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# Developing and Assessing Professional Competencies: a Pipe Dream?

## *Experiences from an Open-Ended Group Project Learning Environment*

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**Abstract**
Daniels, M. 2011. Developing and Assessing Professional Competencies: a Pipe Dream? Experiences from an Open-Ended Group Project Learning Environment. Acta Universitatis Upsaliensis. *Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology* 738. 109 pp. Uppsala. ISBN 978-91-554-8024-0.

Professional competencies are explicitly identified in the primary learning outcomes for science and engineering degrees at many tertiary institutions. Fulfillment of the requirements to equip our students with these skills, while formally acknowledged as important by all stakeholders, can be hard to demonstrate in practice. Most degree awarding institutions would have difficulties if asked to document *where* in degree programs such competencies are developed.

The work in this thesis addresses the issue of professional competencies from several angles. The *Open-Ended Group Project* (OEGP) concept is introduced and proposed as an approach to constructing learning environments in which students' development of professional competencies can be stimulated and assessed. Scholarly, research-based development of the *IT in Society course unit* (ITiS) is described and analyzed in order to present ideas for tailoring OEGP-based course units towards meeting learning objectives related to professional competence. Work in this thesis includes an examination of both the meanings attributed to the term *professional competencies*, and methods which can be used to assess the competencies once they are agreed on.

The empirical work on developing ITiS is based on a *framework for educational research*, which has been both refined and extended as an integral part of my research. The *action research methodology* is presented and concrete examples of implementations of different pedagogical interventions, based on the methodology, are given. The framework provides support for relating a theoretical foundation to studies, or development, of learning environments. The particular theoretical foundation for the examples in this thesis includes, apart from the action research methodology, constructivism, conceptual change, threshold concepts, communities of practice, ill-structured problem solving, the reflective practicum, and problem based learning.

The key finding in this thesis is that development and assessment of professional competencies is not a pipe dream. Assessment can be accomplished, and the OEGP concept provides a flexible base for creating an appropriate learning environment for this purpose.

*Keywords:* Computing education research, engineering education research, computer science, open-ended group project, professional competencies, action research, educational research framework, learning, communities of practice, constructivism, conceptual change, threshold concepts, problem based learning, ill-structured problem solving, international student collaboration, constructive controversy, reflection

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*To my father and my late mother*

# List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I Daniels, M., Berglund, A., and Petre, M. (1999). Reflections on International Projects in the Undergraduate CS Education, *Computer Science Education*, vol. 9, no. 3, 256-267.

II Faulkner, X., Daniels, M., and Newman, I. (2006). Open Ended Group Projects (OEGP): A Way of Including Diversity in the IT Curriculum, in *Diversity in Information Technology Education: Issues and Controversies*, ed. Trajkovski, Information Science Publishing, London, 166-195.

III Daniels, M. and Cajander, Å. (2010). Experiences from using Constructive Controversy in an Open Ended Group Project, *ASEE/IEEE Frontiers in Education conference*, Washington D.C., USA.

IV Daniels, M., Cajander, Å., Clear, T., and Pears, A. (2010). Engineering Education Research in Practice: Evolving Use of Open Ended Group Projects as a Pedagogical Strategy for Developing Skills in Global Collaboration, *International Journal of Engineering Education*, vol. 26, no. 4, 795-806.

V Cajander, Å., Daniels, M., McDermott, R., and von Konsky, B. (2011). Assessing Professional Skills in Engineering Education, *Australasian Computing Education Conference*, Perth, Australia.

# My Contributions in the Papers

I Main author

II We wrote papers in a truly collaborative manner and rotated who was the first name on the list. My contribution is equal to the others.

III Main author.

IV Main author.

V Main author together with Åsa Cajander.

# Contents

# Abbreviations

| | |
|---|---|
| ACER | The Australian Council for Educational Research |
| ACM | Association for Computing Machinery |
| AR | Action Research |
| CER | Computing Education Research |
| CSERGI | Computer Science Education Research Groups International |
| CSEdR | Computer Science Education Research |
| CoP | Communities of Practice |
| HRM | Human Resource Management |
| ICT | Information and Communication Technology |
| IEEE | Institute of Electrical and Electronics Engineers |
| IT | Information Technology |
| ITiS | IT in Society |
| ITP | The IT engineering degree program |
| OECD | Organization for Economic Co-operation and Development |
| OEGP | Open-Ended Group Projects |
| PBL | Problem Based Learning |
| PISA | Program for International Student Assessment |
| SoTL | Scholarship of Teaching and Learning |
| UpCERG | Uppsala Computing Education Research Group |
| ZPD | Zone of Proximal Development |

# 1 Introduction

Empowering people to act based on cultural awareness is one of the competencies I address in this work and this includes being aware of one's own culture. As a first step in that process it seems pertinent to draw the attention to my own upbringing in the Swedish culture and that I share a tendency together with many other Swedes to be cautious in stating my opinions. This often manifests itself in what some might see as a defensive stance, but I want to compensate for this by being rather non-Swedish and starting out by observing that I believe that this thesis develops a sound foundation for learning environments suitable for developing professional competencies for computer scientists and IT engineers. The other contribution is the evolution of a guiding framework and accompanying research methodology for how to conduct educational research. The framework itself emerged from discussions and reflection on the nature of rigor and scholarship in computing and engineering education research. Its development has helped me to reason about choices I have made with respect to research method and approach, but at the same time it is also a contribution to the research.

Basing course units on the OEGP concept is in many ways an inspiring endeavor for an educator, one learns a lot from what the students do and it is heart-warming to see the excitement and pride among the students that fully engage in their learning in accordance with the concept. It can, however, also be a source of frustration, e.g. when one experiences students that just tag along. Much of the work reported in this thesis attempts to deal with this frustration by finding ways to encourage and inspire those students that are in danger of not benefitting from the collaboration essential for a successful OEGP-based environment. The work stems, furthermore, to a large extent from over a decade of working with the IT in Society *course unit*[1] (ITiS).

Returning to the cultural theme, while discussing the title of this thesis I realized that the term "pipe dream" was unknown to many of my Swedish colleagues.

> *A **pipe dream** is a fantastic hope or plan that is generally regarded as being nearly impossible to achieve, originating in the 19th century as an allusion to the dreams experienced by smokers of opium pipes.*[2]

[1] Course unit is used to denote an individual unit in an education degree program.
[2] Wikipedia, http://en.wikipedia.org/wiki/Pipe_dream, accessed March 1, 2011.

Understanding the meaning of this saying is crucial in order to see the connection between the title and the content of the thesis. Is development and assessment of professional competencies a pipe dream? Many might claim that it is. On the contrary I will argue, based on the studies presented in this thesis, that OEGP can provide motivation and context for the purposeful development and assessment of professional competencies in computing and engineering education. This is especially true for the *assessing* part of the title, which typically is either ignored or only addressed through a focus on strictly observable behavior associated with explicitly stated learning objectives in many educational institutions. My work regarding the use of reflections identifies a promising approach to the conduct of holistic assessments of professional competencies. The approach also addresses assessing tacit knowledge [Polanyi 1967].

The issue of *developing* professional competencies is perhaps seen as less of a pipe dream in the education community, but there is a "gap" between the statement of overall goals for degree programs, which generally have clear statements about developing professional competencies, and specifications of individual course units, which rarely include such goals. Development of professional competencies is a complex and uncertain undertaking. A recent national review of Swedish engineering degree programs emphasize the importance of these competencies for graduating engineers, as well as the difficulties higher education institutions encounter in meeting such learning outcomes [HSV 2006].

The fact that "everyone" else seems to be struggling with how to incorporate development of professional competencies in their degree programs makes the issues and solutions presented here especially relevant, since the increased globalization in the workplace appears to provide increasingly strong incentives for educational institutions to address the formal acquisition of such competencies. My work shows that developing students' professional competencies can be addressed through constructing learning environments based on the Open-Ended Group Project (OEGP) concept.

The OEGP concept is central to the work presented in this thesis. The concept was developed in discussions based on real experiences, and with a desire to better understand implications for how to create suitable learning environments. This was built on a firm belief that the OEGP concept is well suited to the development of professional competencies. The reason for this is that the students need to utilize several competencies in order to succeed in a learning environment based on teamwork and inter-cultural and inter-disciplinary communication.

Efforts to encourage and inspire through different forms of scaffolding and to analyze the results of these efforts have been conducted in an action research manner. That is, an issue has been noted and an action, or intervention, has been identified as suitable to deal with the issue. The intervention has then been implemented and its effects studied and analyzed in order to

understand how well it worked. The indicator of success has been in terms of students acquiring professional competencies.

Action research has traditionally involved researchers working with practitioners, whereas I in the ITiS case was both researcher and practitioner. This has, in my opinion, been an advantage, in that I have a good understanding of the practice when wearing my "researcher hat" and vice versa when being the practitioner. There is however a disadvantage in the loss of the valuable and constructive discussions from different perspectives, naturally appearing when the researcher and practitioner are different physical persons.

This thesis starts out with my painting the background through a story of turning frustration into something positive in Chapter Two. The story is intended to give a quick insight into my work and the context of the thesis before stating my two research foci in Chapter Three. The first is related to the development of the computing and engineering education research area in general and the other to the more specific issue of creating learning environments based on the OEGP concept suitable for developing professional competencies. Chapter Four serves a dual purpose, in that it presents results related to my first research focus as well as giving a theoretical underpinning for presenting results related to my second research focus. Further theoretical underpinnings for my research are presented in Chapter Five, followed in Chapter Six by results relevant to the second research focus including a discussion of how OEGP and action research combine to provide a scholarly approach to developing ITiS. Reflections on my research and its impact are discussed and ideas for future work are presented in Chapter Seven, followed by some conclusions in Chapter Eight.

# 2 Background: A Story of Frustration Fostering Creativity

There are many ways to start a story, and one is perhaps to observe that I started my Ph.D. studies thirty years ago on April 9, 1981. The first part of my life as a Ph.D. student relates to traditional computer science in the form of using formal methods to describe and analyze communication protocols and computer hardware. It is, as such, not essential for the background of the work presented in this thesis, even though teaching and discussing education, both content and form, during this period had a strong influence on my later work. This first career also included earning a licentiate degree in 1985 and then working as a lecturer (adjunkt), and spending a year 1989/1990 at La Trobe University in Melbourne, Australia, as a guest lecturer.

The part relevant to this thesis started when I became director of undergraduate studies in 1991, having been involved in the planning of education at Uppsala University even longer than that. The work presented in this thesis draws on research and experience from my journey from frustration about lack of foundations for decisions at degree program boards, early Computing Education Research (CSEdR), the RUNESTONE project and Open-Ended Group Projects (OEGP), through learning theories and action research to developing and assessing professional skills in the IT in Society course unit (ITiS).

The story of this journey provides the reader with a background for the work presented in this thesis. The thesis is based on papers, I – V, which are selected to represent my work over the years. Appendix A contains my publication list in order to give a context to the selection made for this thesis.

**Frustration**

Working with education can often be frustrating, but at the same time is ultimately highly inspiring. This became quite clear to me for instance when I was appointed to the boards of studies, and became involved at first hand in making decisions about the content and running of degree programs. Decisions made in the board of studies had significant impact on how education was set up, and there were numerous occasions when it appeared to me that there was a need for scholarly evidence upon which to base the design of degree programs.

Typical issues were related to course units, e.g. inclusion or exclusion, the sequence, the needed prerequisites, the size, the way it was taught, but there

were also issues such as the goals of the entire degree program, how to reach potential students, and follow up on what happened to the students, both those that achieved a degree and those that dropped out.

**Computing Education Research**

This frustration lead to a search for answers, and for people who knew more about the issues I had encountered in board meetings and in my role as educator and as director of studies at the department. The time is now mid-nineties and we had Vicki Almstrum as guest lecturer at the department. Through Vicki I got in contact with Nell Dale and her group at University of Texas at Austin, which according to many was the only group researching computing education.

Further searching revealed groups at Open University (Marian Petre) and University of Kent at Canterbury (Sally Fincher) in UK and at Monash University (Dianne Hagan) in Australia. We formed a loose alliance, called Computer Science Education Research Groups International (CSERGI), and had thus a base for discussing and conducting research aiming at building up competence in the area. One activity in CSERGI was to run workshops, and one in 1999 was dedicated to discussing and defining the research area. This sparked off more focused research in Uppsala, and a new research area was born. Five years later Anders Berglund defended the first of, at the moment, five theses in this research area at Uppsala University [Berglund 2005, Eckerdal 2009, Wiggberg 2010, Cajander 2010, Boustedt 2010].

The research group at the department was first named Uppsala Computer Science Education research Group, but has subsequently changed name to Uppsala Computing Education Research Group (UpCERG). Our group spans three of the sub departments; Computer Systems, Scientific Computing, and Human Computer Interaction.

**International Projects**

There were few, if any, sources from which to apply for research funding for computing education research. The national council for the renewal of higher education ("Rådet för högre utbildning") did however support large development projects and attendance at conferences in computing education. In 1997 we were successful in obtaining funding for two three year projects. My project was named the Runestone project [Daniels 1999], or if speaking Swedish; "Runsten projektet", which established an international student project collaboration between Uppsala University and Grand Valley State University in Michigan, USA.

Runestone was relatively well financed and can be seen as the start of a real commitment to research in UpCERG. The importance of Runestone as a focus for research is evident from the three PhD theses based on studying aspects of Runestone. Anders Berglund at Uppsala University (Learning computer systems in a distributed project course The what, why, how and

where [Berglund 2005]), Mary Last at University of Texas at Austin (Investigating the Group Development Process in Virtual Student Software Project Teams [Last 2003]), and Martha Hause at the UK Open University (Software development performance in remote student teams in international computer science collaboration [Hause 2004]).

There are several aspects of Runestone that are interesting, but my especial interest is the issues related to the international collaboration. This comes partly from having had a very rewarding year as an exchange student at Case Western Reserve University in Cleveland, USA 1979/1980. I wanted to find ways in which more than just a few students could have a similar experience. Runestone provided many opportunities to reflect on how this could be achieved by adding an international component to our local education setting.

I also started a smaller international collaboration, the NZ project, with Auckland University of Technology, New Zealand in 1998, after having met Tony Clear at a conference in Dublin. It was intended to be a first taste of international collaboration for the IT engineering students and was included as a part of their introductory course. This collaboration is prominent in Tony's master thesis [Clear 2000] as well as in his PhD-thesis [Clear 2008]. A noteworthy spin-off from my collaboration with Tony that connects several of my activities is that two IT engineering students, who had been through the NZ project, the Runestone project, and the IT in Society course unit sequence, came to Auckland and completed their master theses [Hamrin and Persson 2010] with him as supervisor.

**Open-Ended Group Projects**

Runestone, and project semesters, are examples of course units that I observed were rewarding for students, but there were issues surrounding them that made their educational value questionable. This was in the back of my mind when I met two colleagues from the UK, Xristine Faulkner and Ian Newman, at a conference and we ended up having long discussions about our experiences as educators. The more we talked, the more we felt we had a lot in common, both in terms of what we did in our course units and in reactions from students and especially education coordinators. We saw huge potential in the way we organized project course units, but also obstacles. It soon became clear to us that we more or less told the *same story*.

What we talked about was exposing the students to a real problem, one which had no obvious solution and preferably encompassed aspects from many different areas. In short an open-ended problem. The settings we discussed all included students working in groups and where the problem they addressed was clearly impossible for one individual to deal with alone. Our involvement as educators was limited to offering advice and being there for discussions about the students' progress, with an emphasis on observing the quality of how they worked rather than focusing on how good the solu-

tion to the problem turned out to be. Another common denominator was that we saw and accepted that the students could assume very different roles in the projects as long as there was a real collaboration in a group.

We realized that we needed a name for what we discussed and coined the term Open-Ended Group Projects (OEGP). Xristine later earned a Ph.D. [Faulkner 2005] at her university, London South Bank University, based largely on work with OEGP.

**The IT in Society Course Unit**

My work focuses on the IT in Society course unit. This unit was introduced into the IT engineering degree program as a response to industry feedback collected using questionnaires and meetings prior to commencement of the degree program in 1995. This input emphasized that scaffolding the development of teamwork and communication skills were high priority areas for our industry stakeholders.

Running this course unit has been a challenge every year since 1998, and it has been a quite inspiring challenge. The development of a vocabulary and theories related to open-ended group projects was a vital component in meeting this yearly challenge. The open-ended group project idea suited this course unit well, but the (for the students, who had experienced a highly technical preparation in most of their other degree course units) unusual content (e.g. societal aspects) added complexity to setting up a productive learning environment. Much effort over the years has been put into devising appropriate scaffolding to support the students, without compromising the underlying ideas behind the open-ended group project concept. This thesis summarizes much of that research.

**Action Research**

The way I worked with developing the IT in Society course unit (ITiS) evolved in parallel with development of an educational research framework. This combination of development and research led to a model for scholarly educational development and research that were used in combination with the action research methodology. The action research cycle fits the yearly occurrence of ITiS, and the methodology provides a suitable structure for dealing with research-based development of a complex learning environment.

**Point of Departure**

One thing stands out for me when I look back at the story, and that is that most of what I've been working with can be seen to fall under the professional competence hat. Another reflection is that there has been an integrated process between conducting research-based development and developing a research framework. These two aspects form the foundation for the two research foci of this thesis.

# 3 Research Foci

The research described in the papers included in this thesis cover a broad research area, and emerge from fifteen years of action research in using open-ended group projects as a way to strengthen computing and engineering education. I focus on international student projects in an open-ended group project framework and study the development of professional competencies useful in a global workplace. There are two different aspects of this that will be investigated in this thesis, one about the process of scholarly educational development and the other the learning environment itself. This gives rise to my two general research foci:

> *How can research-based computing and engineering educational development be conducted?*

and

> *How can professional competencies be developed and assessed in an international open-ended group project?*

These questions have many answers, and the intention is to provide the reader with insights into the areas, give a sense that both can be successfully pursued, and not least inspire to well founded ideas on how they can be done.

# 4 Research Framework and Research Methodology

This chapter presents results for my first research focus

> *How can research-based computing and engineering educational development be conducted?*

and at the same time provides research foundations for my work. In this chapter I describe the research framework and its development, give an introduction to the action research methodology, and show how this framework and methodology supported research and development of the IT in Society course unit (ITiS).

It is vital to establish a theoretical foundation for the work presented in this thesis in order to provide the reader with insights into how the research has been conducted and the scope and generalizability of the results. The holistic perspective provided by the research framework and the action research methodology on how to address learning issues provide the means to reason about my choices of research methods and the nature of my results.

The structure of a research ecology is discussed in some depth by Crotty in the introduction to his book "The Foundations of Social Research" [Crotty 1998]. He uses the following image to depict the relationship between the four terms *epistemology*, *theoretical perspective*, *methodology*, and *method*.

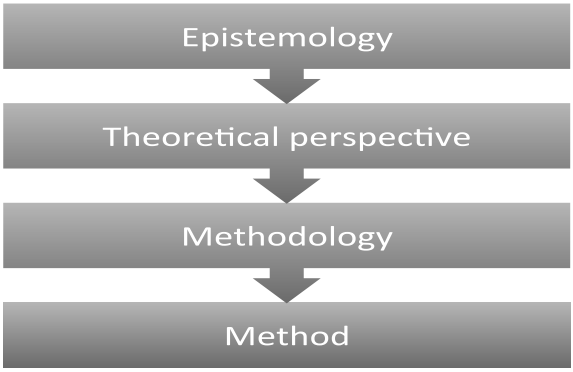


Figure 4.1: A research ecology (adapted from Crotty 1998, p. 4)

The relationship presented in figure 4.1 can be described as follows: The *epistemology* is more or less a fundamental part of the particular researcher conducing a study and it is strongly connected to the *theoretical perspective* the researcher is applying in the study. The theoretical perspective has implications for which *methodologies* that are suitable. The particular *method* associated with the methodology selected in the study is applied according to the theoretical perspective underpinning the study.

Below, a more detailed description of these terms, as used in this thesis, is given before entering into a more detailed discussion of the research framework I have developed and how I use the action research methodology.

**Epistemology**

An epistemology is the theory of knowledge embedded in the theoretical perspective and thereby in the methodology. Objectivism, constructivism, and subjectivism are examples of epistemologies. A theoretical perspective involves knowledge and the epistemology deals with understanding what knowledge is, how we know what we know, or to quote Maynard (1994):

> *Epistemology is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate.* (p. 10)

**Theoretical Perspective**

A theoretical perspective is the philosophical stance underlying the methodology and thus providing a context for the process and grounding its logic and criteria. Positivism, symbolic interpretivism, hermeneutics, and critical inquiry are examples of theoretical perspectives. By stating the theoretical perspective used a reader can gain an understanding of the assumptions, the way of looking at the world and making sense of it that guided the choice of methodology.

**Methodology**

Methodology can be seen as the strategy, the plan of action, process or design lying behind the choice and use of particular methods and linking a choice and use of methods to the desired outcomes. Experimental research, ethnography, grounded theory, action research, and discourse analysis are examples of methodologies. In research one should not just name and possibly describe the methodology selected, but also account for the rationale it provides for the choice of methods and the way the methods are used.

**Methods**

Methods are the techniques or procedures used to gather and analyze data related to some research question or hypothesis. Sampling, questionnaire, participant observation, interview, focus group, case study, narrative, statistical analysis, interpretative methods, and content analysis are examples of methods. It is important to be specific in describing how a method is used, e.g. stating what interview technique is used, and in what setting, instead of just describing it as carrying out interviews.

