a special focus on eHealth.

The two main intentions behind the addition of this gamification component to the course were first to increase students' motivation by encouraging them to collect as many points as possible and thus do the best work possible, and second to reinforce their learning outcome by having them analyse and assess their peers' projects. The students were expected to:

- give more time and thought to their course project in order to collect a maximal amount of points and end up among the three teams presenting before the jury;
- follow closely the work of their peers (the three other teams pertaining to the same seminar group) in order to be able to rate their work.
- be motivated by the gamification component when presenting the projects.

V. Method and Data Collected

The Theory of Planned Behaviour (TPB) will help us understand how students behaved in a critical incident related to the gamification component described above. The critical incident will thus provide a focus for data collection and the TPB will provide a structure to capture underlying factors for the behaviour. The deeper analysis of the students' behaviour made possible by the TPB will then allow a better understanding of the critical incident.

Part of the data used when analysing the critical incident are from two anonymous surveys sent to the students of the course. The surveys had a response rate of 51% and 37% respectively, and included likert scale questions as well as open ended questions. The survey questions related to the learning experience of the course, and included multiple choice answers as well as free text answers. The questions included for example:

- How satisfied are you with the course in general?
- This has been especially good about the course:
- This could be improved in the course: (Make your suggestions as constructive as possible.)
- To what extent have you made the effort to benefit from the course content?
- What do you think about the idea to have a competition as a part of the course?

The surveys were sent out in the middle of the course, and after the course had finished. In the analysis, we have also used data from participatory observations in the created learning situations, and especially in the critical incident as well as written communication with students. The data is categorised according to the different aspects described in the TPB, as depicted in figure 2.

VI. The Critical Incident: Description and Analysis

A. Description

The critical incident analysed in this paper is related to the gamification component introduced in the course. The behaviour of most students were quite the opposite compared with the intentions behind the gamification intervention. The unexpected behaviour had its pinnacle on the day before the presentation of the three top projects for the external jury. One of the groups that was a candidate for being selected to be in the final seminar with the jury stated that they would refuse to present, and another group was chosen as their substitute. Then later on yet another of the three groups declined the opportunity to present, and we ended up having only two groups presenting. There were indications of students

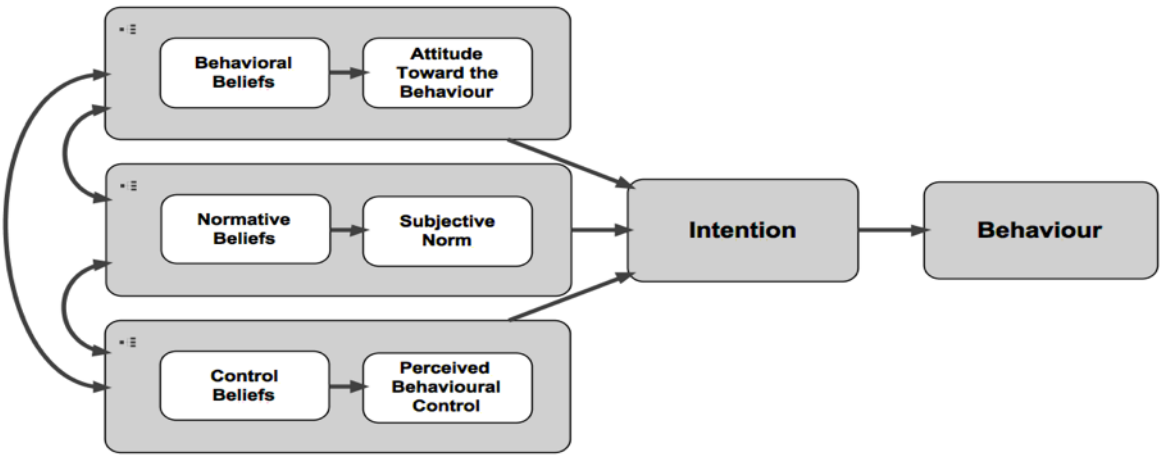


Fig. 2. Schematic representation of the Theory of Planned Behaviour.

consciously performing at a lower level than their ability and eventually only one student showing up (out of a potential forty students) at the final event.

Some of the students clearly thought that presenting in front of a jury is only extra work, and that they would not benefit from it at all, as indicated in these quotes:

> *"Our group purposely did a subpar job so that we wouldn't have to do an extra presentation in front of a jury."*
>
> *"Completely unnecessary that we should put our energy on presenting for a jury. You do not seem to understand how students work. A competition where the prize is to do an extra presentation.."*
>
> *"The competition should definitely be taken out of the course. It is obvious that almost nobody wants to "win" it. It may be an opportunity for some people, but if you are not at all interested in working with HCI it is simply a punishment for performing well."*

There are also positive sides to the event, and in the course evaluation 70% thought that the competition should be kept as a part of the course. Two of the students wrote:

> *"It's a great motivation to really be good at the seminars."*
>
> *"The competitive environment is a good strategy."*

During the two student presentations faculty were positively surprised by the quality of the work, and the open atmosphere in the groups. The jury members asked questions related to the design projects presented, and during the coffee break the students giggled and mingled with the jury members, for example joking about bribing them so that they would win the prize. After the winners had been announced the jury stayed behind to discuss the different projects with students and faculty, at the same time as the winning team took photos of their group to post in social media holding up the awards to be visible in the photo. Faculty experienced the final seminar as a positive learning experience for the students present, who really took the opportunity to network and to make a good impression.

Table I presents the two most relevant observations about the student behaviour in the critical incident as well as the corresponding.

TABLE I
TWO CASES OF MISMATCH BETWEEN INTENDED AND OBSERVED BEHAVIOUR

Identifier	Students behaviour related to the critical incident	Intended behaviour
SB1	Refusing to present. Two groups, one eligible and one selected for the presentation before jury, refused to take part in presentation.	Students would attend the final seminar, and look forward to presenting their ideas for redesign in front of a jury.
SB2	Not attending. Only two of around 40 non-presenting student showed up for the final presentation before jury.	Students would attend their peers' final presentation before jury.

B. Analysis

In this section we will use the Theory of Planned Behaviour (TPB) to make a deeper analysis of the behaviour of the students in the two cases presented in table I. This is done through sorting the data into the three different beliefs of TPB:

- *Attitude towards the behaviour*: According to the TPB the aggregated "behavioural beliefs", or likely consequences of the behaviour, produce a favourable or unfavourable "attitude towards the behaviour".
- *Subjective norm*: According to the TPB the aggregated "normative beliefs", or beliefs about the normative expectations from others, result in "subjective norms".
- *Perceived behaviour control*: According to the TPB the aggregated "control beliefs" are factors that facilitate or impede performance of the behaviour, and they result in "perceived behavioural control norms".

Tables II and III list the identified behavioural beliefs according to this sorting.

TABLE II
ANALYSIS OF SB1: REFUSING TO PRESENT

Attitude Toward the Behaviour

Some identified behavioural beliefs are:

- Presenting in front of a jury is extra and unnecessary work.
- The effort needed to prepare and carry out the presentation is too big in relation to the benefits I will draw from it.
- Not presenting takes away the risk that I might fail in doing a good presentation.
- Presenting would not provide learning that is of interest to me.
- There are other courses that have a more relevant content than this course. If I don't present I will have more time for those courses.
- There will be no negative consequences if I skip the presentation.
- My grade will not be affected if I skip the presentation.
- Someone else could present if I don't present.
- There will be no consequence since the teachers can't do anything if I refuse to present.
- Professional skills such as presentation technique and networking abilities are irrelevant for me to learn.
- I am good enough already, and I don't need this learning opportunity.
- Few of the students will really bother if I refuse.
- I will pass the course independently of whether I present of not.