## 4.2 A Framework for Educational Research and Development

Educational research results stem from a wide range of different research traditions. Computing and engineering educators are often unfamiliar with the kind of results educational research produces and these results can be non-trivial to use as a basis for development. The difficulties stem from educators having specific questions related to a particular course unit or to general issues regarding some particular aspects of the computing or engineering domains, whereas educational research results often are at an abstract level regarding learning in general. Practical models with which to pursue research-based development of computing and engineering education are needed as a result.

There are also issues to consider when computing and engineering educators conduct educational research. One example, from reading the literature, is that they seldom document the learning environment and especially not the context in which it exists. This might be due to space limitations on conference papers, but could also depend on the authors being too focused on their own learning environment. Neglecting to do this reduces the trustworthiness and usefulness of the research results.

The questions of interest to computing and engineering educators are mostly related to the development of a course unit, both in terms of how to construct a learning environment and understanding what is happening during, or after, an instance of a course unit. The ways to find answers to these

types of questions vary, but are often based on using qualitative methods [Berglund et al. 2006].

In order to understand and evaluate results it is important to know which research methods were used, which research methodologies they belong to, and the epistemology and theoretical perspective that underpins the study. This section is based on early work on defining a framework for our ideas about how to conduct computing education research [Pears et al. 2002, Pears and Daniels 2003]. That there is a place for such a framework can be deduced from this statement by Crotty (1998):

> *Research students and fledging researchers – and, yes, even more seasoned campaigners – often express bewilderment at the array of methodologies and methods laid out before their gaze. These methodologies and methods are not usually laid out in highly organized fashion and may appear more as a maze than as pathways to orderly research. There is much talk of their philosophical underpinnings, but how the methodologies and methods relate to more theoretical elements is often left unclear. To add to the confusion, the terminology is far from consistent in research literature and social science texts. One frequently finds the same term used in a number of different, sometimes even contradictory, ways.* (p. 1)

### 4.2.1 Learning environment

The context of research question is an essential part in understanding results for a broader community than the local colleagues. The context includes, for instance, the degree program in which a course unit exists and the formal specification of the course unit, e.g. learning objectives and content. The students taking the course unit and especially the educators responsible for an instance of a course unit also constitute part of the learning environment.

The influences the educators bring to the learning environment are both explicit, for instance the selection of examination methods and tools provided, and implicit in the influence of their epistemology regarding learning and knowledge. Tools are to be understood as representing anything that is brought in to the learning environment to aid the students' learning, and the range of what is considered a tool is almost limitless, examples being assignments, books, clickers, labs, quizzes, and web-based self-study material. The importance in capturing the epistemological view derive from that it may influence how much students are encouraged to be active in their learning and also what constitutes learning in the view of the educator(s).

The research questions can range from concrete aspects of a particular course unit to general educational issues, e.g. in computing education how to establish a learning environment for novices learning to program. My questions are related to aspects of using open problems in a computing and engineering learning environment. These questions are better understood if a reader has a clear view of the intended learning environment.

A visual representation of the context influencing the development of a research question, i.e. the external scope, is given in figure 4.2:

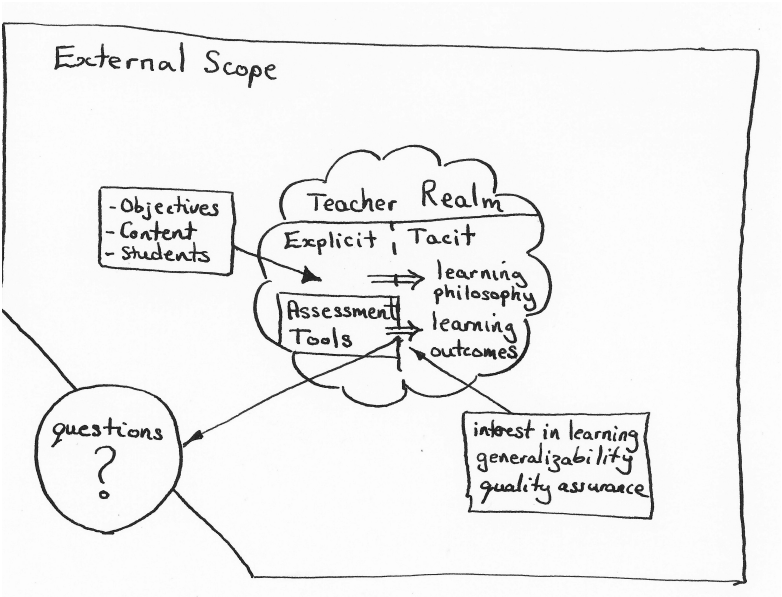


Figure 4.2: The learning environment for the research question

Figure 4.2 is part of a graphical approach to describing the context and influences that have a bearing on the development and conduct of educational research. This figure provides a detailed view of one aspect of the more general framework presented in figure 4.3, that has grown out of discussions in Uppsala Computing Education Research Group (UpCERG).

Figure 4.2 is intended to capture the relation between the overall learning environment, especially how it is viewed by the educator (or educators) involved, and the research question. The researcher is reminded to consider and explicitly document the external scope in terms of for instance:

- Formal specifications of learning objectives for the course unit.
- Educational context in the form of degree program.
- Information about the students attending the unit.
- General issues related to the research question such as the educators:
    - Interest in learning.
    - Desire to find transferable answers.
    - Striving for quality assurance.

An important objective is to capture issues with respect to the educators involved:

- Explicit choices such as the most appropriate means of assessing students and the available educational tools.
- Tacit influences, such as epistemology and their view on what constitutes learning.

### 4.2.2 Research Setting

Capturing the relevant aspect of the learning environment is an important step in the process of developing research questions. The next step is to find a suitable method with which to find an answer to the formulated question. There is no underlying assumption in terms of epistemology or theoretical perspective in the research framework, nor on which research methodology to base the use of the selected methods on. The framework is intended to support the researcher in selecting methods and documenting the theoretical rationale for the choice. That is, the framework should be used to provide the researcher with a clear connection between the aspect of the research question addressed by the chosen research method and associated research methodology and the assumed theoretical base, i.e. epistemology and theoretical perspective, for the answers provided.

Making well-informed choices of which method to use is often beyond an individual computing, or engineering, educator wishing to conduct a research study and the communication with scholars from other disciplines to learn more about the available methods might be problematic. This problem is, in our experience, to a large extent based on not sharing a common research terminology, nor having the same research interests. The framework is intended to support both making the choice and facilitating communication, by providing a base to place the question and scaffold thinking about where to find ways to reason about the question and the limits and possibilities of different approaches to investigating the question.

The epistemology and theoretical perspective are associated with the person who formulated the question, although it is of course possible for a person to choose between different theoretical perspectives depending on which aspect of a research question they might wish to address. The choice of epistemology and theoretical perspective is not part of this framework, but we have introduced choice of discipline as a level in the framework. This is done in order to get a frame of mind about where to find suitable research methodologies and methods, e.g. that different disciplines within social sciences might be a good place to start if one wants to find out something about cultural influences in a learning environment.

The next step is to find a suitable research methodology that has promise with regard to the question. The discipline lens might be useful in finding this, perhaps through interaction with researchers in that discipline. The first steps in the process, i.e. to capture the relevant aspects of the learning environment, phrasing the research question, and selecting the potential discipline to aid in finding an answer, provides the start for creating a common ground between the computing, or engineering, educator(s) formulating the question and the researchers in the selected discipline(s). This could typically lead to changes in how the learning environment is viewed, e.g. that more aspects should be documented.

In the framework we depict computing (and engineering) education research (CER) as the outermost layer, in which the studies based on the chosen research methods are performed. It is here that the questions are answered.

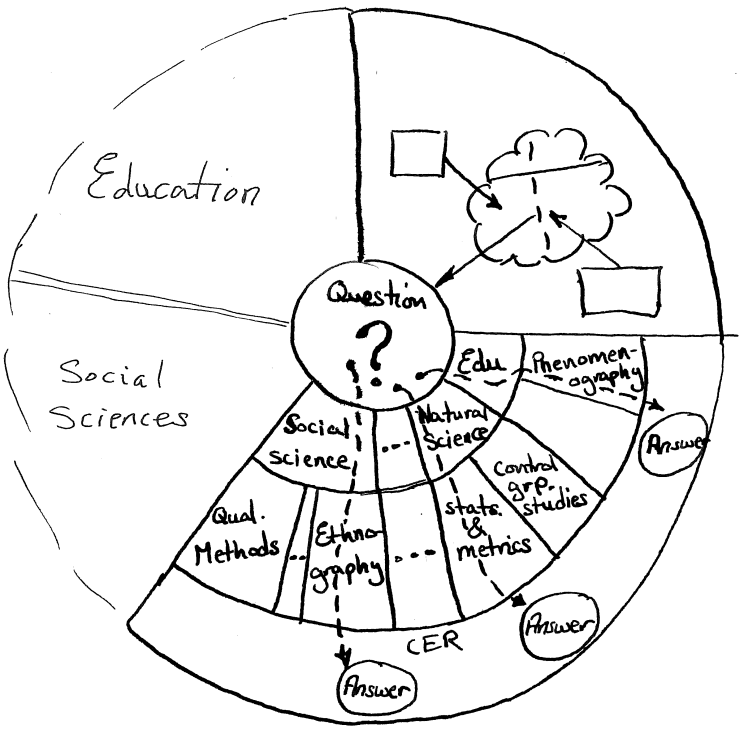


Figure 4.3: The educational research framework

An objective of this framework is to raise the level of scholarliness among educators and educational researchers in the computing and engineering discipline. The idea is to provide a structure for integrating development and research and aid in capturing the relevant issues that will make development and research efforts more transferable. The work reported on in this thesis, apart from presenting the framework as a result, is an example of the influence arising from this general framework in that it provided a context for addressing learning environment questions based on a variety of learning theories, as well as setting the stage for working in an action research manner.

## 4.3 Action Research

The term *action research* is attributed to Kurt Lewin at MIT, who used it in his paper "Action research and minority problems" [Lewin 1946]. He described the methodology as comparative research on the conditions and effects of various forms of social action and research leading to social action that uses a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action, or in other words experimenting by making changes and simultaneously studying the results, in a cyclic process of planning, action, and fact gathering. Lewin had a strong positivist view and this is thus an example of a research methodology that is connected to different theoretical perspectives.

Action research includes a strong relationship between the researcher(s) and the practitioner(s) and an open attitude to which data collection methods to use [Rasmussen 2004, Reason 2006, McKay and Marshall 2001]. The essence of action research is well captured by Carr and Kemmis (1983) who state that an action research activity has two essential aims, i.e. to *improve* and to *involve*, and that the focus of the improvement lies in three key areas: improving a practice; improving the understanding of a practice, and improving the situation in which the practice takes place.

The rather open description of action research lends itself to different interpretations. Approaches to action research are widely discussed in the literature, e.g. [Reason and Bradbury 2007, Elden and Chisholm 1993, Cajander 2010], where it is pointed out that there is a common core that has been adapted to different contexts. The way action research is carried out is heavily influenced by the specific problem addressed, the relationship between the researcher(s) and practitioner(s), and the discipline within which the research is situated.

The role of the researcher in action research is also a topic of discussion. Extreme positions on the role of the researcher include a focus on the research aspect and data gathering, almost to the point of being a spectator in the process, or a focus on the service aspect by fully collaborating with the practitioners in solving the problem [Westlander 2006]. In practice, and certainly in my case, a situated approach which is a mixture of the two poles is used, typically due to the complexity and situated nature of the problems addressed [Cajander 2010].

A duality of the role of the researcher is discussed by McKay and Marshall using a model with two different cycles; an explicit problem solving cycle and a research cycle [McKay and Marshall 2001]. I also use this model in paper IV. McKay and Marshall also emphasize another aspect of action research; that one result of working in this manner can be seen as developing a theory around the issue addressed. Paper IV in this thesis describes how action research is used to create a theory about how to create a learning environment in the IT in Society course unit. The constructed theory is aimed at

providing a base for supporting acquiring professional competencies suitable for a global workplace.

The role of the practitioners in action research is also discussed in the literature [Elden and Chisholm 1993], with a growing interest in considering practitioners as peers in the research process. Practitioners in the research presented here are students, clients, educators and other experts who contribute with their knowledge and understanding. The extent of involvement has varied depending on the problem addressed.

### 4.3.1 Action Research in the IT in Society Course Unit

An illustration of the steps within a single action research cycle in the context of developing the IT in Society course unit (ITiS) is given in figure 4.4.

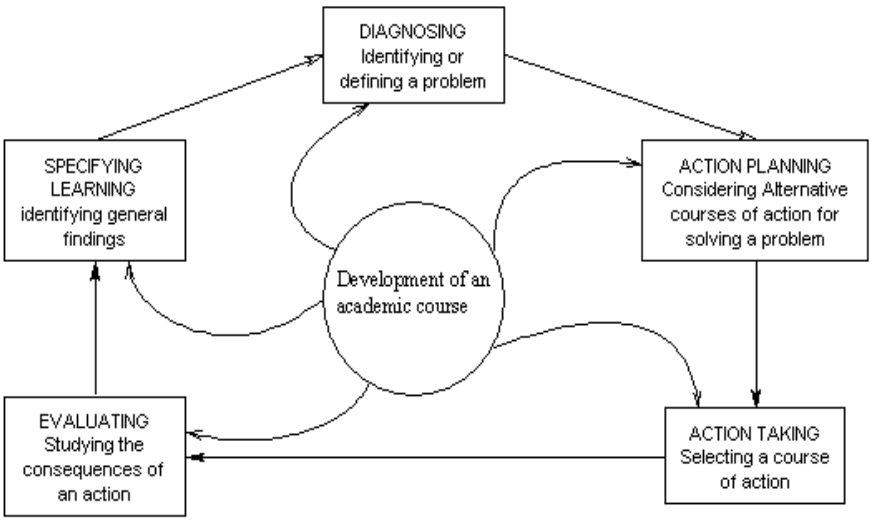


Figure 4.4: The Action Research Cycle (adapted from Suman and Evered 1978)

A starting point for a description of the action research cycle can be the top box, where identification and an initial analysis of the specific problem to be addressed are done. The next box in the cycle represents the process of preparing for setting up an action plan addressing the identified problem. This involves, apart from describing different alternative actions, documenting the theoretical underpinnings for selecting an action. The "action taking" box represents the selection process, where the alternatives are compared in order to find the most appropriate action for addressing the identified problem. This process also involves reasoning about the methods to be used in evaluating the outcome of the action. The next step is to carry out the selected action plan, including gathering and analyzing data generated from the chosen research method. The last box before returning to the starting point represents abstracting answers relative to the identified problem,

answers that will be used in starting the next cycle by looking at the problem with the added information from the action research cycle at hand.

Taking a lap around the action research cycle has some clear connections to activities described in the research framework presented in section 4.1. For instance, the starting point can be seen as selecting the research question: selection of research methods and documenting the theoretical underpinnings is an activity that is made easier by the research framework. Making answers more transferable typically involves anchoring them in a theoretical context and this is an activity that is facilitated by the research framework.

This model describes a rational and systematic inquiry action research, however, I concur with Reason (2006) who argues that these cycles are slightly "messier" than the neat diagrams drawn. The research presented in this thesis has also elements of being more diffuse and tacit as described by Reason (2006), even though the academic year provides a natural planning window for an action research cycle.

The academic year cycle provides an opportunity for reflection, taking stock of the progress made and learning gained in the previous cycle and serving as a logical planning point for the subsequent cycle. Outcomes and observations arising from an action plan for the current course instance naturally feed through into the design of the next.

The areas of ITiS addressed in the action plan for the following course instance are typically different, at least partially, from those addressed in the current (and previous) instance(s). Another difference between cycles is that the pedagogical and conceptual framework the course instance is based on might have changed, and these changes are an integral part of the analysis for each action cycle. Five elements are emphasized within the framework inspired by McKay and Marshall (2001), which enable a conscious separation of the practice components from the research elements. They point out that this enables the researcher to avoid a common trap in action research: having the work described as “consultancy”. That is, they worry about not being taken seriously so using the research framework to anchor the answering of research questions in an applicable theoretical context addresses, and solves, the same issue. The five elements are:

- **F**, the research framework or conceptual element informing the research, which in the terms used in this thesis correspond to epistemology, theoretical perspective and concepts underpinning the research;
- $\mathbf{M_R}$, the research methodology to be adopted;
- $\mathbf{M_{PS}}$, the problem solving method that will be used in the practice situation;
- **A**, the problem situation of interest to the researcher (the research questions);
- **P**, the problem situation in which we are intervening (the practice questions of interest to the practitioners).

Examples of application of this framework to my work on ITiS is presented in table 4.1 by giving an overview of different issues and approaches used to develop ITiS over the years. The table can thus serve as an introduction to the work presented in Chapter Six. The content in each of the five elements and how it is used to guide research is more specific when considering a single instance. This will be demonstrated in the discussion of the use of constructive controversy [Johnson and Johnson 2009, Smith et al. 1981] in a pedagogical intervention in the course unit.

This cyclical pattern of action-research-based development has produced a progressive improvement of the theoretical base for creating a learning environment suitable for promoting and assessing professional competencies. This progression has not been straightforward, and many challenges have been encountered, and some still remain, along the way.

| **Element** | **Description** |
|---|---|
| **F** (Framework) | Constructivism, the OEGP concept, threshold concepts, conceptual change, communities of practice, cognitive load, collaborative technology fit, etc. |
| $\mathbf{M_R}$ (Research Methodology) | Action Research |
| $\mathbf{M_{PS}}$ (Problem solving method) | ITiS course unit and task design, international collaborations, local sponsor, reflective practitioner model |
| **A** (problem situation of interest to the researcher) | • How does OEGP support or hinder the work of global student teams?<br>• How does OEGP develop student skills in global collaboration?<br>• How does OEGP develop each student's professional skills and ability to cope with ambiguity and complexity, and to take responsibility for his/her own learning? |
| **P** (a problem situation in which we are intervening) | • Improving teaching and learning through active learning approaches<br>• Students as active co-researchers<br>• Collaborative learning models<br>• Developing student capabilities in teamwork, cross cultural communication and use of IT<br>• Providing an interesting and meaningful learning experience<br>• Improving viability of student teams engaged in international teamwork |

Table 4.1: Examples of elements of research investigating the IT in Society course unit

# 5 Theoretical Background

The research framework presented in Chapter Four does not restrict the choice of epistemology, theoretical perspective, methodology, and methods. The second research focus

> *How can professional competencies be developed and assessed in an international open-ended group project?*

establishes some boundaries for what is relevant in this thesis and my preferences further constrained the choices. The action research methodology described in the previous chapter is used in my work. The purpose of this chapter is to provide a theoretical background which supported the innovations introduced in each action research cycle. This includes presenting:

- *Constructivism* [Piaget 1970], since it is the epistemological underpinning of my work.
- *Conceptual change* [Posner et al 1982] and *threshold concepts* [Meyer and Land 2003], since they are essential theories related to how I view learning taking place.
- *Communities of practice* [Wenger 1998], since it is a theory for learning relevant to the type of learning environments I create and study. It also provides a terminology with which to discuss learning in these environments.
- *Ill-structured problem solving* [Jonassen 1997], since ill-structured problems are fundamental to the learning environment I am interested in.
- *Reflective practicum* [Schön 1983, 1987] and *problem based learning* [Kolmos et al. 2010], since they are instructional methods that closely resemble the open-ended group project approach that I study.
- *Professional competencies* [OECD 2005], since they are what the learning is aimed at in my studies. This includes giving definitions of these competencies and examples of how to assess them.

This theoretical background, and especially the way it informs my work, is essential in order to understand the broader implications of the studies presented in this thesis. The chapter concludes with a summary of how I relate this theoretical background to learning in an open-ended group project environment.

## 5.1 Constructivism

Constructivism is a view of learning that stems from the cognitive revolution against the behavioristic view [Säljö 2000]. Säljö describes the constructivist view of learning as having an emphasis on the active part of the individual in constructing an understanding of the environment and not seeing learning as a passive absorption of information. The view can be interpreted as everything being subjective and there being no objective reality, but as pointed out by von Glasersfeld (1990) the existence of a mind-independent ontological reality is not in contradiction with constructivism.

There are several research traditions in constructivism, but it is beyond the scope of this thesis to go into details and make clear distinctions between them. I will instead present a general overview of constructivism and give some insights into the different traditions.

Jean Piaget describes cognitive development as changes of the world view, that is adaptation to the environment, through corrections based on experiences [Piaget 1970]. This interaction with the environment is seen to take place through two parallel processes; *assimilation* and *accommodation*. Assimilation is the process of taking in information about how the environment is organized and functions. It can be seen as filling in more information into a structure that already is in place and where there is no need to change the structure based on the new experiences. Accommodation is needed when a new experience requires a change of the structure used to understand the environment. An alternative way to view assimilation and accommodation is to see that in assimilation it is the environment that is adjusted to suit the individual and that in accommodation it is the individual that adjusts to the environment.

Marton and Booth (1997) reason about a difference between an *individual* constructivism and a *social* constructivism. Individual constructivism has an emphasis on understanding the inner workings of learning by focusing on the learner's active role. The environment, e.g. acts and behaviors in "the outer", is in the individualist view seen as something that needs to be explained and this explanation is done by "the inner", i.e. by mental acts in the individual. Social constructivism on the other hand has a focus on the importance of cultural practices, language, and other people in the learning process. This can be seen as "the inner" consciousness being explained in terms of the "outer" society. Marton and Booth draw no line between "the outer" and "the inner" in that they regard the world neither as constructed by the learner (individual constructivism) nor as imposed upon her/him (social constructivism), but as constituted as an internal relation between them. They say "There is only one world, but it is a world that we experience, a world in which we live, a world that is ours." [Marton and Booth 1997, p. 13].

**Zone of Proximal Development**

The work by Lev Vygotsky (1978) is situated in the social constructivism tradition. He describes learning as internalization of knowledge. This was derived from studying social interactions and observing how the interaction, including noting how tools such as culture, language, and symbols, affected construction of knowledge. Internalization can be seen as the process of making a tool ones own. In his studies he noted an interesting area in the range of abilities, from where things could be done independently to where they could not be done even with guidance from someone more skilled. This area was named the *zone of proximal development* (ZPD).

ZPD can be seen as the area where learning is about to take place but some form of scaffolding is still needed in order to accomplish a task or explain a concept. Vygotsky saw this as happening through a dialogue where unstructured thoughts and concepts were exposed to a more structured scientific view of a mentor. The upper level of the zone expands when new development processes are created in interaction with others and the lower level is raised when those processes have become internalized.

An important aspect is that the ZPD defines the possible development processes at the time. This has implications for both what constitute a suitable learning environment and how assessment of learning can be done.

## 5.2 Conceptual Change and Threshold Concepts

Concepts, and how they change, are central to how I view learning. The theories regarding conceptual change and threshold concepts give insights into the concepts that are relevant to the learning process.

Entwistle (2007) specifies concepts in the following way:

> *"Concept" is most frequently used to describe a grouping of objects or behaviours with the same defining features that has become recognized through research or widespread usage.* (p. 124)

Concepts can be seen as being composed of other, clearly defined, concepts [Ausubel et al. 1978], that can be captured in hierarchical trees. This is particularly the case in natural science, where concepts often are clearly defined in a commonly accepted way within a discipline. A difficulty with this view is that concepts are not static, they can for instance be contested from another theoretical perspective or (with additional experience) be seen as evolving into something more complex. It is also interesting to note that it is possible to view concepts from individual perspectives so that there is a possibility of multiple views of the same concept. It is also reasonable to view concepts as being situated in a cultural context [Halldén 1999], since con-

cepts can be identified by the different context in which they are used, whether it is in everyday discussions or within an academic discipline.

**Conceptual Change**

A typical view of conceptual change in natural science education is to replace a naïve version of a concept with a more scientific one. This change might require an accommodation, and is often resisted, due to the preference to assimilate new information rather than accommodating. In making a change it is helpful to have a grasp of the broader view, but this typically involves understanding the concept at the less naïve level, which is known as Meno's paradox [Day 1994]. A consequence of this, i.e. that the initial understanding of the refined concept is typically only partially understood, leads to a need to revisit the new ideas several times and thus that conceptual change is a process that takes time.

Halldén (1999) identifies three processes in which conceptual changes occur. The first is to see it as replacing naïve versions of the concept with more refined versions. The second is to introduce the more refined and complex versions as modifications of the old, more naïve version. This can be considered as an example of assimilation, as described above. The third is an independent development of a new version of how to understand a concept, which is similar to the accommodation process described above. The association to assimilation and accommodation is my own observation.

Posner, Strike, Hewson, and Gertzog (1982) develop and discuss a more general theory of conceptual change. They view learning as something the student is active in and they use the terms assimilation and accommodation as described above in setting their epistemological base. They stress the need for a set of existing, current, concepts in order to investigate, and learn from, a new phenomenon in the environment. They use the term conceptual ecology to refer to these concepts. They are interested in the process of accommodation, and they investigate; 1) under what conditions one central concept comes to be replaced by another, and 2) what features of a conceptual ecology govern the selection of new concepts.

A central concept is one that is useful in solving the problem at hand; it is thus clearly dependent on the learner's environment. Posner et al. state that if accommodation occurs, there must be dissatisfaction with existing conceptions, and the new conception must be intelligible and initially plausible. These conditions are relative to a person's conceptual ecology. Posner et al. identify the following aspects of a conceptual ecology as important for the occurrence of accommodation:

- Anomalies, i.e. character of the failures of the current concept.
- Analogies and metaphors that help make a new concept intelligible.
- Epistemological commitments about what counts as explanation in a field.
- Metaphysical beliefs and concepts about the world in general.

- Other knowledge such as knowledge in other fields and competing concepts.

In this theoretical framework accommodation of a new central concept, a conceptual change, is seen as something not abrupt, but rather gradual and piecemeal, which can be compared to the definition of liminal space described in the threshold concept section below. They also stress that something that on the surface looks like accommodation might instead be some elaborate form of assimilation.

**Threshold Concepts**

Work by Perry (1970, 1988) on students at Harvard and Radcliffe Colleges in USA on their view of knowledge led him to identify a pivotal point in student development. This point is associated with a distinction between "awareness of knowledge as provisional" and seeing knowledge as "evidence used to reason among alternatives". The difference between these perspectives is the distinction between dualistic and relativistic views of knowledge. Entwistle (2007) uses the work of work Säljö (1979) to reason similarly about the concept of learning. He identifies a point at which a learner makes the transition from seeing learning as "applying and using knowledge" to "understanding what has been learned", which he identified as a transition from viewing learning as reproduction to seeking meaning. Knowledge and learning are seen to be examples of concepts that can have a range of interpretations, from naïve to sophisticated. The studies by Perry and Säljö identify particular stages in the development of these concepts from naïve to sophisticated that have a transformative effect on the persons passing through these stages

Meyer and Land (2003) refer to a concept whose acquisition is of a transformative nature as a *threshold concept*:

> *A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress. As a consequence of comprehending a threshold concept, there may be a transformative internal view of a subject matter, subject landscape, or even world view.* (p. 1)

It is important to note the transformative aspect, which is what makes a threshold concept different from an ordinary concept, even one that is important in a scientific area. When students acquire threshold concepts, the epistemological commitments of their conceptual ecology are changed to better conform with the appropriate scientific community.

Meyer and Land define threshold concepts as follows:

1. *Transformative* in that a significant shift occurs in how a subject is viewed once it is understood. It can in some cases lead to a change of personal identity.
2. *Irreversible* in that it is unlikely to be forgotten and will require considerable effort to be "un-learned".
3. *Integrative* in that it opens up previously hidden interrelations and creates new understandings relative to the subject.
4. *Bounded*, in that there will be new thresholds to pass once the concepts have been understood.
5. *Troublesome,* as in knowledge that is "wrong" in some sense, and that can lead to *troublesome knowledge* [Perkins 1999].

The transformative aspect of threshold concepts makes them interesting to focus on in a learning environment. The need for transformation suggests looking at students views of the concept before and after acquisition; however, it is also important to look at the period during which the change is taking place. Meyer and Land (2005) describe how the learner is in a state of liminality when trying to understand a threshold concept. The process is often both problematic and humiliating, and often involves oscillating back and forth between intermediate states before the final transformation. All of this can serve as a metaphor for what goes on when a student is trying to understand a threshold concept in a learning environment.

The issue of helping students through the liminal space needed to understand the threshold concept is an interesting educational challenge. This challenge is complex as can be seen from the observation of *proxies* made by Meyer and Land (2005). They point out that providing simplified versions, proxies, of the threshold concept might lead to students getting stuck at these proxies instead of learning the real concept and using them to be able to "fake" understanding of the real concept. They also observe that threshold concepts are *discursive*, since they generally do not have a singular nature and are not something that has one true and valid interpretation. That is, they wish to avoid a reader concluding that there is a "right" version of a concept as could be inferred from using the notion of "fake" understandings.

Eckerdal et al. (2007) empirically identify different aspects of partially understanding a threshold concept. They postulate that there is a theoretical and a practical aspect to attaining a threshold concept, and that partial attainment may mean that a student has grasped the concept in a theoretical sense without having a concrete understanding, or capability, to use the concept, or vice versa. They also identify the need to realize the learning objective associated with grasping the concept, which can also be part of a partial attainment of the concept.

## 5.3 Communities of Practice

The term *community of practice* (CoP) was coined by Jean Lave and Etienne Wenger (1991). A CoP is a group of people who share a concern or a passion for something they do and who learn how to do better as they interact regularly[3]. Wenger gives three crucial characteristics that collectively define a CoP:

1. *The domain:* A CoP has an identity defined by a shared domain of interest, membership of the CoP implies a commitment to the domain, and therefore a shared competence that distinguishes members from other people.
2. *The community:* A community is created as members engage in joint activities and discussions, help each other, and share information.
3. *The practice:* Members of a CoP are practitioners that develop a shared repertoire of resources, e.g. experiences, stories, tools, and ways of addressing recurring problems.

Wenger (1998) has used the CoP concept to form a theory of learning that places learning in a social context. CoP is a conceptual framework and as such, is useful in obtaining general principles and recommendations for setting up learning environments. The theory is based on the following four premises; 1) we are social beings, 2) knowledge is a matter of competence with respect to valued enterprises, 3) knowing is a matter of participating in the pursuit of such enterprises, and 4) meaning – our ability to experience the world and our engagement with it as meaningful – is ultimately what learning is to produce.

Wenger sees learning as a social participation process where *meaning* is created as a part of discussing experiences. *Practice* and *community* are essential components of his theory, where the practice of interest is identified in discussions of actions and the community is identified by discussing who belongs to the community. He points out that the *identity* of a learner in a community is changing as the individual is learning.

*Meaning* stands in relation to the community, since its value is defined there. Some communities might have their own very different value systems from those of the rest of the society, e.g. the assassins guild on Disc World [Pratchet 2002] and the Mafia families in our real world, but this is beside the point as seen from learning in a CoP. The essential message in this theory of learning is the focus on learning arising from interactions.

CoP has been used in two recent Ph.D. theses in our research group (UpCERG[4]). Wiggberg (2010) used it as a foundation for discussing and analyzing activities in student projects, and especially for looking at learning in a student project. He showed that the students in such a project can be seen as

[3] http://www.ewenger.com/theory/communities_of_practice_intro.htm
[4] www.it.uu.se/research/group/upcerg

a CoP. Cajander (2010) used CoP as vehicle for understanding the interrelations between different groups in an organization. The focus on learning in Wengers theory was helpful in understanding how organizations change.

Schön (1987) uses the term community of practitioners (pp. 32-33). He notes that the group has knowledge and shares conventions of using media, language, and tools that sets the members apart from others. This is similar to the communities Wenger discusses, but Schön ties communities to institutional settings, like courts and schools. Schön's ideas about reflective practitioners, and the related reflective practicum, will be presented in the next section.

Schön's ideas about learning are interesting in comparison to CoP. He points out that a professional's knowing-in-action, tacit knowledge [Polanyi 1967], is embedded in social and institutional structures and is organized around characteristic practice situations including constraints and possibilities provided by the professional knowledge and supporting systems.

Work by Barab and Duffy (2000) ties communities of practice nicely to constructivism and learning environments. Work on situated cognition by Brown, Collins, and Duguid (1989) is relevant in understanding learning in CoP. For further reading concerning general aspects of constructivism and design of learning environments consult Duffy and Cunningham (1996).

## 5.4 Using Open-Ended Problems in Education

Open-Ended problems are a natural way to induce discussions in a student group. As pointed out earlier, I view discussion as an essential component in learning. There is however an issue that reminds me of the inscription over the entrance in the main university building at Uppsala University:

> *Tänka fritt är stort men tänka rätt är större*[5]. (Thomas Thorild 18th century philosopher)

in that it is important to influence the students in what they learn. I just want to note that I don't think that there is a right way to think, but there are nevertheless typically some specific learning objectives associated with a course unit.

The literature around ill-structured problem solving is quite relevant with regard to using open-ended problems in education, and especially to the question of how educators intervene.

[5] Thinking freely is great but thinking right is better

### 5.4.1 Ill-Structured Problem Solving

The ill-structured problem solving aspect of setting up an open-ended group project (OEGP) learning environment is reported in work by Amie Hauer and myself (2008). Problem solving is considered a fundamental learning activity [Davidson and Sternberg 2003, Jonassen 1997] and a central competence in engineering degree programs. It is also important to note that problem solving is situated and thus different for different disciplines; this often blurs the idea of what problem solving means in a given situation. In this work, problem solving is seen as the search for answers to difficult or perplexing questions or situations.

It is important to distinguish between two general groups of problems in learning environments: well-structured and ill-structured. Ill-structured problems are those whose goals or bounds are unspecified, unclear or insufficient in various ways. They are considered to be more complex, real-world or indeterminate in their end goals in comparison to "well-structured" problems [Davidson and Sternberg 2003, Reitman 1965, Simon 1977, Simon 1979, Sweller 1988, Xun and Land 2004]. It should be noted that well-structured problems are prevalent in today's education environment, even though ill-structured problems are the ones students more frequently encounter in everyday and professional practice [Xun and Land 2004, Jonassen 2003]. This is unfortunate in that the sought after competence to deal with ill-structured problems in the work environment is poorly addressed by experiencing mostly well-structured problems.

However, tackling ill-structured problems is generally not straightforward. First, solving ill-structured problems requires different competencies and competency levels than solving well-structured problems [Reitman 1965, Simon 1979, Sweller 1988, Xun and Land 2004, Kester et al. 2005]. This means, that theorists often disagree on the characteristics of ill-structured problems, even though most agree that knowledge of the nature of ill-structured problems is important both for learning goals and in teaching students how to solve ill-structured problems [Jonassen 1997, Reitman 1965, Sweller 1988, Chen and Ge 2006, Hong, McGee, and Howard 2000].

**Cognitive load**

An important aspect of ill-structured problems is knowledge of human cognition and how we solve problems. This is crucial, especially with ill-structured problems, because it appears that novices have a choice of either focusing on goal attainment (solving the problem) or learning how to solve the problem (schema acquisition) [Davidson and Sternberg 2003]. The interference between these competing goals, keeping in mind that novices must spend more time in information-search because their domain knowledge is limited, sometimes induces learners to solve the problem at the expense of

acquiring schemas that they may then apply to future problems [Sweller 1988].

It is thus essential to include bounded rationality, external support tools, and scaffolding in discussions of problem solving. Because ill-structured problems are naturally more difficult, this suggests that appropriate scaffolding experiences must occur before a learner is able to successfully tackle a more advanced ill-structured problem type.

With this in mind, ill-structured problems increase cognitive load (especially for less experienced learners), due to problem representation/formulation difficulties in the beginning, and require schema acquisition to be in place or resolving the problem may take more time. Other relevant factors that affect the ability to deal efficiently with problem solving include problem recognition (deep vs. surface) and problem transfer [Davidson and Sternberg 2003], cognitive load, and the split attention effect [Kester et al. 2005].

There are therefore clear indications that some form of scaffolding is appropriate in using ill-structured problems in learning environments. Work on bounded rationality is relevant to this issue, it is especially important to consider students' use of external structures in aiding them in the problem solving process (computer simulations, archiving team documents) and to look at how schema acquisition is managed by students during the learning process [Xun and Land 2004, Simon 1996]. This is expressed in work by Davidson and Sterberg as realizing that when the information search-space continues to increase as more and more information is available, there is an increasing need to better understand how to manage large search spaces, utilize external structures for learning management, and learning how schema acquisition is impacted by problem formulation and information search [Davidson and Sternberg 2003].

The issue of high cognitive load [Sweller 1988, Kester et al. 2005] in learning environments built around ill-structured problems is a concern. The need for externalized support or scaffolding to help cognitive and metacognitive processes is addressed in work by Xun and Land (2004) and also by Simon (1996). It is important to note that cognitive load is highly dependent on the skill level of the problem solver [Sweller 1988, Xun and Land 2004, Chen and Ge 2006]. A novice is in much higher need of scaffolding in order not to run into a cognitive overload where little or nothing is transferred to long-term memory [Kirschner et al. 2006]. Using experts as models for novice learners can be a way for novices to scaffold their learning, considered in the context of Vygotsky's zone of proximal development [Chen and Ge 2006].

### 5.4.2 The Reflective Practicum

Schön (1987) describes the *reflective practicum* as a generalized educational setting (learning environment) where the ideas and principles come from the use of design studios in architectural education. Central in his work is reflection-in-action, i.e. the thinking what you are doing while you are doing it, in dealing with complex, new and uncertain, perhaps even conflicting, situations in practice. The ability to do this in a constructive manner is what Schön refers to as professional knowledge (competence) and he argues that this is based on more than a generic problem solving and decision making capacity, it is a reflective practice. A reflective practicum provides opportunities for learning the broader competencies he claims are essential for being a professional and which cannot be taught. The pedagogical idea in Schön's work is to coach students to see the connections between means and methods used and results achieved.

The reflective practicum in the form on a design studio is elaborated in his book (1987), and the following themes are addressed: (p. 18-19)

- *Designing as a form of artistry*. What are the kinds of knowing at work in architectural designing?
- *Fundamental tasks and predicaments of a design studio*. How ought we to explain the sense of confusion and mystery that pervades the early stages of a design studio? In what sense are design competence teachable – or learnable? What are the characteristic roles and tasks of students and studio instructors?
- *Dialogue of student and coach*. If we think of the interaction of student and coach as one in which messages are sent, received, and interpreted, what are the forms of communication available to coach and student? On what factors does communicative efficacy depend?
- *Forms of dialogue*. What are some of the principal models of communicative interaction between coach and student? To what kinds of learning are they particularly suited?
- *Coach and student as practitioners*. Depending on the forms of dialogue at work in the studio, student and coach are subject to different sets of complementary demands. What are the characteristic problems they are called on to solve in their interaction with each other?
- *Coaching artistry*. Design coaches who are good at their work display a kind of artistry in their own right. What are its distinctive patterns of knowing?
- *Impediments to learning*. What are some of the ways in which the dialogue of student and coach can go wrong? What competences can overcome these impediments to learning?

These themes and questions are also applicable to reasoning about open-ended group project based learning environments. Schön reasons about this in terms of reflection-in-action, knowing-in-action, and knowing-in-practice.

Knowing-in-action is about publicly observable competencies, e.g. riding a bicycle or instantly analyzing program code, where the person performing them has a difficulty describing how the action is done. This is what Polanyi (1967) described as tacit knowledge, with its own specific patterns. The knowing-in-practice is the knowledge associated with a community of practitioners, as described in the previous section.

Thinking about an action that has an element of surprise associated with it, whether pleasant or unpleasant, can be seen as reflect-on-action if done after the action, or as stop-and-think if the action is interrupted. Both of these, according to Schön, are distinctly different from the process of reflecting in the midst of the action, in that they provide an opportunity to question the current knowing-in-action patterns. The element of surprise is important, in that reacting to familiar variations in actions does not require reflection.

Schön makes a distinction between seeing professional knowing as knowing the drill and presuming that there is always a right answer, and seeing it as reflection-in-action, also based on knowing the drill, but when surprised, coming up with a solution even in the absence of a right answer. The second view builds on the assumption that there might not exist any professional knowledge that fits the case, nor that every problem has a right answer. It is the latter that is the focus of a reflective practicum.

Schön (1987, p. xi) describes his work on the *reflective practitioner* as forming a new epistemology of practice. In the taxonomy of this thesis, I would describe this as a theoretical perspective, since it uses practice as the basis for (professional) knowledge.

### 5.4.3 Problem Based Learning

Problem Based Learning (PBL) is an instructional method where students are supposed to work cooperatively to solve real world problems as a way of learning to learn [Kolmos et al. 2010]. The learning-to-learn aspect is addressed by raising students' curiosity in order to initiate learning a subject, as well as preparing the students to think critically and analytically, and to find and use appropriate learning resources. Kolmos et al. summarize the characteristics of PBL as follows:

- Ill-structured, complex problems that are often drawn from the real world provide the focal points and act as stimuli for the course unit and educational degree program.
- Learning is student centered.
- Educator takes on the role of a supervisor, as a coach or facilitator.
- Learning is realized in small groups of students who analyze, study, discuss and propose solutions to (possibly) open-ended problems.
- Learner assessment is enhanced by self and peer assessment.

PBL has thus many characteristics in common with the open-ended group project (OEGP) concept. This is further emphasized by Kolmos et al., who

state that a PBL learning environment promotes competencies such as problem analysis and problem solving, project management and leadership, analytical skills and critical thinking, dissemination and communication, innovation and creativity, and social abilities.

These competencies are developed through the practical training in coordinating a group to work effectively as a team. The model also promotes building on prior knowledge in new situations. The result is that PBL is an excellent method for developing new competencies and preparing for dealing with changing requirements. This learning process is not an easy one and students often initially react with shock, denial, anger, and resistance, but it is mostly followed by acceptance and confidence. This is a scenario that mirrors the one described in the initial discussions about OEGP [Daniels 2010].

Reflection in the form of self-assessment is an integral part of PBL, as is peer-assessment. Both these forms of assessment are identified as important professional competencies, and are examples of components of a learning environment that is drastically different from what the students are used to. Presenting the rationale behind the PBL concept early in the educational degree program and giving training sessions have been found to be essential in introducing the students to PBL.

Central to PBL is the selection of problems. Kolmos et al. characterize a good PBL problem as follows:

- It is engaging and oriented to the real world.
- It is ill-structured and complex.
- It generates multiple hypotheses.
- It requires a team effort.
- It is consistent with desired learning outcomes.
- It builds upon previous knowledge/experiences.
- It promotes development of higher order cognitive skills.