Subjective Norm

Some of the normative beliefs found in the data are:

- We do not learn through presenting in front of a jury.
- Groups have tried not to win the competition, others do not want to win.
- My fellow students expect me not to (want to) present.
- The HCI course is not important to me / for my computer science education, and the others do not expect me to put effort into this course.
- We should focus on learning the core computer science things such as databases, communication protocols and the like.
- My teachers might be a bit disappointed at me since I do not present.
- The jury would expect me to present something I am unable to present.
- The final seminar is not my responsibility. It is the responsibility of the teachers.
- My peers will know that we refused to present, and they will think that was ok.

Perceived Behavioural Control

Some of the normative beliefs found in the data are:

- I feel no obligation to present.
- There are clashes with other classes at the time of the presentation.
- There was little time to prepare the presentation.
- If other students in my group have clashes with this course and cannot attend, we will not present our group's work.
- Presenting in front of a jury was not a part of the course description, and hence not a compulsory part of the course.
- The teachers can't do anything if I refuse to present.

VII. DISCUSSION

One can discuss these results in relation to the notion of social identity, which can be seen as a part of the subjective norm. The social identity related to how students ought to feel, do, and think in order to be recognised as legitimate, as "a real" computer science students. If recognition as a real computer science student entails an interest in and competence in technical problem solving [31], then students may distance themselves from "softer", more social, or subjective aspects of computing in order to not be marginalised.

The following quote demonstrates how showing an interest in HCI can imply to be marginalised as a computing person. The quote is taken from an interview at the end of study year 3, that was conducted as a part of Peters longitudinal study [32].

> *"The teacher [of the HCI course] was very interested in HCI, and we could really feel that. We thought: 'He is not a real computer scientist!'. (laughs) But then it turned out that he actually could program and that he was as good as we are, perhaps even better. Just that he had an interest for that which was a bit fuzzy."*

Showing an interest in this course can hence imply to be seen as incompetent when it comes to more technical aspects. This could explain the following quote by one of the student in the evaluation:

> *"For many students (like myself) [the competition / gamification component] is an incentive to NOT do (too) well, since they simply do not want the prize."*

Previous studies into the identity development in this particular study program suggest that the norm, after the second year of studies, is to value technical competence and, in particular, proficiency in programming complex system behaviours that are hidden to users of the system [31]. The main topic of the HCI course is, by that standard, neither highly regarded nor seen as relevant to the students future professional activities. The current changes to the course were made with these research results in mind.

Faulkner describes two engineering identities, a technical and a more heterogenous [33] [34]. She finds that many

TABLE III
ANALYSIS OF SB2: NOT ATTENDING

Attitude Toward the Behaviour Some identified behavioural beliefs are: • There will be no consequence if I don't attend. Other people could attend. • I will have time to do more important things if I don't attend. • Not attending will not affect my grades. • Not attending will not affect my learning.
Subjective Norm Some of the normative beliefs found in the data are: • Nothing important or interesting will happen during the presentations. • The other students don't expect me to be interested in their work. • The other student's don't want me to listen to the presentation. • Other students expect me to have other, and better things to do. • The teachers will be disappointed if I don't come. • Other students expect me to be interested in other, more important subjects within the programme. • Other students are not interested in the topic of the course, and don't expect me to be interested either.
Perceived Behavioural Control Some of the normative beliefs found in the data are: • I feel no obligation to attend. • There are clashes with other classes at the time of the presentation. • Attending the presentation was not compulsory. • The final presentations were the teachers responsibility. • I have heard and seen the projects being presented before, and probably few new things will emerge.

male students take on a technical identity, possibly because this identity converges with available mens gender identities, i.e. being rational (not subjective), solving difficult problems, doing the technical and not the social. And as most students in the course were male, this could explain some of their thoughts about the course content.

It should be noted that this analysis was made post mortem, and that we thus missed the opportunity to develop a questionnaire explicitly developed for the Theory of Planned Belief [23] for gathering data specifically about the critical incident. This could be seen as a general problem with analysing critical incidents, since they typically occur when not expected. The data is nevertheless rich enough to give interesting insights and this study should hence be seen as an example of the potential of the method we propose.

Using the Theory of Planned Behaviour in this way gives a structured view of motivations and beliefs from a student perspective. It pinpoints aspects where teachers beliefs differ from students and that can be addressed (in this course and in previous courses). Examples are:

> *"Presenting would not provide learning that is of interest to the student."* (SB1)

and

> *"Nothing important or interesting will happen during the presentations."* (SB2)

These quotes show that students do not see presentations and the following discussions as learning opportunities and thus do not see the benefits of interacting with the invited jury.

Using this structure, the frequency of aspects connected to students trying to optimize use of their time become clear. From that perspective, non-mandatory attendance together with the perceived non-core topic and lack of benefit become compelling arguments not to attend.

VIII. CONCLUSION

This paper introduces the Theory of Planned Behaviour (TPB) as an approach to the analysis of critical incidents in higher education. Critical incidents are by their very nature often unexpected, which complicates the process of analysis, since well structured empirical data is seldom available.

In this paper we have demonstrated how TPB is applied in practice to a critical incident which emerged at the conclusion of a course in our department. The analysis both illustrates the use of the method, and its application to data such as student reflections, course evaluation survey data and teacher reflections and observations.

The analysis reveals several tensions in the academic setting and helps to provide a structured view of student expectations of the consequent implicit educational norms to which they expect both their peers and teachers to conform.

We find the method useful as a part of the overall quality analysis process in our department and recommend it for wider systematic quality assurance work in engineering education.

In this paper we used TPB to gain insights into the behaviour of the students and that there is a focus on negative, from the faculty point of view, behaviour. We posit that the study of positive, from the faculty point of view, would

provide important insights with regard to creating educational settings. To use TPB in analysing faculty behaviour is perhaps not as obviously useful, but further work should be done in investigating this avenue of educational research.

ACKNOWLEDGMENT

The authors want to thank PhD Mikael Laaksoharju for being in support of the changes made in the course. We also want to thank Thomas Lind for helping out with the setup of the course, and for support when running it.

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Why are we Here? Student Perspectives on the Goal of STEM Higher Education

Aletta Nylén, Åsa Cajander, Mats Daniels and Arnold Pears
Department of Information Technology
Uppsala University
Sweden
aletta.nylen@it.uu.se

Roger McDermott
School of Computer Science and Digital Media
Robert Gordon University
Aberdeen, UK
roger.mcdermott@rgu.ac.uk

***Abstract*—A key component of the tertiary education system is the negotiation of common expectations in terms of pedagogy and the manner in which learning is scaffolded in the learning context. This paper addresses this interplay of perspectives by drawing on two elements of our previous work, a longitudinal study of student identity development [1] and a study contrasting project course students' experiences with teachers' expectations [2]. The paper develops a model of student interaction with teachers and the higher education system, which contributes to a better understanding of the consequences of recent changes and trends in higher education, e.g. demands for activating students, increased level of detail in course specifications, and examination of "non-core subject content". This is an immensely complex area and we approach this challenge with a focus on the issue of students rejecting learning opportunities. Through this lens we will identify and illustrate some essential aspects of how to adapt educational settings to better accommodate how students behave and view the goal of their education.**

***Keywords*—professional competencies; intellectual alignment; student learning**

I. Introduction

Effecting change in STEM education has emerged as a recent focus in disciplinary centred higher education research in science and technology over the last few years. One of the central questions in this research is to understand factors which might explain the slow pace of change in teaching and learning at university which has been experienced over the last two decades. Tremendous investment and related efforts over the past few decades have built up a substantial knowledge base about STEM learning and many effective pedagogies and interventions [3]–[5]. Yet prestigious organizations such as the National Research Council, ASEE and Royal Academy of Engineering are increasingly expressing dissatisfaction with the rate of implementation, adoption, and scale-up of research-based instructional strategies [6]–[8].