A related issue is how to use problems in a PBL course unit. One strategy is to set up the learning environment as a string of problems. A more advanced version is to start out with a set of specific problems designed to address some specific knowledge or competence followed by a more comprehensive problem intended to integrate the knowledge and/or competence gained from the specific problems. A similar strategy is to raise the complexity of the problems from introductory through complex to comprehensive. Another version is to have a case study solved together with a facilitator followed by an individual problem. A more traditional format is to have a problem followed by a lecture, where the order of problem and lecture is reversed, compared to traditional methods.

## 5.5 Professional Competencies

There is general agreement that professional competencies are important aspects of student outcomes from most, if not all, degree programs. The agreement of what is actually meant when talking about professional competencies is however not as universal, nor is there consensus as to how these competencies should be developed or assessed. Professional competencies are both general and specific to a discipline or particular context; the scope for the competencies addressed in this thesis is the IT area.

The issue of what is meant by professional competencies will be addressed by presenting work from an international set of organizations, including the Organization for Economic Co-operation and Development (OECD) from the European Union, the Australian Council for Educational Research (ACER), and ABET (formally known as the Accreditation Board for Engineering and Technology) from USA.

Work by ABET and ACER will be used to address the issue of assessing professional competencies, which is a complicated task, given that there is no clear agreement of what is meant by professional competencies in the first place. The issue is further complicated by the confusion regarding terms used in assessment, or as stated by Gloria Rogers, former managing director of professional services at ABET in her statement on the their website[6]

> *What is meant by the word outcome? Objective? Goal? Standard? Performance criteria? Triangulation? …. And the list goes on. Unfortunately, the language of assessment is not precise, and* ***there is no right way to define many terms associated with assessment****.*

Professional competencies and assessing persons with regard to them is a central research area in human resource management (HRM). Unsurprisingly, this topic is particularly important to industry. Some insights into how this is addressed in HRM will be provided.

### 5.5.1 Definitions of Professional Competencies

The definition of professional competencies could be a thesis in itself; the intention here is to present some approaches to defining competencies and give the context for these definitions. Three large organizations from three continents are used to give a broad overview of the area.

**OECD**

The Organization for Economic Co-operation and Development (OECD) countries started the Program for International Student Assessment (PISA) in

[6] www.abet.com (assessed February 20, 2011)

1997 [OECD 2005]. The goal of this effort was to ensure that students towards the end of their compulsory schooling had the required knowledge and skills needed for full participation in society. This effort includes a periodic assessment and comparison of skills in reading, mathematics, science and problem solving. At the same time, there is an understanding that success in life depends on a far wider set of competencies. The Definition and Selection of Competencies (DeSeCo) project [OECD 2005] is intended to provide a framework for an understanding of competencies in general. This understanding is based on definitions and assessment methods. It is designed to set overarching goals for education systems and lifelong learning.

The view in this project is that a competence is more than just knowledge and skills, but also the ability to deal with complex situations in particular contexts. The idea is to capture what is needed to deal with such situations in general through the definition of a few key competencies. These key competencies must:

- Contribute to valued outcomes for societies and individuals;
- Help individuals meet important demands in a wide variety of contexts;
- Be important not just for specialists but for all individuals.

They are classified in three broad categories: being able to use tools for interacting with the environment, being able to engage with others in heterogeneous groups, and being able to take responsibility for ones own life in a broad social context and act autonomously. Central to all categories is the ability to think and act reflectively.

The world view of the DeSeCo project is that technology is changing rapidly and continuously, that societies are becoming more diverse and compartmentalized, and that globalization is creating new forms of interdependence.

*Using Tools Interactively*

The three competencies in this category address the need to keep up to date with technologies, to adapt tools to ones own purposes, and to conduct active dialogue with the world. The first competence is the ability to use language, symbols, and text interactively, which concerns using spoken and written language skills, computation and other mathematical skills effectively in multiple situations. They associate this competence with *communication competence* and *literacy*. The second competence is the ability to use knowledge and information interactively, which requires critical reflection on the nature of information itself. This competence is needed in order to understand and form opinions, make decisions, and carry out informed and responsible actions. The third competence is the ability to use technology interactively, which is based on an awareness of new ways technology can be used in everyday life. Harnessing the potential of information and communication technology (ICT) is part of this competence.

*Interacting in Heterogeneous Groups*

This category also contains three competencies related to dealing with the diversity in pluralistic societies, placing importance on empathy and social capital. The first is how to relate well to others; this includes initiating, maintaining and managing relations with personal friends, colleagues and customers. They compare this with emotional intelligence; it includes respecting and appreciating other values, beliefs, cultures, and histories in order to create a welcoming environment. The second competence is the ability to cooperate with others who share an interest. It is important to be able to balance between needs of others and one's own personal interests. The last competence is the ability to manage and resolve conflicts. Conflicts can arise from differences in needs, interests, goals, or values, and the competence is about being able to manage the differences in a constructive way rather than negating them.

*Acting Autonomously*

The third category is related to needing to realize one's identity and set goals in a complex world, to exercise rights and take responsibility, and to understand one's environment and its functioning. The competence to act within the big picture is the first competence they mention; this is about being able to understand and consider the wider context of actions and decisions. The second competency in this category is the ability to form and conduct life plans and personal projects, which they describe as requiring an individual to interpret life as an organized narrative and to give it meaning and purpose in a changing environment. The third and last competency is the ability to assert rights, interests, limits, and needs, which range from everyday situations to highly structured legal affairs.

**Australian Council for Educational Research**

The Australian Council for Educational Research (ACER) report on the development and evaluation of a graduate skills assessment (GSA) test [ACER 2002]. They selected some graduate skills and competencies for the test, but the report provides an introduction to competencies in general. Skills and competencies are described at a very abstract level as allowing people to adapt to and operate in a variety of workplaces.

ACER was commissioned to generate assessment for transferable competencies that have broad relevance to academic work and graduate employment. They looked at competencies at a meta-level where identifying, selecting, and applying an appropriate repertoire of more specific knowledge and skills to deal with a task were required under the premises that such competencies are likely to be transferable.

The Mayer competencies [Mayer committee 1992] presented a list of employability skills and competencies that they considered suitable to be addressed by formal education. They were:

- Collecting, analyzing, and organizing information.
- Communicating ideas and information.
- Planning and organizing activities.
- Working with others and in teams.
- Using mathematical ideas and techniques.
- Solving problems.
- Using technology.
- Cultural understanding.

ACER saw these as limited in that they omitted personal traits and were not based on any theory of skill development. This can be contrasted with a rather different statement from the Association of Graduate Recruiters in UK [Association of Graduate Recruiters 1995], where self-reliance skills are seen as particularly important. Examples of such skills are self-awareness, self-promotion, exploring and creating opportunities, action planning, networking, matching and decision making, negotiation, political awareness, coping with uncertainty, development focus, transfer skills, and self-confidence.

In ACER's exploration they made a distinction between academia and employers as stakeholders for valuing competencies and they propose the following list of competencies:

- Communication/structured written response.
- Problem solving/applied reasoning/strategic.
- Analytic skills.
- Critical thinking.
- Logical reasoning.
- Ethics/citizenship/social responsibility/empathy.
- Creativity.
- Interpersonal skills/teamwork/leadership.
- Skeptical but open-minded.
- Flexibility/tolerate uncertainty.
- Capacity for or commitment to lifelong/independent learning.
- Numeracy/ability to quantify.
- Literacy.
- IT familiarity/IT use.
- Personal skills/self-management/reflective/confidence/self-reliance/initiative.
- Global/national/historical/cross-cultural perspective.
- Information literacy/management/research skills.

There were clear differences in how often the different competencies were referred to, with the first two on the list and the interpersonal skills/team–

work/leadership competencies coming out clearly at the top. ACER also addressed the assessment of competencies and this is reported on below.

**ABET**

ABET (formerly known as the Accreditation Board for Engineering and Technology) accredits degree programs, primarily in USA. It is an influential source for defining what is meant by professional competencies for computing, engineering, and related disciplines. For example, ABET requires that a computer science degree program must enable students to attain, by the time of graduation [ABET 2010a]:

a) An ability to apply knowledge of computing and mathematics appropriate to the discipline.
b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
d) An ability to function effectively on teams to accomplish a common goal.
e) An understanding of professional, ethical, legal, security and social issues and responsibilities.
f) An ability to communicate effectively with a range of audiences.
g) An ability to analyze the local and global impact of computing on individuals, organizations, and society.
h) Recognition of the need for and an ability to engage in continuing professional development.
i) An ability to use current techniques, skills, and tools necessary for computing practice.

All of these fall under what could be seen as professional competencies, and d) – h) also in the often viewed as "too-fuzzy-to-deal-with" category that is of interest in this thesis. ABET also give a similar list for general abilities that applied sciences degree programs should be able to demonstrate that graduates have and this list also contain the following [ABET 2010b]:

- An ability to function on multidisciplinary teams.
- An ability to identify and solve applied science problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of solutions in a global and societal context.
- A recognition of the need for and an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice.

- An ability to apply knowledge of mathematics, sciences, and other related disciplines.
- An ability to conduct experiments, as well as to analyze and interpret data.
- An ability to identify, formulate, and solve applied science problems
- An ability to function on teams.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- A recognition of the need for and an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern applied science tools necessary for professional practice.

There is thus a long list of competencies that must be examined in an ABET accreditation. More concrete interpretations of these competencies can be obtained from looking at how the accreditation process is using these lists. This will be briefly covered in the following section.

### 5.5.2 Assessment of Professional Competencies

What is assessed is strongly related to the wishes of stakeholders, as expressed in the Australian council for educational research (ACER) report [ACER 2002]. The view from industry is covered in the human resource management (HMR) section, whereas a more academic view is captured in the ABET and ACER sections.

**Human Resource Management**

Companies have traditionally had a need to assess competencies when hiring new employees and when manning new endeavors. A general overview of assessment in the industry was obtained in an interview with Anna Gullikssen, a human resource management (HRM) strategy specialist with Assessio Sverige AB.

Judging the suitability of a person is typically partly based on some form or other of personality test, e.g. Myers-Briggs type indicator [Briggs Myers and Myers 1995] and instruments based on the five-factor model [McCrae and John 1992], and behavioral observations in realistic settings, e.g. assessment centers [International Task Force on Assessment Center Operations 2009].

*The Five-Factor Model*

The five-factor model is a result of long development with roots in ancient Greece where Hippocrates and Galen divided people in four personality types; the choleric, the melancholic, the phlegmatic, and the sanguine. The

five factors recognized today are openness, conscientiousness, extraversion, agreeableness, and neuroticism (OCEAN) [McCrae and John 1992].

- *Openness* stands for being inventive and curious rather than consistent and cautious, and is described as having an appreciation for art, emotion, adventure, unusual ideas, and a variety of experience.
- *Conscientiousness* stands for being efficient and organized rather than being easy-going and careless; it captures tendencies to show self-discipline, acting dutiful, and aim for achievement, typically having a planned rather than a spontaneous behavior.
- *Extraversion* stands for being outgoing and energetic rather than solitary and reserved; it indicates energy, positive emotions, and a tendency to seek stimulation in the company of others.
- *Agreeableness* stands for being friendly and compassionate rather than being cold and unkind; it captures being cooperative rather than suspicious and antagonistic towards others.
- *Neuroticism* stands for being sensitive and nervous rather than secure and confident; it indicates a tendency to experience unpleasant emotions, such as anger, anxiety, depression, or vulnerability, easily.

According to personality psychology researchers, these five factors are considered to be over-arching domains that capture the basic structure behind all personality traits. They are not claimed to be orthogonal, nor to cover all aspects of a person's personality, but are identified as being important factors in suitability for a particular position. They are not competencies in the meaning used in this thesis, but they can certainly be seen as important aspects of a person in relation to the person's competencies, and they are subject to being possible to change, e.g. through education.

*The Assessment Center Approach*

The personality tests are complemented with an assessment center approach [Terpak 2008] where case studies and work related simulations are used to complement information gained by personality tests. An assessment center is a process in which a person is evaluated on competencies critical for a particular position. The International Task Force on Assessment Center Operations presents guidelines on how to operate assessment centers [International Task Force on Assessment Center Operations 2009] in which they define an assessment center as follows:

> *An assessment center consists of a standardized evaluation of behavior based on multiple inputs. Several trained observers and techniques are used. Judgments about behavior are made, in major part, from specifically developed assessment simulations. These judgments are pooled in a meeting among the assessors or by a statistical integration process.*

The guidelines are aimed to:

- Give guidance to those who design and conduct assessment centers.
- Give information to those who make decisions about using assessment center methods.
- Give instructions to those that work at an assessment center
- Give guidance on use of technology in assessments.

Of particular interest in the context of this thesis is that the guidelines stress that a job analysis of relevant behaviors must be done to determine important competencies. This is referred to in HRM literature as competency modeling. One part of a job analysis is to clearly define behaviors that can be observed in assessment procedures. The job analysis literature also states that a relation between assessment technique, observable behavior, and desired competency must be clearly defined.

The HRM definition of competency is rather vague; there is a general idea that a competency must be related to success in the target occupation. Otherwise, it refers to aspects such as organizational strength, organization goal, valued objectives, constructs, and groupings of related behaviors or attributes. The HRM literature also states that the competencies they are interested in are those that have a behavioral dimension that can be observed. The competencies used are however not vague in a real setting, since they are clearly distinguished and have associated observable behaviors.

Markus et al. (2005) list three approaches to competency modeling; 1) the *educational* approach, 2) the *psychological* approach, and 3) the *business* approach. The educational approach relates to the development of skills, achievement of standards, and awards of credentials and is focused on observable behavior related to a particular role with clearly defined standards. The psychological approach focuses on personality traits and their relation to a job function. McClelland and Boyatzis define competencies as "a generic body of knowledge, motives, traits, self images and social roles and skills that are causally related to superior or effective performance in the job." [McClelland and Boyatzis 1980, p. 369]. The business approach relates to organizational competencies for competitive advantage and deals with collective learning in organizations, thus competencies are seen from a larger-scale perspective. The last two approaches have clear relations to the communities of practice (CoP) concept [Wenger 1998]. Markus et al. point out that the goal of a competency model, regardless of approach, is to provide an operational definition for a competency and measurable observable performance indicators or standards against which to evaluate individuals.

The particular rules for what is required to be called an assessment center is not essential in the context of this thesis, but it is worth noting that they require that multiple assessment methods must be used and that at least one of these methods must be simulation. The reason for the latter requirement is that it is essential to be able to base the assessment on real behavior, and preferably in as realistic situations as possible. They also stress the need to

have more than one person doing the assessment and that there is a clear procedure for how these assessors pool their observations.

Another interesting aspect is the clearly stated need to educate the assessors. They point out that the education should include learning about the competencies in question, how behavior is associated with the competencies and how to observe those behaviors, connection between exercises and observations, and common mistakes made in observations. The learning aspect is also hinted at as an output of an assessment center, in that the purpose could shift partly or even wholly to be about educating the assesses, who in the latter case should be called learners instead.

*Summary*

The HRM area focuses on objective measurements and personality tests that are said to be more reliable than interviews. Assessment is, however, complex; some aspects, especially tacit knowledge [Polanyi 1967], are hard to capture. The competence of the assessor becomes a critical factor in the process. Past experiences and track record are often central factors in assessing people, and most newly examined students have little to show in these areas. University education can clearly improve its record in documenting students' competencies and experiences.

**Australian Council for Educational Research**

The five graduate skills (i.e. competencies) selected by Australian council for educational research (ACER) to be tested were [ACER 2002]:

- *Critical thinking*, where the ability to think critically about viewpoints and arguments is assessed. Comprehension, analysis, and synthesis are expected in assimilating and evaluating viewpoints and arguments.
- *Problem solving*, where the ability to analyze and transform information as a basis for making decisions and progressing towards the solution of practical problems is tested. Insight into the problem of dealing logically with key information is expected, as are analytical, logical, and quantitative reasoning.
- *Interpersonal understanding*, where the ability to show insight into the feelings, motivation, and behavior of others is assessed. Understanding approaches to helping or working with others, such as feedback and teamwork, is expected.
- *Argument writing*, where the ability to develop a point of view about an issue and to structure a clear, coherent, and logical argument for that view is tested.
- *Report writing*, where the ability to comprehend, select, organize, and clearly present a summary report based on facts, figures, and pictures is assessed.

The first three of these were tested with multiple-choice test and the latter two in a written assignment. The reason for this choice was that they wanted competencies that were in the cognitive dimension and thus easier to assess, and also competencies that were judged as having a significant degree of transference in that the competence should be useful in different contexts.

Competencies that are related to personality traits were thus avoided on the premise that the outcome of the test would have sufficient association with an ability to put the tested competencies in action in the real world. The test is thus far from what is described under for instance the assessment center section above.

**ABET**

An interesting perspective on assessment from an academic point of view is the assessment (accreditation) of degree programs done by organizations such as ABET. Of specific interest is how the long list of competencies stated as essential student outcomes is dealt with. This list is only a suggestion, since a program to be evaluated is asked to provide its own educational objectives. Most institutions simply adopt the list, since they otherwise have to provide evidence for how their goals imply those on the list.

The fulfillment of the objectives for a program must be assessed and the institution also needs to provide a quality improvement strategy for the cases where they fail to meet the objectives. It is this self-study that the program evaluation visitors (PEV) look at in their evaluation process. The process involves examining materials relevant for assessing the objectives and improving weak areas and discussing the process with faculty who are doing the assessing. A clear goal is to have measurable program outcomes even for professional competencies, in a similar way to the goals for assessment centers, and to demonstrate that they are met. The programs evaluated must show that this cycle has ben run through at least once.

## 5.6 My View on Learning and Professional Competencies

Roger Säljö opens with the following statement in his book "Lärande i praktiken" (Learning in practice) [Säljö 2000].

> *Huvudsyftet med denna bok är att argumentera för att mänskligt lärande bör förstås i ett kommunikativt och sociohistoriskt perspektiv. Kunskap lever först i samspel mellan människor och blir sedan en del av den enskilde individen och hans eller hennes tänkande/handlande*. (p. 9)[7]

[7] The main purpose of this book is to put forth an argument for the case that human learning should be understood in a communicative and socio-historical perspective. Knowledge first comes to life in the interaction between people and then becomes part of the individual and his or her thinking/acting. (my translation)

That is, he states that his book will argue that human learning should be understood in a communicative and socio-historical perspective and that knowledge first appears in interaction between people in the process of becoming a part of an individual's thinking and acting. This is also how I see learning, and it is the base for my work.

This view fits well with the communities of practice (CoP) concept, in that interaction between the members of a CoP develop through interaction with each other. The notion of moving from peripheral to central has a close connection to the zone of proximal development (ZPD) in that the more central persons can provide challenges in the ZPD that will move the peripheral persons towards more central positions and in the process learning more about the relevant issues for the CoP.

I also see the theories about conceptual change and threshold concepts as good models for how I view learning taking place from an individual perspective. These theories do not include interacting with others, but to me both have a clear connection to interacting with others as sources for ideas to contemplate and as sounding boards for changes in understanding. When it comes to learning relevant to a course unit, I see Schön's theories about the reflective practitioner as aligning well with this image of changes in an individual through influence from the surrounding practice.

My view is that learning occurs all the time and everywhere, which means that one of my goals is to create learning environments that extend as much as possible into the students' everyday life. Part of this is to use ill-structured, open-ended, problems, since I view them as creating thoughts that will linger in the students' brains, in a manner similar to the liminal space mentioned in association with threshold concepts. I also see open-ended group projects (OEGP) as a suitable strategy for creating learning environments in that they create opportunities for interactions and also serve well in creating realistic environments for developing professional competencies.

This view is graphically illustrated by Schön (1987)

> *In the varied topography of professional practice, there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution through the application of research-based theory and technique. In the swampy lowland, messy, confusing problems defy technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or society at large, however great their technical interest might be, while in the swamp lie the problems of greatest human concern.* (p. 3)

Ill-structured problem solving is in my opinion also a suitable source for developing professional competencies. This is due to students developing strategies to deal with the "unknown", which is a significant part in many professional competencies. Take the cultural awareness competence for

instance, where it is impossible to predict all the situations that might occur. The dealing with the unknown is an example of how elusive aspects of (professional) competencies can be, and I see using realistic and complex learning environments, such as CoP and the reflective practicum, as suitable for developing students' professional competencies. The reflecting aspect is, as I see it, essential in capturing the learning opportunities in these complex settings.

Ill-structured problem solving gives, in my opinion, rise to issues with cognitive load. Limits, such as the number of information chunks a person can deal with simultaneously being 7 +/-2 that was demonstrated by Miller (1956), is important to take into account when setting up learning environments. This consideration should be guiding when to introduce scaffolding in a learning environment. It should also be taken into account that some scaffolding might give the students a false sense of having learnt something, which can be seen as not passing through to a threshold concept.

I see the following professional competencies as central for an ability to work in a global environment.

- Having general communication and distributed teamworking skills.
- Having a cultural awareness including understanding societal impact.
- Being open minded to solutions in a creative and innovative way.

This list corresponds well with the competencies listed by the ACM task force on Globalization and Offshoring reported in [Aspray et al. 2006].

# 6 Open-Ended Group Projects and the Development of Professional Competencies

The development of the *open-ended group project* (OEGP) concept, paper II in this thesis, is an important part of my work. I will present the concept together with the course unit *IT in Society* (ITiS). Some of the pedagogic interventions made over the years to promote development of professional competencies are presented in papers III – V. Four of these interventions are highlighted in this chapter.

## 6.1 Open-Ended Group Projects

The open-ended group projects (OEGP) concept is presented in paper II. Several of my publications present the OEGP concept and build on different aspects of the concept. It is central for my work and as such warrants a section of its own before I move on to present and analyze some of the pedagogical interventions made in the IT in Society course unit (ITiS).

A strength of the OEGP concept is its intuitive nature, but it is still important to present the boundaries for the concept as well as its educational rationale. I will relate the presentation to the theoretical background introduced in Chapter Four, look at addressing professional competencies and especially global collaboration, and give some examples of the use of OEGP at Uppsala University.

### 6.1.1 Characteristics of an OEGP

An OEGP-based learning environment addresses ill-structured problems. These can preferably be proposed by an industry partner and would in that case provide extra motivation for the students. The students' motivation is derived from different sources, one being that the problem is typically seen as both relevant and current and another being that it is close to the perceived manner in which professionals work. Reports from industry imply that students with an OEGP experience in their studies are preferred over those that lack such experiences [Daniels et al. 2002].

The problems addressed in an OEGP should be of high complexity with no clear solution and have many possible solution approaches. This is simi-

lar to what Brooks and Brooks (1999) describe as a "good problem". That is, a "good problem":

- Requires students to make and test at least one prediction.
- Can be solved using only equipment and facilities that are available.
- Is realistically complex.
- Benefits from a group effort.
- Is seen as relevant and interesting by students.

They state that a constructive approach to learning presupposes the existence of "good problems" that need solving by the learner. The difference with problems in an OEGP is that they are intended to be of a higher complexity than what is implied by Brooks and Brooks for their "good problems". Another difference is that the problems in OEGP are to be defined and redefined.

A distinction from traditional learning environments is that the educator is not supposed to be the source of all necessary knowledge and skill, but rather to have a mentor role, similar to the role in the reflective practicum and PBL. One reason for this approach is to move away from the view that there is one single correct solution. Another reason is the intention to activate the students and to encourage them to discuss and help each other, thus creating a community of practice. The mentor role also allows for a closer and more personal contact with the students, as compared with a classical lecture, and the potential to better observe if a student is in a liminal space with regard to some concept. Another way of looking at the role of being a mentor is to become aware of the zone of proximal development for the individual students and use this knowledge to tailor the learning environment for them. A perhaps daunting feature of an OEGP for an educator is that he/she also might get into unknown territory regarding what is needed to make progress in the project.

It should be noted here that the educational focus of an OEGP is more on the process than on the product. The product, as in the solution to the given problem, is important in the motivation it provides. The challenge is rather to not let this motivation negatively influence the motivation to focus on the process, since it is vital in an OEGP to motivate the students' learning of how to work with an ill-structured problem in a manner related to how professionals work. This aspect of an OEGP is covered in some detail in Wiggberg's thesis (2010).

Another motivational aspect is that students define what the problem actually is and how it should be delimited. This leads to a sense of ownership and thus increased motivation to solve the problem. This is no silver bullet, there might be students who neither understand, nor assume ownership of, the set problem, and who might have better understood the problem if it was set by a educator. Educators setting the problem is however contradictory to the learning goals in an OEGP-based learning environment, and those stu-

dents should perhaps have had a better preparation earlier in their studies regarding their ability to deal with open-ended problems.

### 6.1.2 Relationship to Ill-Structured Problem Solving and PBL

OEGP is related to the ill-structured problem-solving concept in that the problems selected in an OEGP based learning environment are of the ill-structured type. A goal of an OEGP is that the students develop a competence in handling ill-structured problems, so it is reasonable to view ill-structured problem solving as an integral part of the OEGP concept.

The concerns about high cognitive load stated in the section on ill-structured problem solving are thus also valid for OEGP based learning environments. Reduction of the cognitive load can, if needed, be handled through implementation of various versions of scaffolding. Several of the pedagogic interventions are of this type.

Problem Based Learning (PBL) also bases part of its founding ideas on ill-structured problem solving, and is also in other aspects, such as the focus on activating the students, educators taking a supervisory role, and being based on a constructivist epistemology, similar to OEGP.

A difference between PBL and OEGP is the intended use of the respective concept, in that PBL clearly is intended as a base for entire whole degree programs. This can be seen on the course unit level, where PBL has developed different scenarios for using problems coupled with a reasoning about how they fit in the overall degree structure. OEGP is aimed to serve individual educators in creating meaningful learning environments in a course unit. It is not intended to serve as a strategy to construct degree program, even though it is possible to use the concept to specify places in a degree program that should base learning on OEGP.

### 6.1.3 Professional Competencies and OEGP

The nature of the OEGP concept makes it a suitable candidate to base a learning environment on when learning objectives include development of some professional competencies, e.g. ability to function in teamwork situations. Competencies can be seen as developing within a community of practice (CoP), and an OEGP-based learning environment can be tailored to mimic much of what goes on in a CoP. Furthermore, the OEGP concept is to a high degree based on interaction between students and the use of ill-structured problems related to the future profession of the students. These characteristics of OEGP imply that the concept is well suited to promote learning professional competencies.

Professional competencies are thus developed through using them in the educational setting. This implicit support can be complemented by explicit provision of information on professional competencies. Using reflections is

a method that can be used to aid in the process of going through a conceptual change with regard to some professional competencies, e.g. working in a distributed team.

### 6.1.4 Examples of OEGP at Uppsala University

The IT in Society course unit (ITiS) will be expanded on below, but I have been involved in other examples of learning environments where the OEGP concept has been used, i.e. The NZ project and the Runestone project. I will present them briefly.

**The NZ project**

The NZ project started on short notice 1998 after having met Tony Clear from Auckland University of Technology (AUT) at the ITiCSE conference in Dublin the month before. This can be seen as empirical evidence of the flexibility of the OEGP concept.

The setting was that IT engineering students in their first course unit had a small component in which they collaborated with third year students at AUT. The pedagogical idea for the Swedish students was to get a first insight into the issues arising from international collaboration. The students in New Zealand had evaluation of collaboration tools as an added learning objective.

There are a few papers published that center on this project. Two of them focus on the first instance and on using groupware in general for international student collaboration [Clear 1999, Clear and Daniels 2000]. The other two focus on how to get the collaboration started using ice-breaker assignments [Clear and Daniels 2001] and 2D and 3D avatars [Clear and Daniels 2003].

This project did succeed in the intention to get the message that international collaboration is difficult to manage across. The downside of this was the frustration it caused. With hindsight it is our observation that more efforts should have been made towards explaining the pedagogical idea and the OEGP concept, since critique about it being poorly organized finally contributed to the decision to abandon the project in 2008. That the project had issues with practical problems and how the one with firewall restrictions were handled is discussed by Clear (2003).

**The Runestone Project**

The Runestone project started based on looking for ways to take advantage of Carl Erickson from Grand Valley State University (GVSU), Grand Rapids, Michigan, USA, coming to Uppsala during the 1997/1998 academic year. The ideas resulted in a three year grant from the national council for the renewal of higher education ("Rådet för högre utbildning") and including

the Runestone project in a course unit in the third year in the IT engineering degree program.

The project comprises working in teams of six, the first year eight, where half of the team members are from another country. The basic assignment is to develop a system in which a physical device is remotely controlled. The assignment is of such complexity that it is impossible to solve individually and that there are many different possible approaches to addressing the assignment.

There have been many changes to the Runestone project over the years. Examples are that 1) GVSU is no longer participating and have been replaced by universities in Turku, Finland and Shanghai, China, 2) the assignment is based on another hardware platform, 3) the instructions to the students have evolved, 4) another student cohort, the Systems in Technology and Society Engineering degree program, has been added in Uppsala, and 5) educators have been changed. The underlying idea is still intact though.

There are a large number of publications related to the Runestone project from the first one presented at the ASEE/IEEE Frontiers in Education conference in Tempe 1998 [Daniels et al. 1998]. I wrote a longer report concerning the initial ideas and results [Daniels 1999] and a recent paper presents the current situation [Pears and Daniels 2010]. The theses by Berglund (2005), Hause (2004), and Last (2003) provide insights into different aspects of the Runestone project.

## 6.2 Example: The IT in Society Course Unit

The IT in Society course unit (ITiS) runs during the 7th semester of the IT engineering degree program (ITP) at Uppsala University. ITP started in 1995 and this course unit was different to most other units in that it contained areas from several disciplines, e.g. computing, technology, psychology, and language. The course unit was also relatively large in that it ran a full semester and counted as studying half time during that period.

It was created in a response to industry asking for graduates with better communication skills. Previous experiences with departments from the social sciences giving course units for the engineering students were discouraging, in that the students typically found out how to pass them with very limited learning due to being very efficient in knowing how to pass examinations. The solution was to let the IT department host the course unit and recruit suitable competence from the social sciences.

The first instance of ITiS was run in 1998. The scenario presented to the students was that the educators had a consulting company and that the students were recruited to solve problems for a number of clients. The clients and the problems were real although no money was involved nor any promise of products. Working with the clients was the major part of the course

unit, but there were also lectures on relevant issues, e.g. group processes. The students worked in teams of four or five, but from 2001 all students worked in the same project. There have been a few different clients, but since 2002 the setting has been the health sector, i.e. the Uppsala Academic Hospital. This environment fits well with the learning objective in ITiS that the students should be able to constructively participate in a project dealing with a complex and multifaceted problem set in a real environment.

The number of students in the course unit has varied between 20 and 45 over the years. Since 2005, we have collaborated with Rose-Hulman Institute of Technology, Terre Haute, Indiana, USA, adding 4 to 10 American students taking their Communication in a Global Society course unit to the team. This collaboration has varied some, but the 2008 instance can serve as an illustration of the structure.

### 6.2.1 The 2008 Instance

The person responsible for IT strategies at the Uppsala County Council, under which the Uppsala Academic Hospital serves, introduced the educators to the issue of patients accessing their medical records over the Internet, which was made possible by a change in Swedish law two months before the course unit started. Students from both Uppsala and America were initially asked to gather information relevant to this topic. Most of the American students visited Sweden during the 3rd week of the course and at the end of this week the two student cohorts produced a project design (in collaboration with the customer), as well as agreement on how to collaborate. The main course deliverable was initially conceived as a report on the issue, but after discussions with the students and the customer a white paper and a process report were agreed upon as a revised deliverable. The white paper was to be used by the customer as a means to draw attention to the issue at the European Union council in Brussels, Belgium, and the process report was to be a reflection upon the process of engaging in the collaboration itself.

The rest of the American students, plus some of those who came in the 3rd week, came over for a week towards the end of the semester when the white paper was presented. The client had invited staff from the hospital, local politicians and also people working in Brussels to the presentation and was very pleased with what the students delivered. The progress report was turned into a paper that was presented by one of the students at ASEE/IEEE Frontiers in Education in San Antonio, Texas, 2009 [Cajander et al. 2009a].

### 6.2.2 Educational Issues

ITiS is based on the OEGP concept and the following issues that have been identified over the years are important in the context of this thesis. The first being the fact that there is a real client and the consequent focus on deliver-

ing a product. This focus can have unwanted consequences for the learning outcomes due to the way, and with what, students chose to work as pointed out by Wiggberg (2010).

Having a real client also means that an uncertainty factor is introduced, or as our client the last couple of years often says to the students:

> *You should talk with the right people, but the problem is that they seldom have time to talk with you. Persons having plenty of time to discuss with you are probably not the persons you should interact with.*

This is of course a drawback in a project running over a relatively short time period. It is a common problem that the students get stuck waiting for responses. Many students have difficulty working with different aspects of a problem, although this is an important learning goal. This difficulty could of course be due to laziness, but is in many cases caused by inexperience with having a holistic view of a problem. It could also be a case of the "not my problem" attitude that is not uncommon among the students.

The "not my problem" issue is also related to problems with cultural differences in that students note that something does not function as they expect and attribute it to "them" being different instead of trying to work out how to deal with the situation. The unwillingness to try to sort out issues stemming from cultural differences might be due to previous experiences of failure.

Many problems can be attributed to students not becoming part of the community or being peripheral in the community of practice sense [Wenger 1998]. These students have a tendency to become quite anonymous and can be hard to identify as having problems. Being peripheral in a highly complex project makes it difficult for a student to achieve a holistic view and will further his/her perception as an outsider, not least by causing misunderstandings about the project.

One perhaps surprising issue is that some students do not consider acquiring professional competencies as something to take seriously. Dealing with this and the other issues is part of the action research approach to developing ITiS. Different forms of scaffolding have been introduced and analyzed in this manner and I will present four of these interventions in the next section.

## 6.3 Pedagogical Interventions

There have been many pedagogical interventions in the IT in Society course unit (ITiS) over the years, some being modified from year to year, with an aim to address the educational issues presented in 6.2.2 in order to improve the learning environment. Following the terminology introduced in table 4.1 based on the McKay and Marshall model for action research [McKay and

Marshall 2001], these interventions fall under the problem solving method element, $\mathbf{M_{PS}}$ I will present four of the more important interventions, i.e.:

- All students in one project.
- Introducing an expert on cultural awareness.
- Using constructive controversy.
- Using reflections.

The first two will be discussed briefly and latter two in more detail.

A constructivist epistemology, as presented in Chapter Five, and the OEGP concept compose the basic theoretical underpinning for all of these interventions. They are thus part of the framework, **F**, element in the model for action research. The research methodology element for each intervention, $\mathbf{M_R}$, is action research even though early work followed an action research approach without being consciously aware of this methodology. The latter can be seen by using the action research methodology to analyze a particular pedagogical intervention.

### 6.3.1 All Students in One Project

Using a real client and having international collaboration are important parts of ITiS in order to enable all students to interact with persons in the work force as well as with non-local students and to add complexity to the interactions between the students. However, there are issues related to implementing these objectives that represent the **P** element in terms of the action research model, e.g. real clients can be very real in that they can suddenly become difficult to get access to due to some unforeseen event and student cohorts can change in size quite dramatically over the years.

The approach to solve those issues, the $\mathbf{M_{PS}}$ element, has since 2002 been to only have one project with a stable client. Since 2003, the client has been the Uppsala county council and the associated academic hospital. There might still be difficulties with getting access to the workplace, but selecting a problem that involves different aspects creates many instances where it makes sense to interact with the workplace, thus reducing the vulnerability of the situation. Since all students work in the same project it is possible for those who for some reason have difficulties in getting access by themselves, to piggyback on others who have managed to work out a functioning interaction.

The problem of interest to the researcher, the **A** element, was how the OEGP concept was affected when all students were in one project. The observation was that having all students in one project lead to other issues, new **P** elements, and provided thus input for another action research cycle. Examples of issues were the division of work and creation of subgroups e.g. the mix of American and Swedish students in a subgroup have varied over the years. The problem solving method ($\mathbf{M_{PS}}$) was to step in with restrictions,

for instance, we decided that a subgroup with members from both Sweden and USA must have at least two members from each site.

Another observation was a tendency to assign non-critical tasks to students from USA due to the project having its customer in Uppsala. The problem solving method ($\mathbf{M_{PS}}$) for this problem was to influence, if necessary, to which subgroups the American students are allocated, and the initial tasks which these students will be assigned. The ambition with the influence is to create a situation where the work done by American students are more interdependent and thus becomes more critical to the progress of the project.

**Relation to the OEGP Concept**

Placing all students in one project fits well with the OEGP concept in that a learning environment with many opportunities for interaction is created and where a student, potentially, is exposed to a wide variety of competencies and interaction partners. The likelihood is that there will be learning situations well suited for the student's zone of proximal development (ZPD) [Vygotsky 1978] and the students' current view of concepts, which can then develop in a conceptual change process.

Adding ZPD to the **F** element and looking at the research question (**A**) of how having all students in the same project affects learning in ITiS form an interesting starting point for another action research cycle.

### 6.3.2 Introducing an Expert on Cultural Awareness

Over the years we have noticed difficulties in the collaboration between the two cohorts due to cultural differences, and we have tried to make them aware of this without much apparent success. That is, the problem element (**P**) is that cultural differences make communication problematic. We assumed that the level of trust might have been a factor in this and the problem solving method ($\mathbf{M_{PS}}$) was to introduce a session with an expert on cultural awareness. Trust is also a key factor in such a collaboration [Jarvenpaa et al. 1998, Panteli and Duncan 2004, Coppola et al. 2004] and the trust concept is a framework element (**F**) in this case. The researcher interest (**A**) is how trust in an international OEGP can be built and to evaluate if the intervention ($\mathbf{M_{PS}}$) with the expert on cultural awareness helped the students in building trust between the cohorts. Course evaluations, reflections, and observed behavior all indicate that this intervention is both popular and functions well [Laxer et al. 2009], as is reflected in this quote from a participating student:

> *The lecture gave me some insight in the cultural differences between Sweden and America. For example, I've never realized that being quiet could be thought of as being stupid.*

The first year this session was only held for the Swedish cohort, but based upon feedback, such as the above quote, it was judged important by the educators that both cohorts heard it. The session has since then been integrated in the program for the first week when the American cohort visit Sweden.

**Relation to the OEGP Concept**

Introducing a culture awareness expert is an intervention that facilitates the communication between the American and the Swedish cohorts and is thus an important form of scaffolding as seen from the OEGP standpoint. Helping the students to better understand each other, actually also within a cohort, increases the exchange of ideas and provides more opportunities for learning.

### 6.3.3 Using Constructive Controversy

Using constructive controversy is an interesting intervention in that it came from a theoretical perspective. This can be seen as starting from the research interest cycle of the dual action research cycle described by McKay and Marshall [McKay and Marshall 2001] and in this case the concept is part of the framework (**F**). I read about the constructive controversy concept and thought instinctively that it could be useful in the IT in Society course unit (ITiS). The issue (**P**) I had in mind is true collaboration, in the sense that I wanted the students to really collaborate and build on each other's progress and not just divide the work between themselves. From the research interest point of view the problem (**A**) could be phrased as "How could the constructive controversy concept promote true collaboration in ITiS?".

Being able to truly collaborate is a professional competence that we have promoted over the years in an "optimistic" fashion, i.e. more or less hoping that a vision of thus creating a solution of higher quality would be driving the students towards such a form of collaboration. This is in many ways similar to the situation addressed by the intervention to include a seminar session with a cultural awareness expert, in that us telling the students about benefits with a behavior is not enough to drive a substantial change in the student cohort.

A speed-dating technique is the approach, the problem solving method ($\mathbf{M_{PS}}$), developed, based on the constructive controversy concept, to scaffold the students towards true collaboration. I will look into the last three course unit instances and describe the reasoning in each action research cycle.

## Theoretical Background

*Constructive Controversy*

Johnson and Johnson (2007) define constructive controversy as follows:

> ***Constructive controversy*** *exists when one person's ideas, information, conclusions, theories, and opinions are incompatible with those of another and the two seek to reach an agreement.* (p. 38)

According to the constructive controversy concept, the important aspect of a learning situation is the focus on seeing different aspects of an issue and an ambition to find a solution to the issue from this wider view [Johnson and Johnson 2009, Smith et al. 1981]. The key aspect for the concerned educator is the seeking of agreement.

The constructive controversy concept is typically compared with *concurrence seeking* regarding the conflict or controversy side and with *debate* relating to the issue of bringing up alternative views. The drawback with concurrence seeking is the danger of not considering alternative solutions and becoming too focused on the positive aspects of the solution selected. An analogy is to see all "problems" as nails when one has a hammer as a tool. On the other hand, debate does address the issue of not giving enough space to alternative solutions, but the problem is that there is no incentive to look into the virtues of alternative solutions. The whole point is to prove one's own solution to be superior to all others.

The benefit of constructive controversy is that alternative solutions will be presented and adequately considered and efforts will be made to find ways to reconcile the differences in finding a satisfying solution considering the different aspects that have been brought forward in the process. The idea is that the participants need to have a thorough understanding of the different aspects, including questioning their own solution, in order to be constructive in their seeking of agreement. There is an emphasis on creating new solutions as opposed to sticking to original ones.

Johnson and Johnson's discussion of learning environments based on constructive controversy use the following six stages (2009):

1. Students are assigned problem/decision, initial conclusion.
2. Students present and listen, are confronted with opposing position.
3. Students experience uncertainty, cognitive conflict, disequilibrium.
4. Cooperative controversy.
5. Epistemic curiosity, information search.
6. Incorporation of new information, adaption to diverse perspectives, new conclusion.

*True Collaboration*

In the cognitive psychology domain, collaboration is distinguished from cooperation [King 2007, Dillenbourg et al. 1996]. This is captured by King (2007) as follows:

> *Generally the term collaborative learning means that learners are engaged in activities that are intended to introduce socio-cognitive processes. This meaning implies an important distinction between collaborative and cooperative learning. Cooperative learning often involves separate activities by individuals through the distribution of labor or task components, with little of the joint activity that induces socio-cognitive processes so characteristic of true collaborative learning*. (p. 18)

This description of collaborative learning fits well with my view on true collaboration.

*Speed-Dating*

Speed-dating has developed from being a way for young people to meet their future spouse to becoming a general technique for effective meetings. The key features of this approach are that each one (group) meets everybody else (all other groups), that there is a time limit on each meeting, and that there is a format for the discussions at the meetings.

**The 2008 Action Research Cycle**

The speed-dating concept was introduced in the 2008 version of the course unit as a student initiative. The students, faced with a major restructuring of their white paper, needed a way to get the whole cohort up to speed with the new direction as well as identifying concrete examples of what to enter into the new structure. An afternoon was set aside in which each of the seven subgroups met with all the other subgroups and tried to identify common issues [Cajander et al. 2009a].