A number of the factors that inhibit innovation and systemic change have been discussed in the works of Borrego and Henderson, among others. Factors such as collegial conservatism, quality assurance processes [9], and curriculum structure have been the major focus of much prior work. Curriculum and learning outcomes are also strongly linked to the pedagogical approach applied to the learning situation. The far reaching impact of student agency in the change process has been discussed by Barker [10], and in particular the sensitivity of educational systems to student criticism.

We have observed a recent increase in mismatches between teachers intentions with educational settings and student behaviour. This ranges from students using course specifications, often outdated, to avoid learning activities, to students increasingly avoiding engagement in learning activities they consider not being needed in order to pass a course. The increased use of student active pedagogy has, in our opinion, been an important factor in creating this mismatch, and perhaps also a reason for seeing an already existing mismatch more clearly. This will be discussed later further on in the paper.

A key component of sustainable change is the negotiation of common expectations among players in an educational system, e.g., in terms of pedagogy and the manner in which learning is scaffolded in the learning context. Conservative expectations can have a negative impact on the STEM change process []. A better understanding of the interplay between expectations and recent changes and trends in higher education, e.g. demands for activating students, increased level of detail in course specifications, and examination of "non-core subject content", is one key to how educational settings can be adapted to better accommodate how students behave and view the goal of their education.

In this work, we develop new theories and models that can be used to reason about the interplay between different players' motivation in educational settings. We present a number of cases where teachers have observed unexpected student behaviours and discuss these from the perspective of interplay and alignment of motivation using the proposed theories and models.

Our vision is to create a framework that will facilitate pedagogically sound changes in STEM higher education. The effect on students should be the focus for change. We see student attitude towards their study time as an essential factor in this endeavour. Students should, in a successful educational setting, view the time allotted for learning associated with a course as something to fully use. That is, a student with a solid previous understanding regarding the learning associated with a course should cover a larger "area" of learning than a student not as prepared. Both these students should feel at home in the educational system. Well functioning alignment

between students, faculty, and the higher education structures are at the core for this to happen. The following quote from Brophy [11] captures this dilemma.

> "Especially needed are strategies for helping students come to value what they are learning for its perceived self-relevance and potential life application (not just to enjoy the activities in which they are engaged). Second, even those aspects of the school curriculum that are well worth learning may not become valued as such by students unless their exposure to them is designed to connect with their motivational zones of proximal development and is mediated in ways that scaffold not only their learning but their appreciation of what they learn."

The remainder of this paper is structured as follows. We commence with a survey of the field as background to the work presented here. Then we introduce our proposed framework for understanding the major players in higher education, followed by an overview of the theoretical underpinning for the framework. The framework is then applied to some cases of poor alignment between players. Some final remarks are given in the conclusion.

II. Survey of the Field

This trend towards student-centric and student active learning, is building on an increasingly influential body of work in the higher education research literature [12]–[15]. Research has shown that implementing a student-active curriculum clearly has many advantages for student performance in individual courses [16], but also that there are potential pitfalls associated with widespread use of some common student-active classroom techniques affecting the students' experience of their education [16]. Understanding the role of motivation in this evolving area is essential for exploiting the potential of student active pedagogy.

A number of studies investigate the effects of teacher and student motivation on behaviours and quality of student experience and performance. For example, Schiefele [17] establishes that students' interest in the topic and achievement motivation predict both their experience of the learning situation and their achievement, independently of their ability. Bolkan et al. [18] show that students that are motivated to process the learning material perform better than less motivated students, regardless of clarity of instructions. Kunter [19] investigates how teachers' enthusiasm correlates to choice of instructional methods and students' perception of the learning situation. Schiefele et al. [20] developed a model where teacher interest is described as consisting of subject, didactic and educational interest. The model is then used to investigate the effects on student motivation [21]. The study finds that teachers' educational interest is a strong predictor of the characteristics of the teachers' classroom setting. Structure, and actively monitoring classroom rules, help to structure the learning environment and thus increase student learning time, which in turn shows strong effects on student motivation.

None of these studies take into consideration the effect that educational structures have on student and teacher behaviour and motivation. Neither do they investigate the effect student motivation may have on teacher performance. Our proposed framework complements and extends these earlier results by providing a structure that permits researchers to gain a more holistic understanding of motivations and behaviours present in an educational system, and an understanding of the impact of these factors on terms of the development of professional competencies.

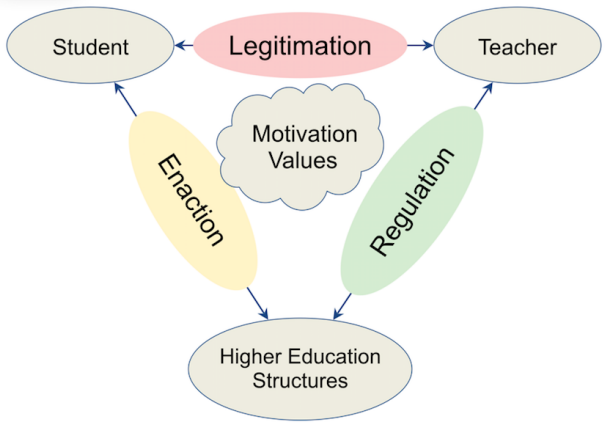

Fig. 1. The Educational Value Model

III. Framework

Our proposed framework is intended to support reasoning about the motivations and behaviour patterns of staff and students engaged in higher education (Figure 1). We link several other theories with the framework to support new approaches to reasoning about motivation and behaviour, and especially how they align with student activities which deal with learning of, and development of, professional competencies.

Our point of departure draws on ideas from Variation Theory [22] to theorise that experiences of motivation, and the resulting learning behaviours of engagement and disengagement, are negotiated within a broader academic system the major actors and interrelationships of which are illustrated in Figure 1. Using this approach we argue that motivation, values and derived behaviours in the learning context are being negotiated in interaction between these major actors. Each arrow represents a tension and a scope for experience, communication and negotiation of relevance. For instance students and teachers interact during the learning process in ways that reinforce or undermine self-esteem. The processes associated with this relationship can be viewed as consisting of actions that are involved in legitimation of both the learner and teacher in their roles, and in the context of the learning situation.

Similarly the other two arrows represent symmetric relationships between the other two major elements of the

educational system visible in our model. We view the interaction between the student and the educational system as one of "enaction" where the student through engaging with the curriculum and higher education system try to understand their role and objectives in relation to that system. For teachers the relationship with the higher education structures is more characterised by the regulatory and quality assurance nature to these structures as they are experienced from an academic teaching perspective.

IV. Analysis: Theory and Method

A. The Theory of Planned behaviour and the Reasoned Action Approach Extension

The proposal also leverages the Reasoned Action Approach (RAA, see Figure 2) developed by Fishbein and Ajzen [23], which is an extension of the Theory of Planned Behaviour (TPB) [24], [25], as a means to capture behaviour coupled with beliefs. The approach considers beliefs as strong predictors of behaviours and is used here to give a structure for investigating factors underlying an observed behaviour. TPB has been used to investigate human behaviour in different areas, where perhaps healthcare [26] is the closest to our proposal. Both TPB and RAA are well established theories regarding understanding human behaviour, and provide the necessary link between the systems view presented in Figure 1, and the empirical data collection and analysis. RAA provides direct support for the analysis of our two qualitative data pools. This theory is not further expanded on in this paper. It is only included to give a holistic picture of the framework.