This turned out to be a well-functioning way to get a large portion of the students aware of the entire project and how their own work fitted, as well as providing useful insights into who could address an issue that subsequently surfaced in the work to create the white paper. My co-educators and I were of the opinion that the resulting collaboration was of a depth and genuineness that had a much stronger sense of true collaboration than in earlier instances of the course unit. This is of course not solely due to the speed-dating exercise, but the contribution was deemed to be highly important.

The speed-dating event was deemed to be a good starting point for a more structured version of a constructive controversy intervention as a means to create true collaboration in the 2009 course instance.

**The 2009 Action Research Cycle**

The speed-dating event in the 2009 instance was set about ¾ of the way into the project and was planned according to constructive controversy ideas. The students assigned to be project coordinators were provided with a "package" consisting of pre and post meeting assignments as well as a description of how the meetings should be conducted. The plan followed the six stage frame given by Johnson and Johnson (2009) as described below.

*Stage 1- Students are assigned problem/decision, initial conclusion*

This stage can be seen as being composed of two parts in our setting. The first part was the work they did in their respective subgroup. They spent most of their time prior to the speed-dating event in becoming "experts" in the domain of their subgroup. The second part was the actual assignment for the speed-dating event. Each subgroup was to identify something they wanted from each of the other subgroups that would be beneficial for them.

Each subgroup had a prior understanding of what the other subgroups were supposed to do and actually had done, mainly from the initial discussions about the essential aspects of the project and a mid-term presentation for the client. The subgroups did however not have much enthusiasm for identifying what they wanted the other subgroups to contribute. Several commented that it was unnecessary work that interfered with the work they were doing already and that they had a hard time coming up with valuable things the other subgroups could do to be of direct use to them.

*Stage 2 – Students present and listen, are confronted with opposing position*

This was the most active phase of the speed-dating "package", where each subgroup had a short meeting with all the other subgroups. The students were not supposed to be confronted with an opposing position as such, but rather confronted with a number of demands on their time and expertise, as well as confronting the other subgroups with demands based on their understanding of what the subgroups were supposed to do.

The level of confrontation varied for the subgroups, but each did experience other views on what they should do and got into a situation where they had several good ideas to choose among. The conflict was however reduced for most subgroups due to the suggestions considered as valuable being, according to several students, along lines they had already considered doing themselves.

*Stage 3 – Students experience uncertainty, cognitive conflict, disequilibrium*

This stage was supposed to be reached due to each subgroup being exposed to different views on their work and how it best could contribute to the project. The idea was that each subgroup should be faced with several potentially good alternatives, which would create uncertainty about which to

choose. The explicit demand to only oblige one of the other subgroups was supposed to increase uncertainty.

The students played along with these rules in the speed-dating event, but there was an underlying "understanding" that a subgroup would not do anything unless they did find it essential for the progress of their work. The uncertainty was thus not as prominent as intended, but there was a different type of uncertainty present. This uncertainty came from the subgroups finding unexpected views about what they were doing.

*Stage 4 – Cooperative controversy*

In our example, this stage somewhat overlapped stage 2, since the controversy about how to cooperate had been raised in that stage. There were still issues to deal with regarding how to conduct the cooperation. A slightly different controversy in this stage was to get into a situation where different options on cooperation were present and they could not all be followed. It was also not clear how the chosen cooperation should be carried out.

This stage was however not as strongly stressed since the cooperation was mostly done in a serial mode as a suggestion from one subgroup followed by action by another subgroup. It appears that most students did not see it as cooperation at all.

*Stage 5 – Epistemic curiosity, information search*

The discussions were supposed to bring many different aspects of what could be done in the project to the surface. The idea was that these aspects would spark a curiosity about what could really make the project better and thus provide incitement to dig for more information.

This occurred, but most students felt at this time pressed to deliver what they already saw as the contribution of their subgroup to the project as such. There were some reports on new insights and a genuine new understanding of what a wider perspective on their work could lead to in terms of improving the project. These were however considered more as good ideas to note rather than something to act on due to not enough incentive to change what they were doing.

*Stage 6 – Incorporation of new information, adaption to diverse perspectives, new conclusion*

This stage consisted of coming up with an agreement with one other subgroup on how to proceed with the suggestion that subgroup had made. The agreement was supposed to be based on a mutual understanding of the value of the time spent with regard to the project as such. This stage was intended to also include carrying out what was agreed on.

This resulted in some creative ideas and discussions about what was essential for the progress of the project. The general aura was however of it being an academic exercise that they could put on hold while doing the

things they previously considered important to do. Contributing to this was the low buy-in from the project coordinators in the value of the speed-dating "package". The project coordinators arranged the activity and participated as listeners in meetings, but they reported that they did not have their heart in the activity, since they felt it was forced on them by the course unit educators.

As can be seen from the analysis above, the speed-dating functioned well in making the students aware of what the other students really did. In the final reflection almost all students expressed that the speed-dating was the occasion when they really understood what the other project subgroups worked with. This was an important aspect of the speed-dating event, since there was a clear lack of communication between the groups before the speed-dating. The subgroups were content with working on their own problems without really knowing how this fitted into the context of the other subgroups.

The speed-dating did however not lead to true collaboration. This is perhaps most visible when looking at the culture and international aspects, economy, and ethics subgroups. These subgroups represented aspects of the project that were seen as peripheral to the result. Statements with the implication that the system architecture and usability subgroups were the important parts of the project were not uncommon, and not least in the other three subgroups.

This could be explained by using the reflective practitioner concept [Schön 1983], where the students lacked confidence in relying on reflection as a basis for what to work on. It appeared as they did not trust in the value, or rather their ability to contribute anything of value, to the project in a situation where the problem they addressed mostly looked like a swamp in contrast to the safe ground they were used to when working with issues closer to, what they saw as, IT-work where rigorous methods could be used.

Most students pointed out that the timing of the speed-dating event was problematic. They were too focused on finishing the report in the way they already had agreed on at the time of the event. Some suggested that there should have been an event early in the project followed by another one towards the end of the project.

The American students were only part of the preparation and the wrapping up stages. As a consequence, the whole event was not very relevant for them.

The perhaps most interesting insight came from comparing the two course unit instances. The actual speed-dating event was more thought through in the 2009 instance and included ideas from the constructive controversy model, but the 2008 instance was, as seen by the educators, more successful in reaching the true collaboration goal. The conclusion was that the difference was not due to the speed-dating event as such being less efficient in the 2009 instance, but rather in that the 2008 instance had a contributing con-

structive controversy factor. The 2008 students were faced with the dilemma of what to do with their report, i.e. continue with the direction they already had taken or making a major restructuring. They had a real incentive to truly work together in order to reach their goal, in that the restructuring required them to integrate knowledge from the different subgroups in writing the text.

One ironic observation is that the ambitious leadership provided by the project coordinators probably contributed significantly to the lack of true collaboration. They "paved the way" in such a way that conflicts rarely occurred, and thus also reduced the need for the other students to interact in order to make the project progress. Almost all students reported that they were highly satisfied with the way the project coordinators lead the project. A rare few did however comment on the strong leadership resulting in a lack of collaboration between the groups.

Almost all students realized in the meeting about the final reflection that it would have added an interesting depth to the result if a closer collaboration between the subgroups had occurred. This was partly due to recognizing that the client had many questions relating to the cultural and ethical aspects of the project and partly due to the educators pointing out that important aspects brought up by the economy subgroup had not really influenced the prototype solution they had developed.

**The 2010 Action Research Cycle**

The speed-dating event in the 2010 instance was introduced earlier and required the American cohort to be present at the event. The added agenda for the speed-dating event was to support improved communication between the two cohorts. The action plan also included giving more responsibility to the students in how to actually carry out the event, as a response to the lesser motivation for the event in the 2009 instance as compared to the 2008 instance.

Requiring that the event include the American cohort lead to a loss of enthusiasm in the event. The use of Skype made overseas participation possible, but also introduced awkwardness due to it being difficult to really participate. The difficulty partly stemmed from confusion about what the purpose of the event was. That the students saw themselves as having ownership of the project was clear when they arranged another speed-dating event the week after and then with clearer instructions about what should be done.

Handing over control to the students resulted in an event that had less of the characteristic of constructive controversy concept. There was not much of a controversy in the event other than some differences in opinions about how to proceed with compiling the report structure, which was the issue to be constructive about.

**Relation to the OEGP Concept**

True collaboration is a natural consequence of a well functioning OEGP and it is closely related to engaging the students, to motivate them. There are however obstacles in the way, not least the inexperience among the students with the OEGP concept. The speed-dating implementation of the constructive controversy concept shows promise as a way to support the students in achieving the true collaboration professional competence.

### 6.3.4 Using Reflections

The problem situation (**P**) addressed in this section is that we as educators in the IT in Society course unit (ITiS) often reacted to students seldom seeing their own part in problematic issues, and especially in cases where they viewed the international collaboration as a burden. We wanted them to see that slow progress often also depended on themselves and especially that they should consider what more they themselves could do. That is, we wanted them to reflect on situations in the project and their own role in it, in order to become more aware of how they could contribute. Reflections were identified as an approach to address this lack of awareness, i.e. being the problem solving method ($\mathbf{M_{PS}}$) selected and also, as a concept, part of the framework (**F**). Fincher, Petre, and Clarke (2001) place special emphasis upon the value of reflection in computer science project work:

> *Reflection on experience underpins the process of successful learning and is essential to the success of education.* (p. 226)

Furthermore, not only is reflection on experience educationally valuable, but engaging in reflective practice engenders a mindset that is invaluable for effective professional performance. The value of reflecting is for instance well documented in the reflective practitioner model drawn from the work of Schön (1987) in which professional work is seen as an ongoing process of reflective practice involving self monitoring, continual improvement and action cycles (plan, act, observe, reflect).

> *The term 'reflective practitioner' admits a variety of strengths and an openness in terms of beliefs about teaching methodologies. The teacher, as reflective practitioner, is committed to evaluating and re-evaluating performance both individually and collegially in order to sustain the never-ending drive to performance improvement. The more we learn the more there is to learn.* [Hinchcliff, 1997]

The reflective work assessed in ITiS is aimed at developing such professional competencies.

**Theoretical Background**

The connection between the development of professional competencies and the capacity to reflect on experience is found in work on positive learning dispositions, e.g. Claxton's 'four Rs': resilience, resourcefulness, reflectiveness and reciprocity [Claxton 2002]. This is a useful classification for the development of 'leaning how to learn' and the extension to the lifelong learning competence. The disposition of reflectiveness naturally finds counterparts in a network of concepts such as metacognition, self-regulation, self-direction, and self-efficacy [Higgins 2009].

Further links between the development of professional competencies and reflection is found in the work of Nicol and his co-workers (2006, 2009) on formative assessment and feedback. Nicol situates his work in the context of the enhancement of self-regulated learning, defined as:

> *An active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features of the environment.* [Pintrich and Zucho 2002]

This approach was incorporated into the REAP project [REAP 2007] and has been influential in motivating curriculum change in Scottish Higher Education.

*Media for Reflection*

Some form of learning journal (whether paper-based, electronic, or simply a set of discrete reflections on learning) is a prime candidate for a vehicle to facilitate the development of self-assessment and reflection [Moon 2006].

While the use of paper-based journals or lab-books may well be more familiar to engineering disciplines, the social features of a blog provide an important additional element that serves to encourage dialogue between educators and students about the learning process. In particular, the commenting facility plays an important pedagogical role in promoting the development of social and academic support networks and student self-regulation. From these a number of pedagogical benefits were observed, such as:

- Timely feedback allows students to discern the strengths and weaknesses of their performance. It provides an opportunity to make decisions about how they may subsequently modify their own work and so increase learning autonomy.
- The action of supplying commentary on work done by peers provides students with the opportunity to develop the capacity to make objective judgements with reference to externally-set marking criteria.
- This ongoing student-educator and student-student dialogue also serves to clarify the subtler (and often unstated) characteristics of

what counts as "good performance" in the context of a particular assignment.

- Individual students can monitor the relationship between their own understanding of high performance and that of their educator and also their peers. This is a significant factor in the development by students of appropriate mental models of the learning process.
- On a practical side, advice and academic support from peers may be articulated at a more appropriate level and be perceived as less of a threat to student self-esteem.
- The alternative perspective that such peer feedback may present can serve to motivate perseverance on tasks and provide a degree of mutual support and validation for efforts made.
- The repetitive nature of tasks like blogging also increases time-on-task and allows students to iterate the feedback cycle in a natural way.

This link between successful reflective practice and increased learning autonomy suggests that the narrative structure of blogs may be used profitably to encourage an atmosphere of developmental improvement. Students come to realise that the relationship between their current state of knowledge and the established subject matter does indeed evolve. This understanding that the acquisition of expertise does not happen instantaneously and that their conceptual model of a topic will change, evolve and deepen over time is an important characteristic of mature learners.

Finally, blogs give a useful two-way feedback mechanism that allows students themselves to offer commentary on the provision and suitability of educational activities. They can therefore be used to provide high quality information to educators about the nature of the student experience. Such information may go well beyond academic concerns and offer insights into the social, economic and intellectual milieu of the student which may, for example, affect the way in which the course is delivered or simply increase the educator's appreciation of the (variety of) student experiences.

*Reflection Terminology*

There is a lack of clarity, or precision, in the terminology used. Concepts such as reflection, reflective thinking, and critical thinking are defined in different ways by different authors and it is not always apparent how these overlap, or their relationship to other ideas relating to student empowerment (such as self-regulation and self-direction).

This lack of precision in the terminology also manifests itself in the wide variety of theoretical frameworks that underpin schemes to identify and assess reflective work, e.g. Boud et al. (1985), Mezirow (1991), Hatton and Smith (1995), Wong et al. (1995), Scanlon and Chernomas (1997), Kember et al. (1999), Moon (2000), and Kember et al. (2008).

*Categorization of Reflections*

Hatton and Smith (1995) have developed a framework for categorisation of reflective writing. This categorization consists of four levels of increasing sophistication of reflective activity, see Table 6.1.

| **Level of Reflection** | **Indicator** |
|---|---|
| Descriptive Writing | The student simply describes experience without significant attempts at analysis. Although essentially non-reflective, it can nevertheless serve as a foundation for later, more complex activity. |
| Descriptive Reflection | The student attempts to provide reasons for their learning experiences based upon quasi-reflective personal judgements. |
| Dialogic Reflection | The student enters into a personal discourse to explore possible reasons for observed outcomes. |
| Critical Reflection | In this context, critical reflection was taken to be demonstrated by the elaboration of reasons for personal learning decisions and experiences, which takes into account a mature understanding of the psychological and pedagogical factors affecting the learning process. |

Table 6.1: Hatton and Smith Framework for Reflective Writing (1995)

**Implementation in ITiS**

Reflection is an intervention that was first introduced as a written and oral individual final report at the end of the course unit. These reports offered students an opportunity to reflect upon and demonstrate what they had learnt about professional competencies, e.g. the results they had achieved, the problems they had successfully overcome, what they had gained personally and professionally from the experience, and where they still had to develop. This report and the follow-up individual meeting was not merely descriptive of the project, but included a broader critical dimension as befits a final year degree course. Many gave insightful descriptions on their performance and learning, such as this comment:

> *I think I took many opportunities to get to learn new things and also to practice what I already know.*

The final reflection followed up with an individual meeting has been used continuously since one of the first course unit instances. Apart from providing the students with a chance to describe and reflect on what they did, it also gave them an opportunity to discuss how things could have been done differently. The latter being an important part for the educators in terms of feeling reassured about the students' learning, since choices and approaches

that were detrimental to the project could be made into learning opportunities in the discussions. In the 2009 instance there were three students serving as full time project coordinators for the 29 students in the project, and they worked so efficiently that it reduced the need for the subgroups to interact and opportunities for true collaboration between the subgroups were thus lost. Reflecting on this, unexpected, outcome provided valuable insights into collaboration and teamwork

The observed educational value of the final reflections led to an action plan that introduced weekly individual reflections throughout the course unit. The implementation in the 2007 instance resulted in too slow feedback on the reflections from the educators due to the sheer volume of reflections. It was also observed that it was problematic to post issues to reflect on that were relevant for all students. The action plan for the 2008 instance had a reduction of the number of reflections as well as using peer feedback in some instances and also using both individual and group reflections. These changes had a positive effect on the quality of the reflections as reported by the educators. The value of the reflections is reported as moderately high, (3.5 out of 5) in the course evaluations.

Students have moreover participated in a conscious process of joint reflection upon their learning in a conference presentation [Cajander et al. 2009a]. In an associated publication [Cajander et al. 2009b] their reflections were further enabled through a joint field trial of a research framework developed by Clear (2008).

**Relation to the OEGP Concept**

Reflections are central in the OEGP concept in that they provide opportunities for the students to better understand their own learning process. Reflections also provide information about a student's current understanding of a concept to the educator, who based on this can adapt the learning environment, e.g. by providing a suitable lecture or ask questions aimed at provoking a conceptual change.

# 7 Discussion

I have presented work that spans a time period of more than a decade and discussing results, impact, and future work becomes intertwined in that some results have already had an impact resulting in new results. The theoretical and empirical research components of this thesis form part of a broader endeavor in Scholarship of Teaching and Learning (SoTL) [Ashwin and Trigwell 2004]. Using their matrix, table 7.1, over pedagogic investigations, where they define three levels an educator is aiming at and three aspects of investigation, provides a starting point from which to discuss the implications and relevance of my research. Ashwin and Trigwell identify conceptions of the meaning of SoTL ranging from a personal goal with a course unit, to the local community of educators at an institution, to the global community of educators. The aspects are 1) what is the purpose of the investigation, 2) how will evidence gathering methods and conclusions be verified, and 3) which is the audience for the knowledge resulting from the investigation.

| Level | Purpose of investigation | Evidence gathering processes will be | Investigation results in |
|---|---|---|---|
| **1** | To inform oneself | Verified by self | Personal knowledge |
| **2** | To inform a group within a shared context | Verified by those within the same context | Local knowledge |
| **3** | To inform a wider audience | Verified by those outside of that context | Public knowledge |

Table 7.1: SoTL: Levels of pedagogical investigation

I started my journey at the first of the three levels of pedagogic investigation identified in SoTL. At this level, the purpose of investigations were to inform myself, the evidence gathering methods and conclusions were intended to convince myself, and the outcome of the investigations was enhanced personal knowledge.

At the later stages of my journey my research addresses level three, where the purpose of investigations were to inform myself, my local colleagues,

and the computing and engineering education community in general. The evidence gathering methods and conclusions were intended to convince the same people. Finally, the results from the investigations were to gain personal knowledge and to generate both local and public knowledge.

## 7.1 Addressing the Research Foci

I set out with two general research foci:

> *How can research-based computing and engineering educational development be conducted?*

and

> *How can professional competencies be developed and assessed in an international open-ended group project?*

and have in this thesis addressed them in the light of my journey from trying to find out where to start in a wish to be more scientific regarding decisions about learning environments to being a senior member of a productive internationally recognized research group in computing and engineering education.

The first focus is captured in two ways, the first being the description of the general research framework for educational research and development and in the presentation of the form of action research I have conducted inspired by the framework. The second way is more indirect in that it is implicit in how the development over the years has been conducted. This is best illustrated in the use of constructive controversy and reflections in the IT in Society course unit (ITiS).

The way the constructive controversy concept and corresponding methods from the educational research area led to a pedagogical intervention in ITiS is an example of how the research framework inspired action research cycles where research and development are combined. Using reflections is a similar example where both motivational and assessment issues are addressed using the same approach. That is, the reflection method is chosen to address the research question of how to raise motivation for actions and also to solve the issue of how to assess for instance the level of cultural competency. The importance of raising motivation to be active is based on the constructivist epistemology where learning is achieved through interaction with the social environment.

Results regarding the second focus are more extensive for the development aspect compared with the assessment aspect, partly due to assessment being influenced by how competencies are supposed to be improved (devel-

oped) in a learning environment. The open-ended group project (OEGP) concept that I was instrumental in coining served as a base for this focus. The framework and the action research approach have anchored the development and the assessment in a theoretical foundation, which have been essential both for gaining understanding of the OEGP concept in general and about specific ways to use the concept in creating learning environments.

The international aspect, e.g. development of cultural and international competencies, is in some cases explicitly covered. An example of this is in the use of an expert on cultural awareness, but the international aspect is mostly addressed in an indirect manner through the competencies central for the ability to function in global collaborations as for instance general communication skills, distributed teamworking skills, and being open minded to solutions in a creative and innovative way. There is a clear and increasing demand for these competencies and there is still much to learn with regard to setting up learning environments promoting them and how to assess how the students have acquired those competencies.

My view is that it has been beneficial to the results in the action research approach to development and research that the researchers also were the educators.

## 7.2 Reflections on Results

Results come in different shapes and forms and I will reflect on the ones I have presented in this thesis. I will first discuss the open-ended group projects (OEGP) concept, followed by how OEGP is manifested in the different instances of the IT in Society course unit (ITiS). A different type of result is the framework for subject-specific education research, such as the concretization of using action research in developing ITiS.

A first step in reflecting on research results can be to categorize the research, and one candidate for categories is the set suggested by Ashwin and Trigwell (2004):

- Pedagogic research into how to teach, e.g. how to set up a learning environment.
- Subject matter research into what to teach.
- Inquiry-based research into how students learn.

This categorization is interesting in that it identifies some areas where research relevant to education can be conducted and my results fall in all three of these categories. The research into the issue of what professional competencies are is in the subject matter research category, using the speed-dating technique is in the pedagogic research area when addressing the issue of how to set it up, but is in the inquiry-based category when investigating the learning outcome and how the learning took place.

The results are however mostly integrated and used together in an action research cycle. This holistic perspective offered by the action research approach is an interesting aspect of using this research methodology in educational research.

The OEGP concept provides a setting that can be used both by individual educators in creating learning environments and for degree program coordinators to plan for inclusion of professional competencies. The promotion of the OEGP concept in the computing and engineering education community is an important contribution of my work.

Using the OEGP concept and undertaking pedagogical interventions based on different theories, e.g. constructive controversy, adds by the theoretical base to the validity of the work. Most of the implementation work presented in this thesis has been in ITiS. ITiS is a rather non-traditional course unit and it has some professional competencies as learning goals. Managing ITiS has thus been a challenge and succeeding in developing it into a course unit that students appreciate and learn from is an achievement. There are thus results relevant at the second level in the SoTL matrix from my work.

The general research framework is a somewhat intangible result in that it mostly is represented as tacit knowledge [Polanyi 1967] in our research group (UpCERG). I have however in this thesis captured some of the tacit knowledge and hopefully inspired others to use the framework in conducting educational studies. The framework provides useful guidance for educational research, which has been used in the interventions in ITiS. This is manifested in the use of the action research methodology, and apart from the actual interventions a clear result is the documentation of how action research is used. Another result is the increased insight into the theories used as base for the interventions. One concrete result of developing and using the research framework is my transition from the first to the third level of pedagogical investigations.

## 7.3 Impact of Research

The impact can be evaluated in different ways and according to various strategies, where one view could be to base the impact as related to the two research foci presented in this thesis. That is, one being on the field of conducting computing and engineering education as such and one being more on development of learning environments and understanding their characteristics in terms of impact on educators and learners. The impact can also be seen as from different perspectives, one drawing on the work by Ashwin and Trigwell (2004) is to look at the impact on me, on the local community at the institution, and then on the computing and engineering education community globally. I will combine these views in this summary.

One local impact related to learning environments is the effect on the IT in Society course unit (ITiS). This is reported on in this thesis and also in a few of my publications. Denoting this as "local" is in my opinion slightly misleading, since it influenced, and still does, most of the IT engineering students graduating from Uppsala University through this course unit and over the last seven years also students at Rose-Hulman Institute of Technology in Indiana, USA.

It is the firm opinion among the educators involved in the course that educational research has improved the ITiS learning environment. This is based on participatory observations from being closely involved in the project process, improved grades in course evaluation, perceived improved quality in final reflections, and a satisfied external customer.

The impact on a global scale can be looked at from the perspective of development of professional skills and how to assess them. Especially if seen as setting a foundation for future discussions and decisions about professional competencies in degree programs.

Research and development projects are in themselves an impact. Two of my grants are particularly noteworthy, the Runestone project 1997 – 2000 and the national center for engineering education CeTUSS[8] 2004. The Runestone project was in many ways a starting point for conducting computing and engineering education research. That it had an impact on educational research is illustrated by the fact that three people earned their Ph.D. degrees based on activities in Runestone. Another impact is that the educational invention in Runestone is still being used in our education and that it is adopted also by other institutions in China, Finland and USA.

A different impact is inspiring colleagues to be more scholarly in their education role, especially in terms of illuminating the potential for development based on theories for learning. This is a central activity in CeTUSS and the importance of reaching both grassroots, such as individual educators, and education leaders, such as degree program coordinators, were pointed out in the external evaluation of the center [Thång and Wisdom 2008].

## 7.4 Future Work

There are many challenges in computing and engineering education and one of them is how to include topics like sustainability and globalization in a constructive manner. The open-ended group project (OEGP) concept is a candidate for setting up a learning environment that will promote students to develop competencies in these, and other complex, areas. Collaboration with experts and educators in creating such learning environments building on the results in this thesis is an important future effort.A

[8] www.cetuss.se

nother future area to work in is to take a more holistic view of degree programs and induce a progression in the students' ability to deal with ill-structured problems. This is to move the OEGP concept closer to the ambitions of problem based learning (PBL) to create a more overarching educational strategy for a degree program.

The action research methodology introduced in the thesis can be used in setting up other studies, both in the IT in Society course unit (ITiS) and in other settings. These studies can include investigating how students spend their time in the course unit and investigating which student behaviors cause other students to lose motivation. The latter is an observed problem that will be dealt with in future instances.

The development of professional competencies is important in degree programs, as is seen by the fact that these competencies typically stand for a major part of the list of learning outcomes for a degree program. There is still much to learn about what they are and how to encourage their development. Conducting a study on which competencies our alumni felt they had and which they wish they had during their first years of employment would be important input in this context.

Defining and assessing professional competencies might not be a pipedream, but it certainly is an underdeveloped area in computing and engineering education. Further work should be carried out towards routines and guidelines for this assessment.

# 8 Conclusions

What are the conclusions of this thesis? Is "Developing and assessing professional competencies: a Pipe Dream?" With my theoretical perspective based on constructivism I would answer:

*It depends, there is no black-and-white answer to such a question.*

If I, on the other hand, answer from a positivistic theoretical perspective I dissect the question, providing clear definitions to the pieces. In this case:

*Given that we define developing, assessing, professional competencies, and pipe dream in the following way . . ., we can conclude that it is not a pipe dream, it can be done using the following methods . . .*

This thesis draws on a constructivist epistemology and the first answer is thus more relevant here. Reading this thesis in order to reach the conclusion "it depends" may be frustrating for a reader with a positivistic theoretical perspective. Such a reader might be tempted to use the trash can on the cover for this thesis, not, as it is intended to symbolize, for the traditional measurement instruments that I find inadequate for assessing professional competencies. However, all is not lost, irrespective of theoretical stance, the results have a pragmatic impact on the development and assessment of professional competencies.

Relating to the second half of the title, "Experiences from an Open-Ended Group Project Learning Environment", there is a clearer answer.

*Yes, it is possible, it is not a pipe dream.*

This answer builds on my research surrounding the IT in Society course unit (ITiS) and development of new approaches to assessment. My expertise as an educator, (in making an assessment) provided ample opportunity to observe, and interact with, the students to assess these competencies in an OEGP-based learning environment.

I have discussed aspects of the research framework and the OEGP concept in Chapter Seven, but I want to add some general thoughts. The reason being that I think it might be easy to miss the adaptability aspect of them. That is, I see both the research framework and the OEGP concept as constructs that grow with the users of them. They are such that they can support a scholarly educator in her/his zone of proximal development (ZPD).

OEGP can be used in a wide variety of settings in a course unit, from a basic variant with small groups to quite complex learning environments aimed at catering for individual needs in cohorts with students coming from different educational backgrounds. The OEGP concept can also be used by curriculum designers to capture learning objectives in course unit specifications, especially in order to form a basis for progression in competencies among the students in a degree program.

The *sense morale* of this thesis is perhaps that following one's convictions even if it takes time, can be very rewarding and that having a research foundation for development, especially with a holistic perspective, provides a means to boost self-confidence and thus aid approaching complex and nontraditional learning environments. Finally, on the theme of time I would like to conclude with one of Piet Heins grooks (2002, p. 5):

**T.T.T.**

Put up in a place
where it's easy to see
the cryptic admonishment
T.T.T.

When you feel how depressingly
slow you climb,
it's well to remember that
Things Take Time.

This might seem especially appropriate considering that I defend my thesis thirty years to the day after my enrollment as Ph.D. student.

# Svensk Sammanfattning[9]

## Utveckling och bedömning av professionella kompetenser: en fantasi?

### Erfarenheter från en undervisningsmiljö baserad på öppna gruppprojekt

Lärande är ett fascinerande område med många relevanta frågor. Hur går lärande till? Vad kan man göra för att underlätta lärande? Vad är önskvärt att lära? För vem är det önskvärt? Hur kan man bedöma vad någon annan har lärt sig? Hur kan man stödja andras lärande? Det är bara några av de frågor som är viktiga att ställa sig som person, lärare, utbildningssamordnare och utbildningsinstitution. Dessa, och andra liknande, frågor är min motivation till arbetet redovisat i denna avhandling.

Dessa frågor har typiskt inga tydliga och slutgiltiga svar. Värdet i att försöka besvara dem ligger till stor del i att förstå olika aspekter på frågorna och svaren, som t.ex. vilka konsekvenser olika svar har. Det ger en grund för att få ett helhetsperspektiv på aktiviteter, vilket är av stor betydelse i så komplexa frågor som att skapa inlärningsmiljöer.

Det finns två områden i avhandlingen, det ena handlar om hur förståelse för utbildningsmiljöer i områdena datavetenskap och ingenjörsutbildningar kan byggas på ett vetenskapligt sätt och det andra handlar om utveckling av kurser med syftet att utveckla studenternas professionella kompetenser och detta illustrerat via kursen IT i samhället (ITiS).

Ett ramverk för ämnesdidaktisk forskning har byggts upp under åren tillsammans med forskningsgruppen *Uppsala Computing Education Research Group* (UpCERG). Det ger stöd för hantering av såväl små och avgränsade som stora och komplexa utbildningsfrågor. Ramverket syftar till att stödja forskaren/läraren att lyfta från egenutveckling utan inverkan på andra till att bedriva studier som har betydelse för den egna verksamheten, för andra i både närmiljön och på ett globalt plan.

Den specifika kursutvecklingen rör kursen *IT i samhället* (ITiS), som ingår i civilingenjörsprogrammet i informationsteknologi och ges på halvfart under höstterminen i årskurs fyra. Det är en projektbaserad kurs där förändringar som; 1) alla studenter ingår i samma projekt, 2) samarbete med en

[9] Summary in Swedish

expert på kulturellt medvetande, 3) kursmoment baserade på teorier kring konstruktiv kontrovers, och 4) användning av olika former av reflektionsskapande moment, beskrivs och analyseras i denna avhandling.

Gemensam nämnare för de två områdena är begreppet öppna gruppprojekt (*Open-Ended Group Project*, OEGP). Det används för att skapa undervisningsmiljön i ITiS på ett sätt så att studenterna förbättrar sin professionella kompetens inom internationellt samarbete kring komplexa problemställningar där användning av IT är central. Det handlar om att förbereda studenterna för deras framtida yrkesroll på ett sätt som industrin eftersöker, bl.a. att kunna hantera öppna problem.

En annan övergripande aspekt är aktionsforskningsansatsen. Reflekterande över användningen är en del av skapandet av forskningsmiljön kring ämnesdidaktik inom datavetenskap och ingenjörsarbete. Själva användningen i olika studier för att stödja utveckling och analys av olika aspekter på ITiS är en del av den forskningsbaserade kursutvecklingen.

Avhandlingen baseras på fem artiklar. Den första är en tidskriftsartikel publicerad i Journal of Computer Science Education 1999: *Reflections on International Projects in the Undergraduate CS Education*. Den är med för att ge en tidig, i sammanhanget arbetet redovisat i denna avhandling, bild av hur tankarna gick för att skapa utbildningsmiljöer som skulle stödja utveckling av professionella kompetenser.

Den andra artikeln är ett kapitel i en bok om breddad IT utbildning utgiven 2006: *Open Ended Group Projects (OEGP): A Way of Including Diversity in the IT Curriculum*. Den är med för att presentera ursprungsidéerna kring OEGP begreppet och hur det kan användas i utbildningssammanhang.

Den tredje artikeln är presenterad på ASEE/IEEE Frontiers in Education konferensen 2010: *Experiences from using Constructive Controversy in an Open Ended Group Project*. Den är med för att ge ett exempel på hur idéer från en lärandeteori kan användas för att ge stöd till studenter i en OEGP-baserad inlärningsmiljö. en pedagogisk intervention

Den fjärde är en tidskriftsartikel publicerad i International Journal of Engineering Education 2010: *Engineering Education Research in Practice: Evolving Use of Open Ended Group Projects as a Pedagogical Strategy for Developing Skills in Global Collaboration*. Den är med för att visa hur en helhetssyn på hur en forskningsbaserad utveckling av kurser ser ut drygt tio år efter den första artikeln och för att visa på hur aktionsforskningsansatsen används i utvecklingen.

Den femte artikeln presenterade på Australasian Computing Education konferensen 2011: *Assessing Professional Skills in Engineering Education*. Den är med för att presentera tankar och hantering av bedömning av professionella färdigheter med hjälp av olika former av reflektion.

# Acknowledgements

This might be the hardest part for me to write. How do I capture a journey spanning thirty years? There are numerous people to thank, who have provided so much joy, knowledge, and wisdom and without whose support I would not be where I am today.

The journey is of course longer than thirty years, having been instilled with a strong and genuine interest for learning, especially in an educational setting, primarily by my parents. Other early images of the value of learning were provided by my grandparents, perhaps especially my maternal grandfather, Folke, who seemed to love education.

A different and much cherished source of additional perspectives on learning are my two daughters, Sara and Hanna, and being by their side in their learning experiences and studies from the cradle up through engineering degree programs at the university. They are the true pride in my life. Discussing learning in elementary school with their mother, Elisabeth, made me ponder the application of learning theories and how to share a common view of a learning situation. Thank you for letting me learn through sharing problems with you about how to understand what is happening in your classroom and how to deal with improving learning.

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The Open Ended Group Project (OEGP) concept has been a threshold concept for me, and I am deeply grateful for the discussions with Xristine Faulkner and Ian Newman which formed my, or rather our, vision of OEGP. The genuine sharing in terms of ideas and how to truly collaborate has stayed with me over the years. Lecia Barker and Amie Hauer have been incredible sources of inspiration to learn more about theories supporting the use of OEGP. Thank you Amie and Lecia, better inspiration is hard to imagine.

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The most influential people for the work presented here are found in the research group, Uppsala Computing Education Research Group (UpCERG). The support and discussions have provided me with an enjoyable, open, and inspiring environment that has resulted, among other things, in increased confidence in our research. Thank you Anders Berglund, Jonas Boustedt, Åsa Cajander, Anna Eckerdal, Arnold Pears, Michael Thuné, and Mattias Wiggberg.

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*Mats Daniels*

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# Appendix: My Publication List

## Book chapters

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# Paper I

# Reflections on international projects in undergraduate CS education

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**Abstract**
Educational methods race to keep pace with the opportunities afforded by technology, and in computer science we need methods that tie together the diverse aspects of the discipline and set them in a realistic human context. Projects have the potential to address various aims and perspectives, and international projects add new dimensions to student teamwork, requiring students to handle collaboration that is remote, cross-cultural, and linguistically challenging. This paper examines some of the educational issues associated with international projects, in the discussion of two examples: PASTICS and Runestone.

**Introduction**
Education in computer science is still seeking its form, in terms both of what is taught and how it is taught. Fast technological development and exceptional growth in the IT industry are contributing factors. In computer science, the fast pace of change is not just technological, but also intellectual and methodological. The discipline of computer science, without a firm traditional underpinning or a firm educational tradition, is buffeted by changing definitions of the domain itself. The relative immaturity of the field is evident in the many tensions that characterise the academic discipline: between science and engineering; between theory and practice (skill/practice [Gör92]); between theory and technology; between training and education; between research and teaching.

Tensions are exacerbated by the current climate. In the face of income-oriented institutional perspectives, the push to satisfy future employers, the competition for students, and so on, the tensions are a matter of continual debate. Hence, the discipline is characterised by an almost unmanageable diversity:

- Academic perspectives: Degrees and courses in computer science cover a wide range of goals and values.
- Representation systems: Changes in notations and programming paradigms are attended by the need to comprehend and have competence with more than one.
- Technical context: Our artefacts must be understood in the current technological context.

This diversity and the pace of change mean that, not only must we provide students with a solid foundation (e.g., theory, reasoning, and skills), but we must also equip them for continual learning subsequently (e.g., an ability to cope with technological change).

One education form that has the potential to cover the spectrum from theory to practice, from technical to social competence, is the project. There are numerous examples of projects in higher education, most local to a department, some run in collaboration with an industry partner [Ber98, Dek97, Jac98], and a few involving collaboration on an international scale [Cle99, Mac99]. Projects involving international collaboration add new dimensions to student teamwork, requiring students to handle collaboration that is remote, cross-cultural, and linguistically challenging. These additional requirements force students to experience project work as crucially socially and culturally embedded — not simply technical — and to pay

extra attention to communication. Our reflective speculation is that a good international project design provides additional occasions for various forms of peer-learning.

This paper uses 'Peer-Assisted Teaching in Computer Science' (PASTICS) and 'Runestone' [Dan98b], two international collaborations, as examples in a discussion of pedagogical issues. There is little published evaluation of how the project form satisfies the requirements for 'good computer science education'; our aim is use the two projects as a basis for reflection on that issue. The focus is on using international projects in undergraduate CS education. Many of the issues are applicable outside CS, but the focus is on how this education form can benefit a discipline with the diversity of requirements and pace of change that characterise CS.

**PASTICS and Runestone**

This section introduces the two projects in brief. Both projects are co-ordinated within the Uppsala Computer Science Education Research Group (UpCSERG), which is a member of Computer Science Education Research Groups International (CSERGI), each having the aim of promoting good practice within computer science education research [Bra92, Den94, Gal96, Isa89].

*PASTICS*

PASTICS (Peer-ASsisted Teaching In Computer Science) is a collaborative project between the Department of Computer Science at University of Helsinki (Helsinki, Finland), the Institute Universitaire de Technologie, Département Génie Télécommunications et Réseaux, Université de la Méditerranée (Marseille, France), and the Department of Computer Systems at Uppsala University (Uppsala, Sweden). The project was run as a pilot study during the spring of 1999.

In the project, Master's degree students in Helsinki, taking a course in 'Computer Aided Learning Environments', teach Java to third-year students in Marseille, taking a course in 'Network Learning'. Hence, the students involved are at different academic levels, and the objectives are somewhat different at the different sites. Some goals are common, like the experience of international co-operation. The main objectives in Helsinki are to learn to use information and communication technology as a tool for learning and teaching, to design such tools, and to undertake and complete a project. In Marseille, where the students were taking an extra year in commercial issues of telecommunications, the experience of having learnt through the Web (since the students were supposed to become technical salesmen of such tools) was important, as were the experience of studying in English, and the actual course content: Java.

The Finnish students designed the Java course, and also interacted with the French students as teachers or teaching assistants on a daily basis. Thus, the course that they designed was for interactive discussion on the course material, not self-study. The main part of the course consisted of Web-pages, with explanations of important concepts, links to material on the Web, and exercises. The material was scheduled on a daily basis, and was each day updated with solutions to the exercises and other modifications. During most of the day, two Finnish students were on-line to answer questions and to discuss with the French, mainly through IRC (Internet Relay Chat).

*Runestone*

The Runestone project, drawing its name from an early (circa third century) communication medium, involves students and faculty at Uppsala University (Sweden), and Grand Valley State University (Michigan, USA), and researchers from the Open University (UK) and the University of Texas at Austin (Texas, USA). The project started with a prototype version (1 group) running in winter 1998 and continued with a full-scale version (8 groups) in winter 1999.

The project's primary aim is to introduce real international experience into undergraduate computer science education in a way that has value for all participants (both students and staff), in particular giving students experience of teamwork with people from a different educational, cultural, and linguistic background, and giving them opportunities for peer-learning. Runestone's secondary aim is to identify effective support structures for remote international collaboration, encompassing strategies for communication, management, and technology use. Runestone will evaluate pedagogical and technical solutions for collaboration, will examine the costs, both in time and money, and will investigate how students learn in such a setting and what they learn.

Group projects with half-American, half-Swedish teams (6-8 students per team, 5-10 weeks per project) are incorporated into existing courses. The students collaborate closely with their foreign counterparts using appropriate communications and computing technology (primarily electronic mail, IRC, and Web pages) to solve a given problem. The students in this project were all CS students at roughly the same academic level (3rd or 4th year), but because they come from different specialisations within CS, they have different knowledge to contribute to the project. The problem that was specified was fairly advanced, designed to cover the spectrum of backgrounds, and involving study areas such as real-time systems, networking, and distributed systems. The problem was to create a Web-based interface to navigate a steel ball through a maze by tilting the maze in two dimensions with stepper motors.

**Educational issues concerning projects**

This section discusses educational issues through reference to results and observations from the two projects. The fundamental question for using projects is whether — and in what respects — it is a good education form, meaning that:

- The syllabus is covered at least as well as through 'conventional' methods.
- The actual time the students spend on the course is related to the 'allotted' time.
- The time staff spend on the course is related to the size of the course and is comparable to other ways of delivering the course.
- The cost, apart from staff time, of running a class is not higher than other forms.
- The course contributes to the personal development of the students.
- The form is motivating to students.

These will be considered in turn in the following sections.

*Syllabus*

Syllabus coverage is one of the main topics in most discussions of project-oriented courses. It is here that the diversity of educational aims (and the tensions between perspectives) is most clearly manifest: even when educators agree that projects are ‘a good thing’, they may disagree fiercely about what they are ‘good for’. Students have (relative) freedom to direct and complete their project, and so outcomes may not be as planned — and may have to be

assessed in their own terms. Projects encompass many non-technical aspects, such as project management, which may draw attention from the technical or theoretical syllabus. It is important that the educational goals are clearly stated and followed up.