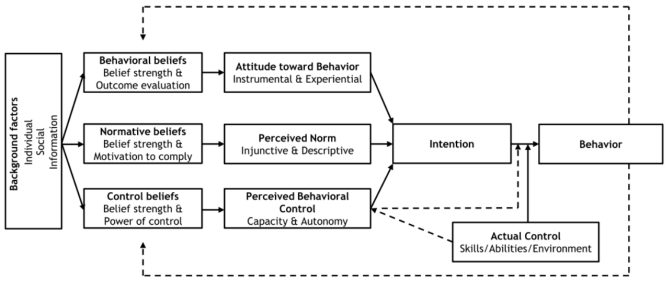

Fig. 2. A Structural View of the Reasoned Action Approach [23]

B. Intellectual Alignment Linking the Envisioned, Enacted, and Lived Aspects of Learning

When viewed from the variation theoretical perspective learning environments link the Envisioned, Enacted, and Lived aspects of learning, but can be experienced differently by learners (with their major focal awareness in the Lived) and teachers (how have their primary focal awareness in the Envisioned, but also expectations of what the Enacted holds for learners). Consequently, when viewed from the teacher perspective the linking of Envisioned to Lived is about facilitating student learning of target skills and knowledge. High level learning outcomes can be viewed as expressions of systemic high level external values and their intent is to partially regulate the teacher's behaviour, but also to communicate a systemic level vision of the goals of the specific teaching and learning activities.

However, in order to achieve intellectual alignment agreement needs to be negotiated between teachers, the academic system, and learners. In this situation learning outcomes are used to both structure aspects of the different types of "players" engagement in education and the alignment of the Envisioned, Enacted and Lived from the perspectives of the different agents proposed in Figure 1. Each of the elements of intellectual alignment can be conceived of in relation to a particular player. This can, for instance, be used to capture learning an aspect of a professional competence for a student and thus provide information valuable to understand how they function in that role more completely.

Intellectual alignment between different players can also be used to study, for instance, the focus on envisioning and enactment of a teacher creating a learning opportunity and place this in contrast with the student's experience in relation to the enacted, the lived experience of the exercise. This helps to make visible tensions in the students' expectations and consequently allow us to reason about motivation and behaviour, in the given learning scenario.

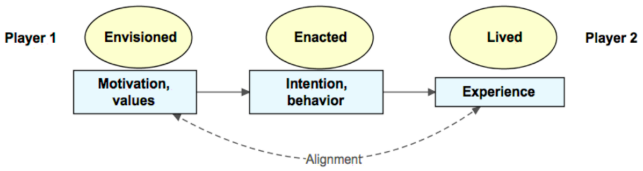

Fig. 3. Intellectual Alignment

V. Application Cases

We use six incidents that occurred in courses given at our own institution to explore student behaviours that we believe result from tension in the interplay between different elements of our model, the bi-directional arrows in Figure 1. We believe that even if only one student displays a behaviour or expresses a view that is in contrast to what might be considered desirable from the teacher's perspective, this is a sign that many students may also be experiencing poor alignment, and that this should be addressed when re-designing learning environments.

It should be noted that we do not necessarily advocate changing the learning activity in response to our analysis. Rather, that the analysis can reveal systemic tensions which require us to provide learners with a more clearly articulated argument for the value of the target learning activity. We hypothesise that the majority of these situations arise due to our inability to clearly articulate the intellectual alignment and intrinsic educational value of the learning activity from a student perspective.

What all these cases have in common is that they have occurred in courses with a strong emphasis on development of professional competencies and/or where many of the learning outcomes are outside the students' envisioned core field of

study. The incidents all occur in connection to assignments where student activity and engagement is requisite for success.

1) Grading: In the 2000 instance of the Uppsala University lead Runestone course students from Uppsala University in Sweden and students from Grand Valley State University in the USA collaborated on joint projects. The teachers on the American side contacted the teaching team in Uppsala about halfway into the course and expressed the view that there was a major problem and that aborting the projects might prove unavoidable.

The Uppsala team was taken by surprise, everything seemed to be proceeding more of less as it had in earlier instances of the collaboration. After discussion it emerged that the problem arose in interpretation of the rubric used to assign final grades in the course. The grading at Grand Valley State was regulated by a rubric based on the American grade scale A-F, whereas in Uppsala a student taking the course received a pass/fail grade. Since the rubric was based on performance in milestone events and was cumulative, this meant that it seemed that there would be no incentive for the Uppsala students to contribute once they had accumulated sufficient marks to pass the course.

It took some effort to convince the American teachers that the Uppsala grading system for pass in practical work required students to work both continuously and to submit complete solutions at every stage, a behaviour more well aligned with the Grand Valley State expectation of a B or A. The project continued, however to evaluate student perceptions of commitment to the project a peer evaluation exercise was included at the end of the course. Students were asked to ”pay their team by allocating part of a $100 salary to each of the team members, including themselves”. They were also asked to provide a brief motivation for the manner in which they had paid each of their project team members. This outcome of this exercise was that the American students gave slightly more money/credit to the Uppsala students than to the other Americans in a team, on average. This incident is reported in detail in [27].

In this case, the application of our model suggests that the situation arose due to poor alignment between the higher education structures and the teachers and students interpreting of them. The American teachers and students saw the grading rubric as an absolute measure of which grade to assign, irrespective of if the student was in the US or in Uppsala. The use of the rubric for grading students in Uppsala was only meaningful if someone actually failed to get to the Uppsala defined ”pass” level. In this case passing in Uppsala also depended on contributing throughout the project. It should be noted that the Swedish Higher Education system is based on a strong sense of work ethics, which clearly played a major role in how the Uppsala students contributed to the project and interpreted the grading rubric.

2) Self-Activation: In 2008 student-centric educational approaches were starting to become popular, and in line with much of the research at the time we redesigned the Real-time and Distributed systems course in the IT Engineering programme. The course was structured around a series of modules dealing with key aspects of real-time and distributed systems, tied to a case study which was used to motivate the content of each module. The case study involved coordinating autonomous rescue robots operating in real time to extract survivors from a disaster site. The case study provided a context within which to study hard and soft real-time systems problems, and the rescue robot scenario posed a range of distributed systems challenges, including atomic transactions on shared data structures, synchronisation and different forms of distributed consensus algorithms.

In each module the case was used to motivate the need for a variety of new material in the area of real-time and distributed systems. Once the scene was set students were divided into small working groups who researched different areas of the material together and prepared joint presentations. Each module concluded with several seminar sessions where all the groups presented for each other, uploaded summary reports on the material they had worked on to the LMS, and then each group worked on developing their system design in the case study using the material compiled by all the teams. When the design case had been revised the next challenge was introduced and a new module began.

The course was heavily criticised by students and reported by the degree coordinator to the board of studies as a course that was apparently of very poor quality. The students reported that they had only learned teamwork and presentation skills during the course, and that the lecturer had failed to properly structure and deliver lectures on the technical content. The examination was based on grading the case study design reports of the teams in combination with an assessment of the student’s individual reflections on the learning goals of the course, together with an evaluation of the extent to which each student had worked to achieve them. The program director deemed this combination of examination methods unreliable and unprofessional.

The following exchange occurred by e-mail after the completion of the course. The Instructor comment is in response to criticism by the student that the course instructional design was inappropriate.

> Instructor:
> I have also an observation. Much of the success or failure of a learning situation depends on the learner and the learner’s motivations. You might benefit from reflecting on your attitudes and expectations of education at University. I would argue that you had every opportunity to seek knowledge and relate it to a relevant problem in this course. You also had the opportunity to discuss your ideas and new knowledge with me during the seminar sessions. Much of the outcome here seems to imply that you expect that teachers will package knowledge and serve it to you so that you don’t have to make much effort yourself to acquire and structure knowledge. Perhaps that is the role of a University in some models, but I don’t think it is a particularly productive model in terms of helping people to develop lifelong learning skills.

> Student:
> I am well aware of that. Where I work/consulted I had to make a program that read a couple of different meters (water, heat, electricity consumptions). There were no one to turn to, and if you asked the manufactures they handed over the wrong documentation, so you had to do a lot of guessing and research just to understand what they said. The University shouldn't do everything, but they should present the basic concepts and terminology, so when you have to implement something you don't do rudimental errors. You should be able to hold a conversation with another student from another university, and not sound like an idiot because you have made wrong presumptions.
> Now if we didn't have lectures I might still be able to do a good report, but I would miss a lot of basic concepts as that specific architecture doesn't implement it. I don't know. Maybe the student should understand that, and research some other processors too, but the likelihood of that happening is quite slim.

In this case, there is poor alignment between learning goals and the student's expectations of what is to be learnt in the course. This is in part due to the Swedish system, where learning goals are specified at several different levels, i.e. for specific courses and general for degrees.

3) Relevance: In an assignment designed to develop students written communication and feedback skills by asking them to give guided feedback on another student's text, one of the students objected to the assignment by submitting work that was not serious and slightly offensive, both to the teacher and to the student that had produced the text.

> Question:
> Is the text interesting? What is particularly interesting?
> Answer:
> The text is as interesting as the assignment. Not.
> Question:
> What can be developed?
> Answer:
> The report, if you turn it into a paper airplane?

In this case, there is poor alignment between the teachers motivation behind the assignment and students behaviour. The teacher sees the targeted skills as relevant for the students future profession and useful during the studies in addition to being a required learning outcome in the education. We do not have any evidence of how the student perceived the assignment, apart from what the student submitted. An educated guess, however, is that the student did not see the professional relevance and, since this was in the first course of CS studies at the university level, the student had looked forward to learning CS - not writing. Hence the assignment did not appeal to the students interests nor expectations.

4) Time consuming: Inspired by a very successful similar course in human-computer interaction (HCI) at another university, our HCI course was redesigned with an element of gamification and a final event which involved presentations in front of a jury of invited industry experts. Faculty of the course had good contacts in the health care area, so health care applications were the focus of the project based course. The teachers planned the course based on the rationales presented above with the intent to create a student centric and motivating learning environment with a direct connection to industry.

To their surprise many students seemed not to be motivated to engage in the setting, and the gamification component and the jury in particular did not have the expected positive impact on student motivation. In fact, for quite a large number of the students taking the course the impact on motivation was quite the opposite to that expected. An example of this is the observation made to the teaching team by the following student.

> "Completely unnecessary to put energy on it, you do not seem to understand how a student works. A contest where the prize is to make an additional presentation? ..."

In this case, there is poor alignment between the teachers ambition to create an inspiring educational setting and the students ambitions to focus on passing the course with minimal workload. The tension here lies both in the component of enaction with implications for legitimation. The student experience of engaging with the structures established in the course (enaction) was not aligned with the values and motives that the teachers ascribed to a prospective student population during the design process. This poor alignment resulted in the students questioning the legitimacy of the teaching team, questioning the validity of the exercise, and observing that they did not embrace the values ascribed to them. This illustrates a need for change in the educational setting in general. The student focus on doing as little as possible is not in the best interest of either the student, or society. However, it reveals a student focus which places value on the degree as a symbol of employability rather than the degree as an opportunity for personal growth and learning.

5) Formalia: The final case teachers who had developed assignments intended to broaden the students' perception of the course contents.

In the first case the teacher had developed an exercise that focused on students developing awareness of the application of key conceptual material by reading about the concepts involved and presenting potential practical applications. However, due to an administrative error the teacher failed to clearly announce the due date for the assessment at the start of the course. As a result of this, the students applied pressure through the director of studies to compel the teacher to cancel the assignment, even though they saw the assignment as both educational and interesting.

> "We think it is a good assignment, it is interesting and we would learn a lot. We would really like to do it, but since it was not announced properly we shouldn't have to."

The second example concerns the introduction of new formative assessment measures into a course. The intervention was the result of low attendance rates at lectures in previous offerings of the course. To address this situation the teachers decided to introduce short quizzes during the lectures. Successful participation gave bonus points towards the final exam. Students used a number of course management technicalities to persuade the teachers to rescind this practice. Finally the teachers agreed to cancel the quizzes for fear of breaking regulations, although in fact on later investigation they would not actually have contravened any formal regulations.

In both cases, there is poor alignment between the teachers ambitions to create an inspiring learning environment and detailed formalia imposed by the Higher Education System in particular the processes surrounding course specifications and course management. It can also be argued that there is poor alignment between the formalia and a focus on student learning. In particular there is poor alignment between the formalia associated with quality assurance systems for courses and the teachers, as well as between these formalia and the students. Both the teachers and the students had assumed that there were regulations that had been violated. That assumptions and myths about rules and regulations in higher education structures can influence behaviour, as in these cases, clearly illustrates that there is room for improvement.

VI. Conclusion

In this paper we have presented and illustrated the use of a framework for analysing the interplay, and alignment of perspectives, between key agents in Higher Education. The model draws on previous work in our research group, e.g. a longitudinal study of student identity development [1] and the PhD thesis of Wiggberg [2] which contrasts students' experiences with teachers' expectations. The above examples show how the framework supports analysis of learning situations and permits a more sophisticated understanding of negative events, especially by identifying where the issue originated. For instance that a learning situation is experienced in a negative manner from the teaching point of view since from that perspective the examples above represent missed learning opportunities.

The framework can also be used to analyse positive events and thus provide insights into why something had a desirable outcome from the teaching point of view. Whether the situation studied is positive or negative is irrelevant for lessons learned. The understanding gained can be used to improve the educational system in general, and teaching staff can use the framework as an integral part of a scholarly approach to education.

We argue that the issue of positive or negative in the cases presented above actually has a "right answer". Take for instance the idea of students actually using all the time allotted to a course, or degree program, to learn. Intuitively this sounds like a positive situation, but for a student it is perhaps more important to be able to pass a course, or degree program, in as short time as possible. This said, from a societal point of view, it is negative that students spend time and energy on avoiding learning activities. This behaviour could however be indicative of degree programs (particularly in engineering) being overstuffed with content.

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Open-Ended Projects Opened Up – Aspects of Openness

Aletta Nylén, Mats Daniels
Dept. of Information Technology
Uppsala University
Uppsala, Sweden
aletta.nylen@it.uu.se
mats.daniels@it.uu.se

Ville Isomöttönen
Dept. of Mathematical Information Technology
University of Jyväskylä
Jyväskylä, Finland
ville.isomottonen@jyu.fi

Roger McDermott
School of Computer Science and Digital Media
Robert Gordon University
Aberdeen, United Kingdom
roger.mcdermott@rgu.ac.uk

***Abstract*—One of the most important areas of competence for professional engineers is the ability to function well in project work, in particular they need to be able to efficiently solve open-ended problems in different collaborative settings. The development of this ability is however not prominent in engineering education despite numerous authors suggesting open-ended problems as a pedagogical tool to promote development of collaborative problem solving competence by including elements of group or project work in courses. In our own long experience of using open-ended problems in collaborative student projects, we have identified a lack of systematic progression in learning outcomes and skill development. We see this as a major obstacle for fully exploiting the potentials of using open-ended problems as an educational tool. We present a framework that provides a structured view of challenges related to openness that students can encounter in educational projects and that has an impact on the overall complexity of the project. We argue that there are different categories of openness to consider when designing educational settings based on open-ended projects. The categories addressed in this paper are: Character of the problems addressed. Character of the teams. Time constraints. Faculty involvement. External factors. Aspects of openness in the different categories are presented and related to professional engineering competencies. Furthermore, it is discussed how variations in project complexity can be accomplished by variations within the aspects and combinations of aspects. In particular, the framework addresses development and progression of professional competencies.**

***Keywords*—engineering education; project work; progression; professional competencies; open-ended problems**

I. Introduction

It is often stated that professional competencies are important in workplaces, e.g. OECD [1], ACM [2], US National Academy [3], Danish Engineers union [4], and IEEE [5], and educational degree programs typically include as overarching goals that the graduates have developed a variety of such competencies. One of the most important areas of competence for professional engineers is the ability to function well in project work, in particular they need to be able to efficiently solve open-ended problems in different collaborative settings [6].

There is however, a gap between these rather abstract, high-level goals and what actually happens in the courses comprising typical engineering degree programs. Examples of this gap is that it is rare that course descriptions contain professional competencies as learning outcomes, and in those that do, this aspect is often marginalised [7]. Another example is the experience as an evaluator in the recent Swedish evaluation of Computer Science and IT degree programs, where learning objectives of professional competencies type were considered, but with a low bar regarding what was considered 'good enough'.

A number of pedagogical approaches that attempt to bridge this gap have been proposed, e.g., collaborative learning [8], team based learning [9], problem- and project-based learning [10], open-ended problem solving [6], open-ended group projects [11]. Reports from using such approaches typically convey increased student motivation and enhanced learning regarding both content knowledge and competence development. Despite this work and these positive reports we argue that there is a resistance to using these approaches stemming from a general insecurity about the meaning of professional competencies and how to assess students. This can for instance be illustrated by Durn and Amandis [12] observation about collaborative skills development in the context of collaborative learning:

> not all the students develop the same collaborative skills ... and not all the students develop the skills at the same level.

Another obstacle might be that most of these approaches use a constructivist approach to instruction, where students are faced with openness and teachers are primarily seen as facilitators that provide minimal guidance. Kirschner et. al [13] argues against using minimal guidance approaches as pedagogical tools. They argue that, with minimal guidance, students need to construct knowledge of procedures as well as content simultaneously, which causes a cognitive load that is beyond their capability. However, we believe that systematic progression in the degree of openness throughout a degree program will allow students to achieve the procedural and content knowledge and experiences needed to be capable of coping with more openness towards the end of the education. Furthermore, knowledge of such procedures and ability to properly apply them, i.e., having professional competencies, are essential learning objectives in degree programs.

We see an understanding of the concept of openness as

a key issue for improving degree programs regarding development of professional competencies. In this paper we will exemplify capturing the progression aspect with the use of course specifications, something that previously, according to anecdotal evidence, have had limited success. The reasons voiced have mostly been about faculty feeling insecure about what the professional competencies in question actually mean and how to assess if (individual) students have acquired them. Of equal, or perhaps even greater, importance is to convey an understanding regarding openness to the student cohort. We see projects as an excellent base for educational settings aimed at developing professional competencies and will give a special focus on pedagogical approaches using projects.

We will in this paper present a framework for reasoning about aspects of openness when designing educational settings based on projects. This framework provides a structured view of challenges related to openness that students can encounter in educational projects, and can thus support specification of progression. The structure is in the form of categories of openness and aspects of these categories are discussed in terms of learning goals regarding professional competencies. The categories addressed in this paper are: 1) Character of the problems addressed, 2) Character of the teams, 3) Time constraints, 4) Faculty involvement, and 5) External factors.

We will first provide an overview of project-based education and competencies needed for engineers in the future as background for our proposal. Then we present our proposed framework for openness, where we describe different aspects of the categories we identified. One way to use the framework is to support definition of progression of professional competencies and we discuss this in general and give a concrete example from an IT engineering degree program. The value of this and other uses of the framework, e.g. assisting assessment, as well as future work are discussed in the conclusion.

II. Taxonomic Studies on Projeect-Based Education

Project-based education has been categorized by many scholars. Shaw and Tomayko [14] classifies undergraduate software engineering courses based on the amount of project work included. They criticize almost fully lectured 'project courses' where praxis is missing or occur only in the form of student presentations. 'Small group projects' instead use half of the course time on lectures and the other half on a project, with the first half granting opportunities to initiate students' knowledge and skills for the project. On the grounds that authentic praxis is the best way to immerse students to software engineering, Shaw and Tomayko prefer 'Large group projects' where students are given a few lectures but mostly work on the project and often for external clients. In this setting, the students work in a large group and are assigned to authentic software engineering roles. Finally, the 'Project only' represents a course implementation with no lectured content included. Knoke [15] extends the model by adding a 'Medium size project model'where small teams implement a realistic project during one semester. A team functions as a software development company and develops a software product for a customer, and is required to document many parts of the project.

Computer science project work has later been categorized by Fincher et al. [16] and Clear et al. [17]. Fincher et al. presented eleven forms of projects based on actual practice at over 50 institutions. These included integrative projects, design and build-projects, projects emphasizing process instead of a product, projects with industry involvement or for real clients, potentially competitive projects where students hand over their components to be integrated into a larger system, final-year individual projects, research-like projects, and so forth. Clear et al. instead reviewed a wide range of course attributes to build a resource for teachers setting out to devise a project course. Their considerations included questions such as what are the goals of the course, who conceives the projects, what documentation is produced, what is archived, what work process is followed, how projects are presented, can Non-Discloser Agreements be included, and how team/sponsor conflicts are addressed. Both Fincher et al. [16] and Clear et al. [17] argued that "function drives that form" [17], that is, when the learning goals of the project course are identified, it is possible to select course attributes according to that goal.

At the same time, Bothe [18] proposed a categorization on the degree of realism in projects. The realism in this taxonomy signified that the project's requirements source is based on a real demand instead of an academic one, real-life application domains are used instead of typical system programs, commercial customers are involved instead of having a lecturer as a customer, product versions are preferred over prototypes, high priority is sought for in place of low priority, deadlines are preferred over no deadlines, large scale projects are commenced instead of small ones, all life-cycle phases are included instead of selected phases, and reverse engineering is preferred over mere maintenance. Bothe specifically noted that from-scratch projects are problematic if high-priority real-customer projects are sought for. He preferred reverse engineering projects for promoting realistic experience and generally raised the challenge with deadlines in educational settings.

Later, Burge and Gannod [19] presented dimensions for categorizing capstone projects. They concentrated on project type, customer identity, user identity, audiences of project work and the deliverables required by the differing audiences, availability of original developers (in case of continued work), and the number of teams working on a single project. Burge and Gannod preferred from-scratch projects because, they argued, such projects usefully expose students to ill-formed situation in terms of requirements elicitation. The authors also argued that multiple teams working on the same problem is not as realistic as having single team fully responsible for the project.

A taxonomic mark is also present in literature reviews. An already dated review by Todd et al. [20] in the North American context revealed, for instance, that one semester was the most common timescale for a project (45%), 83% of capstones were

located in the single department, a small team was the most common team size (1-3 students: 38% and 4-6 students: 49%), in 18% of projects with external funding, the customer directed a payment to the university, and over half of the projects (59%) were received from the department and roughly the same number (58%) originated from external parties, meaning that often both sources were used. Richards [21] reviewed literature to inform design choices in particular regarding group formation and assessment. One of her key conclusions was the importance of fairness within student teams and the call for interventions were the contributions of group members are addressed through self- and peer assessment.

Today, project-based learning has extended to multi-cultural [22] and multi-disciplinary projects [23]. Furthermore, some scholars have specifically emphasized use of open-ended problems in projects, which indicates no inevitable direction or means for students' problem solving [24]. Such problem solving emphasizes 'divergent' thinking over 'convergent' thinking and links with creativity due to increased flexibility and originality [25]. The studies above do not specifically address the use of open-ended problems in projects and effective dimensions therein. The present study complements the taxonomic literature from this perspective.

III. Professional Competencies for Engineers

We have already established that development of professional competencies is regarded as important in engineering education. The work by Pellegrino & Hilton [3] that investigated what competencies are needed for future professionals, which they refer to as 21st century competencies (Table I), is a good example for representing arguments for the importance.

> We view 21st century skills as knowledge that can be transferred or applied in new situations. This transferable knowledge includes both content knowledge in a domain and also procedural knowledge of how, why, and when to apply this knowledge to answer questions and solve problems. The latter dimensions of transferable knowledge (how, why, and when to apply content knowledge) are often called "skills." We refer to this blend of content knowledge and related skills as "21st century competencies." [3]

Their findings are well aligned with the competencies often mentioned as learning goals in engineering education. In the report, competencies are classified based on their domain of operation, cognitive, interpersonal and intrapersonal, see Table I. The work points out that the domains are differentiated for purposes of understanding and organising competencies, but that they are intertwined in human development and learning.

We argue that most, if not all, of the content in Table I require an ability to deal with openness, which aligns well with the concept of open-ended problems in educational settings. As we see it, the aim of open projects in education is not only to develop students behaviors in project work (mainly inter- and intrapersonal), but also to promote development in all of these domains, including learning content knowledge. However, in this work the focus is mainly on developing competencies in all three domains that are directly related to students' ability to be efficient and productive workers and learners in projects.

TABLE I
21st Century Competencies

Main category	Subcategories	Terms used
Cognitive Competencies	Cognitive Processes and Strategies	critical thinking, problem solving, analysis, reasoning/ argumentation, interpretation, decision making, adoptive learning, executive function
	Knowledge	information literacy, ICT, oral and written communication, active listening
	Creativity	creativity, innovation
Intrapersonal Competencies	Intellectual Openness	flexibility, adaptability, artistic and cultural appreciation, personal and social responsibility, cultural awareness and competence, appreciation for diversity, continuous learning, intellectual interest and curiosity
	Work Ethic / Conscientiousness	initiative, self-direction, responsibility, perseverance, productivity, grit, metacognitive skills including forethought, performance, and self-reflection
	Positive Core Self-Evaluation	self-monitoring, self-evaluation, self-reinforcement, physical and psychological health
Interpersonal Competencies	Teamwork and collaboration	communication, collaboration, teamwork, cooperation, coordination, interpersonal skills, empathy/ perspective taking, trust, service orientation, conflict resolution, negotiation
	Leadership	leadership, responsibility, assertive communication, self-presentation, social influence with others

IV. Aspects of Openness in Education

Discussions with students and written reflections on the subject of openness at the end of a semester long open-ended international project course indicate that most of these master level students have rarely encountered openness in their education and that they felt ill-prepared for dealing with a project that was open-ended in many aspects. They actually had difficulties in expressing and came up with varied aspects of what they considered open-endedness to be about. This is probably an effect of the complexity of the openness concept, where complexity actually could be considered as a common aspect of openness. It was also clear from the above mentioned discussions and written reflections that most students saw openness after the initial 'deciding what to do phase' as problematic and unwanted, they often saw the time to decide as wasteful. It is the authors' impression that dealing with

different aspects of openness was seen as important learning goals, but yet also something that could be done faster and/or with more support from faculty. Arguing for openness as a means towards learning professional competencies has been important for motivating students, but more can be done in that regard and this work is a step towards providing support for faculty and students.

The example above illustrates that openness in education can have many facets. We think of aspects of openness as aspects adding to the complexity of a project by facing students with choices. The choices can be of different kinds and magnitudes, ranging from deciding what the assignment is about, what product to produce, to deciding frequency and times for group meetings and distributing work within the team.

We present a framework for aspects of openness in education, mainly in the form of student projects, consisting of five main categories. A number of aspects within each category are presented and discussed. The focus will be on making a connection to implementation in educational settings. Issues, such as progression and connection to the categories of professional competencies given in the section above, will mostly be done in the two following sections.

1) Character of the problems addressed
2) Character of the teams
3) Time constraints
4) Faculty involvement
5) External factors

A. Character of the Problems Addressed

The character of a problem can have a quite varied effect on the openness of the learning experience. A not uncommon variant is that there is an initial phase when there is an openness in terms of deciding what the problem is all about, but once that is decided the problem has transformed into a fixed, and from the students view, safe, assignment. For instance, when students develop software based on their own ideation of project topics and software products therein, there is a tendency that students refrain from further ideation as soon as they have selected the topic and made the design for the first prototype. This indicates a willing transfer from an open-ended situation to a safe place that resembles faculty given problems. Building software necessitates understandings of main use cases and design early on, which grants such opportunities for transforming the situation early on. On the other hand, this transfer is also the aim of the students' work: students must be able to advance their project from an initially open-ended and ill-formed situation. Here, we are nevertheless pointing out the tendency to seek for and remain in the safe place instead of continuing to capitalize on the 'creativity supporting learning environment' – a term used by Apiola et al. [26]. Anecdotal evidence suggests that it is easier for students to delay transfer to a fixed, safe, assignment if assessment is more focused on process and less on product.

There are normally many acceptable solutions to a problem. The extreme point is to have only one, which is something most students are most used to. The advantage with problems with only one solution is that faculty can control what the students do. Such problems are however almost non-existent when the complexity of the problem is increased. Problems with many acceptable solutions can, as described above, be turned into problems with few or only one acceptable solution in the process of dealing with them. The educational setting could, as opposed to the scenario above, be faculty controlled by requiring the students to make a choice about which solution to aim for. The acceptable solutions in an educational setting can also be related to grades, e.g. by requiring an implementation for a higher grade. Problems could also have an internal complexity that defies transformation into safe 'one right answer' problems.

Problems could be such that they are based on knowledge the students already are assumed to possess or to be such that the students are expected to acquire new knowledge. The level of openness can be varied even further by more or less strict restrictions on what knowledge students are to acquire in order to fulfill course learning outcomes.

Thus we have identified the following aspects to be relevant in discussing openness with regard to the character of the problem to address:

- Acceptable solutions - the more acceptable solutions the higher the openness.
- Complexity - higher complexity yield higher openness.
- Knowledge requirements - requiring gaining new knowledge generally means higher openness.
- Problem solving methods - a larger set of potential methods leads to higher openness.
- Process vs product focus - a product focus can lead to a lesser level of openness.

B. Character of the Teams

The character of the teams working in a project can be designed in many different ways. The perhaps most obvious is to vary the number of members in a team. With increased number of members aspects such as heterogeneity of the team and project organisation can be addressed. The heterogeneity aspect can be about gender, culture, and expertise. The expertise aspect can be to let students at different levels in the same degree program collaborate, but other examples are mixing students from different disciplines and/or involving users.

The character of a team is also about how the work is organised. Variations here are for instance how free the students are to choose how they want to collaborate and which tools to use. Other examples regarding organisation are having roles rotating within a team and/or moving students between different teams.

Thus we have identified the following aspects to be relevant in discussing openness with regard to the character of the teams:

- Group size - larger group size generally leads to higher openness.
- Heterogeneousness - the more heterogeneous a team is the higher the openness is.

- Project organization - the more freedom regarding how to organise the higher openness.

C. Time Constraints

Time constraints, such as deadlines, can have a major effect on the openness of an educational setting. For instance, having many and detailed deadlines will restrict the openness considerably. The major deadline is of course the end of the course, which is especially important to relate to when external clients are involved.

Another type of time constraint stems from a combination of factors within and outside the particular educational setting. This is about how students optimize their time, e.g. with regard to the learning resources in the degree program. An example of that is, when students observe a sufficient degree of completion in their learning assignment, they might target their resources elsewhere. This may constrain the amount of explorative learning (e.g., reliance on creativity and divergent thinking) that is expected to occur in an open-ended setting.

Time constraints can also be in the form of members residing in different time zones. This typically occurs in international collaborations, where an additional constraint typically occurs in the form of the respective courses having different starting and/or ending dates.

Thus we have identified the following aspects to be relevant in discussing openness with regard to time constraints:

- Limited time for the project - less time leads to lower level of openness.
- Teams being distributed over different time zones - greater difference leads to higher level of openness.
- Members having non-equal amount of time to spend on the collaboration - greater difference leads to higher level of openness.
- Members having other engagements to different degrees - more other engagements lead to higher level of openness.

D. Faculty Involvement

Faculty involvement is perhaps the major contributor to the openness of an educational setting. Even the most complex setting can have a pretty low level of openness if the faculty involvement is high. Examples of aspects to consider with regard to faculty involvement are amount and type of scaffolding, that is to decide which type of guiding role faculty will take. Related to this is also the issue of when scaffolding should be offered, e.g. detailed deadlines is an example of a technique for providing scaffolding. The timing of scaffolding can also be derived from faculty observations or initiated from the student cohort.

It is also possible to correspond with students regularly without imposing high faculty involvement. One way is to have regular (e.g., on weekly basis) dialogic sessions (the type of scaffolding) with student groups regardless of the potential need for help on the part of students. Such sessions can be very short (e.g., 15 minutes) or long (e.g., two hours) in duration. The goal is to develop an informal setting between the faculty and students, and hence facilitate help-seeking behaviors across a range of learners and learner groups. Such flexibility means that the timing and amount of scaffolding still follows the needs expressed by the students and is not imposed. This regularity, being a part of the course arrangements, also means that the initiation of the scaffolding is, in a way, managed by the faculty, while the flexibility of the sessions indicates that the contents of the sessions are much drawing on the students' initiative.

Thus we have identified and illustrated the following aspects to be relevant in discussing openness with regard to faculty involvement:

- Amount of scaffolding - more leads to lower level of openness.
- Type of scaffolding - all forms lead to lower level of openness.
- Timing of scaffolding - the earlier the lower level of openness.
- Initiation of involvement - faculty initiated lead to lower level of openness.

It should be noted that faculty involvement is more or less unavoidable and how much the openness is affected is highly dependent on what the actual involvement is.

E. External Factors

Some aspects that can be seen as being related to external factors have already be introduced, e.g. students having demands outside the project and international collaborations being influenced by different start/end dates and different sets of public holidays. Other aspects relate to having external stakeholders, e.g., a client ordering the project, external members in teams, and users.

Elements of engagement with authentic environments, e.g., equipment not specifically adjusted for the learning environment or people not connected to the course, adds complexity and unpredictability for both students and teachers. External factors can also be more abstract, as in society in general. Thus we have identified the following aspects to be relevant in discussing openness with regard to external factors:

- Having external stakeholders - having them increases the level of openness.
- Having external members in teams - having them increases the level of openness.
- Engaging with authentic environments - authentic environments yield higher levels of openness.

V. Openness Related to Development of Professional Competencies

Progression of developing professional competencies should be seen from a degree program perspective. The content of Table I can serve as guide in designing this progression. The level of openness is an essential component in such an effort, since just about all of the competencies require an ability to deal with openness. The ability to deal with openness is however a complex endeavour that should be progressively developed.

The framework for openness in education provides a toolbox for reasoning about openness with regard to educational interventions aimed at development of some aspect(s) of professional competencies, e.g. from those listed in Table I. All categories should be considered when designing an educational intervention and progression can be build into a degree program by specifying aspects of the factors identified under each category to be addressed. The level of openness for the selected factors is essential in this specification.

A model of professional competence, where a competence is the balanced use of knowledge, attitude, and skill, can also be used to describe progress. That is, the first step could be to cover only one of these components, e.g. theoretical knowledge regarding team work or algorithms. This could be followed by either deepening the coverage of the component or adding components, the latter could be to work in teams and reflect on the process according to theory. The level of openness increases along with increases in realism in the use of the specific competence.

A similar structure for structuring progression is central in the CDIO concept [27], i.e. Conceive, Design, Implement, and Operate. The Conceive, Design, Implement, and Operate form a chain of progression in the CDIO model and is assumed to be clearly stated in course specifications comprising a degree program. Progression of any aspect, or combination of aspects, in the framework can be seen as following that chain. The level of openness can be specified in the CDIO concept.

VI. Openness Related to 21st Century Skills

We briefly discuss development of two of the subcategories in Table I: *Knowledge* and *Leadership*, in relation to the framework of openness in education. They are chosen, since they represent one aspect that is generally considered natural to develop in open project settings, i.e., leadership, and one that often seen as problematic in such settings, i.e., knowledge.

Note that the faculty involvement is a central category in all settings designed to develop professional competencies, with high level of involvement corresponding to low levels of openness and vice versa.

A. Knowledge

Development of knowledge, a cognitive competence, is a broad area that can be seen as being addressed by every aspect of the framework for openness, although the most central is the Character of problems category. Laying a foundation of basic knowledge is possible, arguably even best, in educational settings with a low level of openness [13]. The more open an educational setting is the less is the control over specific knowledge covered. This does not imply that no knowledge is gained, but rather that it is related to the choices made by students, and potentially meaning that students gain different knowledge. The relevance of the framework for openness in education in the case of progression of knowledge mostly stem from the desired level of control of knowledge offered to students. This is closely related to the issue of learning objectives and assessment, where course specification that include detailed and low level descriptions might severely limit the level of openness.

The model of competence as consisting of a balanced use of knowledge, attitude, and skill imply that knowledge is a component of all other subcategories and terms in Table I. Progression of most of these subcategories and terms typically require educational settings with high levels of openness, and this also includes development of relevant knowledge.

B. Leadership

Development of leadership, an interpersonal competence, is most directly addressed in the Character of the teams and the Time constraints categories. The openness aspect is of outmost importance in developing a degree program where leadership is addressed. The leadership competence is truly complex and there is a need to develop this ability through progression from structured interventions with low levels of openness to highly complex learning situations with high levels of openness. To fully address the leadership competence all aspects of the character of the teams and the time constraint categories should be included at high levels of openness. The External factors category is also quite relevant for the highly open settings, with for instance having an external stakeholder being an excellent opportunity to develop self-presentation skills.

VII. Conclusion

Regarding openness as aspects adding to the complexity of educational projects, we have presented a framework that provides a structured view of challenges related to openness that students can encounter. The framework is suitable to serve as an aid in planning for systematic progression in project work over the course of a degree program. We have identified progression in project work and in development of professional competencies as often lacking and thereby posing a major obstacle for fully exploiting the potentials of using projects as an educational tool.

What is of essential importance is to understand that openness is a complex concept and that a graduate should be fully confident with handling true openness in order to be professionally competent. The framework should be complemented by adding a toolbox of assessment methods related to the aspects relevant for assessing.

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