In PASTICS, although the analysis so far of the data collected is only preliminary, general findings are encouraging: both groups of students fulfilled their learning objectives in 'Computer-Aided Learning Environments' and Java, respectively. The assignment given to the Helsinki students is open-ended; they may design the course to be given to the French students according to their own ideas. One example from the pilot study is that the Helsinki students did not teach the networking aspects and graphic issues of Java as much as was expected both by the staff and the Marseille students. One possible solution is that the two groups discuss the course content more thoroughly before the Finns start to design the course. Another aim that fell short was usage of ICT (Information Communication Technology); a more diversified use of ICT was desired

The project in Runestone is fairly complex, and a specialisation on different tasks is necessary in order to complete the project. This is a desirable feature for the course on the Swedish side, since it is mainly aimed to give experience in using already-acquired knowledge in a real setting. It is a capstone course on the US side, and hence similar arguments hold for the appropriateness of such a set-up. There is on both sides expectation that the students will deepen their knowledge, but it is not important in which of the different areas this happens.

It is interesting to note that in both of these projects the collaborating parties had different perspectives on the place of the project in their education programmes: starting from different backgrounds, having different aims, playing roles in different courses, addressing different parts of the syllabus, even being assessed differently. And yet in general the project work satisfied each collaborator, producing appropriate learning outcomes within each institutional context. The main point of commonality in the educational objectives was that of learning to use information and communications technology appropriately as tools for learning and for solving problems. Concerns about the technology overshadowing the education were not realised.

*Student time*

Another potential problem with project-oriented courses is that the students spent far too much time on them. The authors have on several occasions heard comments from colleagues teaching project-oriented courses like "it really got their attention, they worked day and night with this".

The time studies conducted in Runestone and the interviews in PASTICS show, to our satisfaction, that the students spent roughly the expected amount of time on the course, although in the Runestone project time was a bit ill-spread, with a high load toward the end.

*Staff time*

Another relevant measure is the amount of time the staff spend. It is also interesting on what they spend time.

The collaboration between universities yields savings. Both PASTICS and Runestone have benefited from reduced development costs, since the actual project was mostly developed at one site, Helsinki and Uppsala respectively. Although there was time needed to set up the pilot study, it is clear that staff time was gained in Marseille, since the actual teaching was

made from Helsinki. At Helsinki the extra time for staff was moderate. The time spent with the students in Runestone has not yet been examined in detail, but preliminary feedback from the teachers suggests that time has been saved.

*Personal development*

Language and communication

ICT is *a priori* an essential ingredient in computer science education at university level, since it is both a study object and a tool for learning. The key issues facing the future computer science professionals involve globalisation of the knowledge base, and increasing specialisation and distribution of expertise with resulting need to collaborate in a culturally and linguistically complex environment. So, what is the students' experience of communication and collaboration within an international group project?

In PASTICS, language was maybe the single most important problem. Some of the French students claimed that their knowledge in English was too weak for keeping discussions through IRC with the Finnish students. This group of students reacted by withdrawing from the conversations over the net, and mainly working on their own.

Language per se was not a barrier for the students in Runestone. The Swedish students are highly competent English speakers (with 8-9 years of study and English usage required in many university courses), although they are not necessarily fully confident.

The American students in Runestone didn't perceive communication as a problem, while the Swedish Runestone students as well as the Finnish PASTICS students identified communication as one of the biggest problems. All Runestone students were frustrated by slow or lacking responses to e-mail messages and IRC questions. The students cited multiple missed deadlines as a major problem, although they argued that this might not have happened had the communication been really effective.

There are open questions here about the impact of the communications technology on the quality of the interaction between the students. All of the students were 'e-mail familiar', and much of the within-country interaction was electronic. Other technologies (e.g., video conferencing, conference calls, Web-based tools) were available to them, but Runestone students chose to rely primarily on 'tried-and-true' text-based and often asynchronous communication. Yet they used their chosen tools well and in concert. Frustration had less to do with the technology per se than with the collaborators' exertion of it, e.g.: delays in response, lack of explicit acknowledgement.

In the Runestone project, the constraints of the communications technology, the time differences, and the students' use of communications put a spotlight on the importance of context (social, technological, cultural) to project work — and on the possibility that the greatest barriers to success may be other than technical ability.

International collaboration

Measures should be taken to ensure that the students actually experience international collaboration. This has not been done explicitly in either of the projects, because so far it has not been required; there seems to have been a good international distribution of responsibilities.

Social skill

Social skill is a key to success in an international project; students must transform from strangers to collaborators in short order. The social setting is artificial and awkward; students must become acquainted using low-bandwidth (low feedback) communications while contending with time, culture, and language differences.

The social interaction was rather limited in PASTICS. Some of the French students experienced the language as a problem. Even from the Finnish the interest for social interaction was limited; other interests tended to take up their time.

Social confidence was a limiting factor in communication in these projects. In the Runestone project's pilot year, the students' e-mail and IRC logs are full of jokes — but the students expressed low confidence that their jokes were understood. Social interaction — jokes and talk about personal topics — increased toward the end, during the hectic efforts to make the project fly. Yet, for each of the students, some part of the process or of their counterparts' actions or interpretations remained mysterious. Experience in the second year suggests that frustrations in communication had more to do with what was not said than what was said; students who provided explicit acknowledgements and regular feedback inspired confidence.

Improved warm-up activities improved social confidence. There was in the Runestone pilot relatively little social interaction between the cohorts; the students felt that they didn't know their counterparts very well, and the project didn't help them to get to know each other. In the second year, the introduction scheme was revised, with Web-based personal introductions and some advice about communicating. The full-scale version had several examples of extensive social contact.

Experiencing and functioning in a new (artificially-mediated) cultural setting is evidently ultimately rewarding, and the students gain confidence in their abilities. This is however not easy, and it might turn into a problem that will obscure other goals of the course.

Cultural differences

The students in Runestone and PASTICS noticed only a few cultural differences between the two groups. Some differences were:

- Educational background (e.g., lack of knowledge of C and use of functional programming)
- Age (in the Runestone case where the Swedes were older: 23-24 vs. 20).
- External obligations; the Americans and the French perceiving that they had more job and family obligations, although some of the Swedish and Finnish students respectively work as consultants, i.e. the groups actually worked under similar conditions.

Nevertheless, the students in both Runestone and PASTICS were emphatic that culture was a non-problem; each group described their counterparts as being "just like" or "pretty much like" them.

Peer-learning

Based on anecdotal evidence from our own experience as teachers and preliminary findings from data collected, we believe that having students explain concepts and solutions to one another is a powerful learning technique. Our conjecture is that there will be plenty of occasions for the students involved with international projects to help each other with activities such as explanations, clarification, sharing knowledge or rehearsal of ideas. Occasions for peer-learning can be formal or informal. Formal occasions arise when students at site X

present information for the students at site Y. Informal occasions include questions that arise during day-to-day e-mail or simple study sessions.

PASTICS is in effect a formalised exercise in peer learning. The discrepancies between staff expectations of what would be taught and the courses actually designed indicate that there are discrepancies between staff and student prioritisation of concepts — and that we have more to learn about how students assimilate and structure material. The French students' withdrawal from the IRC discussions due to language difficulties is clear reminder that there are threshold criteria for effective interaction.

In the Runestone pilot, peer-learning between the cohorts was limited; it was largely related to craftsman skills, e.g., better technical solutions. This may be accounted for by the lack of familiarity between the students and possibly by the nature of the project, which could be sub-divided in a way that avoided the need to learn about what the others were doing. Some of the Swedes reported peer-learning within the Swedish cohort, but this occurred largely in face-to-face interactions about which no data was collected.

*Motivation*

Motivation is both crucial and intangible. Student motivation affects their perceptions and expectations, all influencing outcomes. Projects are considered to be efficient in raising the motivation for students, through factors such as: intellectual challenge; team work and social influences; 'ownership' and control; public profile; anticipated rewards or satisfactions (ranging from receiving credit for a 'job well done' to employment prospects); competition; novelty. Motivation is reflected in behaviour, such as: time students are willing to devote to the work, (not just notional time, but actual 'time on task'); intensity of work; expectations; reactions to obstacles and tenacity in overcoming them; willingness to extend themselves, whether in asking questions, seeking information, drawing on disparate resources, or trying alternatives. Students on international exchange, seem, in our experience, to be more motivated to do well compared to their time at the 'home' university.

Students on both projects identified factors that enhanced their initial motivation:

- The extensive international collaboration.
- The project was an 'experiment'.
- There was a challenging project to do.

In the initial meetings in Runestone, some students stated that the real challenge was to make the group work as a team, and to demonstrate the viability of the experiment; others cited both the teamwork and the challenge of the project itself. There were however also factors that decreased the motivation. During the project, motivation was neither constant nor evenly distributed; students cited differences in expectations, motivation, sense of urgency, time available, language skills, local cohesion (and hence local group dynamics), and technical skill, within the groups as one of the main problems. At times the awkwardness of physical separation and, mainly in the Runestone case, different time zones impaired student motivation and enthusiasm.

In PASTICS we observed that the Finnish students judged that their commitment was stronger than the commitment of the French. To a certain degree this difference was due to cultural differences. For example, the concept of time is slightly different at the two sites, a fact that might have been interpreted as a lack of commitment.

## Conclusions

Educational methods race to keep pace with the opportunities afforded by technology. We must understand 'what Computing is' in order to teach it - we must marshal appropriate tools and methods to teach it well - and what we teach will influence what computer science becomes. Projects — and in particular international projects — afford a way to address the diversity of the discipline in a way that approximates to reality. Projects are particularly important for computer science students because their profession will be to build intellectual artefacts that operate within a social and technological context — and increasingly a global context. Projects allow them not just to experience the craft, but also to begin to experience their craft in context.

But we must evaluate our practice of the project form more thoroughly in order to understand how to build effective learning situations. These efforts should be conducted in a scientific manner [Bry88]. Computer science students' maturity in the use of computers and communications technology makes them ideal guinea pigs for international collaboration, with a high likelihood of success. The experiences on the PASTICS and Runestone projects suggest that the international project form itself is motivating to students, but that its efficacy is affected less by technical skills (which we might expect our students to have) than by social and communications skills — and that we can improve outcomes by assisting with some well-judged guidance early in the project. Many pedagogical issues about using projects, and especially in an international setting, are about education in general and not particular to computer science.

We must also look deeper than merely evaluating implementations, deep enough to examine what changes in teaching practice reveal about underlying issues such as concept acquisition, development of skills and expertise, sources of misconception and superstition, learning processes, the roles of different types of interaction between teachers, students, and materials, and so on. We need to know not just the effect of introducing new technology or methodology, but also the price.

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# Paper II

# Diversity in Information Technology Education:
## Issues and Controversies

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Chapter IX

# The Open Ended Group Project: A Way of Including Diversity in the IT Curriculum

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## Abstract

*Modern societies are now beginning to accept that their citizens are diverse but, arguably, have not yet faced up to the challenges of diversity. Schools and universities thus have a role to play in equipping students for the diverse society in which they will live and work. IT students in particular need to appreciate the diversity of society as they specify, design, build and evaluate systems for a wide range of people. This chapter examines the concept of the Open Ended Group Project (OEGP)*

*and uses examples to demonstrate that OEGP forms an effective technique for encouraging students to work together in diverse teams. The appropriateness of OEGP as a means of addressing diversity in the curriculum is examined, and it is concluded that OEGP offers a suitable means of enabling students to develop strategies for accommodating diversity in both their future working life and the wider society.*

## Introduction

Diversity is a very important topic in the education of IT students since they, more than most others, will need to be concerned with considering, and accommodating, a wide range of diversity (cultural, social, physical, cognitive) in possible users when specifying, building and evaluating IT systems. As more and more people use computers in their work and for pleasure, this aspect of IT will inevitably increase. Students may also be expected to work with very diverse groups of people in teams which can span continents and cultures as well as include people with physical disabilities. However, of its nature, "diversity" is difficult to "teach" and cannot be fully covered in a normal curriculum (in both cases because it comes in so many different guises).

This chapter proposes the use of open ended group projects (OEGP) as a means of both introducing aspects of diversity and of providing a way of integrating students from diverse backgrounds. It also examines some misconceptions about the use of OEGP and shows how they can be overcome. The discussion is illustrated with examples drawn from the experiences of the three authors in using OEGP successfully at the university level over many years as a vehicle to reinforce more conventional teaching and introduce new ideas (Daniels & Asplund, 2000; Daniels, Faulkner, & Newman, 2002; Last, Almstrum, Erickson, Klein, & Daniels, 2000; Newman, Dawson, & Parks, 2000). Since the authors all work in different institutions, two in the UK and one in Sweden, they each bring a different perspective and have different tales to tell, but they are united in reporting that the OEGP method is very effective in making students consider issues that they would otherwise not think about, in motivating them to do well and in offering excellent learning opportunities, i.e., it is ideal for both introducing diversity issues and for accommodating diversity among the students.

All three of the authors are lecturers in university information technology/computing departments and they perceive their primary task as encouraging students to learn how to use computers effectively. However, to do this well they must also help the students identify, and be prepared to overcome, potential problems, such as diversity. Although none of the authors has focused specifically on diversity as a topic for students to study, all three have had to accommodate considerable diversity amongst the students whom they have helped to learn and who have reviewed the effectiveness of their teaching with respect to various diversity issues. The two authors from the UK universities have cohorts of students with a very diverse ethnic/racial/color mix and have needed to demonstrate that these issues do not reduce the effectiveness of the students' learning experiences. The other author has focused on the effects of cultural differences when working in groups with members located in different continents, requiring the students to accommodate different time zones and different languages (Daniels, Berglund, Pears, & Fincher, 2004). One of the authors has organized both the composition and the management structures of teams to encourage female students to improve their performance (Faulkner & Culwin, 1999), and all three authors have experience assisting students with a wide range of disabilities (e.g., partial and total blindness, profound deafness, cerebral palsy, paraplegic) become fully involved and integrated into the learning process (which has also, of course, assisted the students' teammates become more aware of these issues).

The next section of the chapter discusses the breadth and multi-faceted nature of the diversity "issue" and examines the problems of addressing this within any university computing curriculum. It then explains why OEGP is, potentially, an appropriate approach for achieving this objective, discussing the ideas underlying OEGP and relating them to the more general concepts of constructivism and Problem Based Learning (PBL). A number of examples based on real experiences are then presented to show how the technique has been used in practice to overcome potential diversity issues amongst the students. Examples will also be used to show how specific diversity issues could be, and have been, explicitly addressed and assessed. The chapter concludes by examining the appropriateness of the OEGP technique, and by recommending that all university educators should consider it as an effective way both of introducing diversity issues into the curriculum and also of accommodating diversity within the student body.

# Background for the Chapter: The Challenge of Putting Diversity into the IT Curriculum

This section commences by examining the task of including diversity issues in the IT curriculum at a university. It outlines some possible dimensions of diversity and discusses the interaction between diversity issues and computer applications, concluding that it would be impractical to include more than a small fraction of the possible subject matter in any university degree program. The section continues by discussing educational constructivism and problem based learning, suggesting that these may offer a much more effective way of getting students to appreciate, and be able to accommodate, diversity issues. The section also explains the relationship between constructivism, problem based learning and the Open Ended Group Project (OEGP) approach. Arguments for using the OEGP approach for diversity education in a university IT curriculum are included throughout the section.

## Diversity in the IT Curriculum: Dimensions of Diversity

As stated in the introduction, the authors believe that diversity is a particularly important issue for students studying computing to consider whilst at university. Such an education should help society accommodate the increasing diversity of its citizens. However, this is not just an altruistic viewpoint, since work by Gurin, Nagda and Lopez (2004) has shown that students involved in programs which address diversity also secure positive benefits for themselves.

The importance of diversity education has increased, and will continue to increase, as legislation against "discrimination" is introduced (e.g., in the UK, as in other countries, there has been legislation against discrimination on the grounds of color and of gender for many years but this has recently been augmented by legislation against discrimination on the basis of disability—the Disability Discrimination Act: http://www.disability.gov.uk/dda/). However, this means that "diversity" is very diverse. At the very least it would ideally be necessary to consider:

- disability, which itself is multi-faceted with each disability, and each degree of severity of a particular disability, posing different challenges for

the sufferer and the people who wish to interact with them (this is exemplified by the much larger number of events in the Paralympics in Athens in 2004, when compared with the Olympics a few years before);

- gender;
- ethnicity;
- race;
- color;
- sexual orientation/preference;
- socio-economic status;
- religion; and
- cultural background.

These "dimensions" are not, of course, discrete. Ethnicity, color, race, religion and cultural background are often perceived as closely interlinked and, in addition, the different aspects can be combined, with each combination potentially introducing new issues. This does, of course, mean that "diversity" cannot conceivably be addressed as a single, teachable subject.

As noted, different aspects of diversity are frequently regarded as being closely interlinked (e.g., the Muslim=Arab=terrorist misconception which has apparently been prevalent in the Western Hemisphere following September 11, 2001). This is an example of people's underlying assumptions (prejudices), which are often unrecognised, and which make it more difficult to address diversity within the curriculum. As is the case for most sections of "civilized society," most students (in European universities at least) do not want to acknowledge their prejudices and will tend to avoid any discussion that questions, or even brings out, their underlying beliefs. Sometimes they aren't even aware that the views they express are indeed prejudices, so ingrained in their culture has the prejudice become. This poses a very substantial problem for conventional lecture-based teaching, since it is likely that students will not "hear" ideas that challenge these prejudices and that different teaching techniques need to be sought. Any amount of telling students that a prejudice is indeed just that and, at the very least, misguided, will not have the impact that forcing them to confront the prejudice will have. Likewise, for minority groups, or individual students who have coped with a particular disability or cultural difference, it may sometimes seem too great an effort to overcome the prejudices of the majority. However, when working in small teams, and

particularly when the team is tackling an open ended problem, as is the case in the OEGP approach advocated in this chapter, diversity has to be accommodated or the team will fail. As an example, if a deaf or blind student joins a team, there is a significant communication challenge which would not occur (for the other students) if each individual was working on their own, since the deaf or blind student has to be communicated with by the remainder of the team and vice versa. As the authors may report from personal experience, all of the team exhibit both pleasure and pride when they have managed to overcome the problems and deliver a successful solution to the task that has been set. This is, of course, rewarding, not just for the teams concerned but also for their teacher. Furthermore, the other teams see that these difficulties are not insuperable and are, therefore, helped to consider diversity issues. The educational effect is enhanced if the team containing the person with disabilities out-performs both expectations and some of the other teams. As will be discussed in later examples, unexpectedly good performances from teams which face "diversity" issues does happen more often than would be expected by chance in the OEGP setting. Research reported by Gurin, Nagda, and Lopez (2004) confirms this observation, showing that confronting diversity issues, and encouraging the formation of diverse groups, provide a significant advantage to students and prepares them for a world which is not homogenous and for cultures which increasingly are having to recognize they are not homogenous.

The challenge of including diversity in any curriculum is further compounded with IT because the subject is, in itself, ultimately diverse, reaching virtually all fields of human activity, and this coverage is still in the process of expanding. Logically, this means that there is a matrix (probably multi-dimensional) covering all of the dimensions of diversity and all of the different applications of IT to be considered if diversity is to be fully "covered," using a conventional teaching approach.

Of course, no curriculum ever attempts to cover more than a small subset of the possible issues in, and applications of, IT and, similarly, it would not be possible to address all of the possible diversity issues. This would apparently mean that a (very small) selection of the possible issues/dimensions related to diversity would be all that would be covered within the curriculum, which raises two questions:

- Which of the aspects (dimensions/issues) within "diversity" should be covered?

- What expectations can there be for "transferability" of knowledge and understanding if the students subsequently encounter a different aspect of diversity or even if they encounter the same aspect but in a different context?

In pedagogic discussions, the issue of transferability occurs more frequently in connection with skills than with knowledge but, in IT, the important thing for the workplace is the ability to apply knowledge effectively to the particular situation that is being addressed. It is the authors' opinion that, like the ability to display a particular skill, this ability to apply knowledge is closely related to self-belief/self-confidence (knowing that "you" can do something because you have done the same thing, or something very similar, before). As will be illustrated by examples, the advantage of the OEGP approach is that students may try out their solutions and approaches in a realistic, but actually protected and safe, environment. Their successes give them confidence and they learn how to adjust their failures so that future attempts can turn these into successes too. With an OEGP approach, responsibility for both successes and failures is focused on the group rather than the educator, but are shared by the members of the group who are encouraged to reflect on the processes they used as well as their output and results. Since an OEGP is a joint effort, it is much easier to survey critically what was positive about it and where things went wrong because the group can do that as a whole and can support one another. It is much harder for a single student working on their own to be self-critical because the "blame" would be all their own. Thus, it is much easier for the individual to find excuses (and other people to blame). The OEGP approach, by sharing responsibility within the group and with the teacher, encourages a self-evaluative approach which aids learning. This is much more typical and realistic in terms of human endeavour in the real world. Very few people work in complete isolation. They are usually part of a team; thus, learning skills that will help them to work in a team and manage teams is a useful experience for undergraduates. The open-ended nature of the tasks is also beneficial in this respect, so the groups are not trying to find the "right answer." Instead, they are trying to identify both important issues and possible ways to address these issues.

## Problem Based Learning and Constructivism

Problem Based Learning (PBL) is a well-established approach designed to encourage students to acquire skills in deploying and reinforcing their existing knowledge while simultaneously learning and integrating new material (Kolb, 1984; Kolmos & Algreen-Ussing, 2001). PBL may be seen as a form of constructivism: learning as an active acquisition of ideas and an assimilation of those ideas into a framework that the learner either already possesses or forms as a result of their experiences. It is not the accumulation of facts; rather constructivism requires learners to be active in their relationship with the material to be learned, and seeks to bring about the modification of learner behavior (and thereby to overcome existing prejudices). Setting problems and asking the learner to solve them is perceived to be an effective way to achieve goals of this type, which provides the link between PBL and constructivism.

Brooks and Brooks (1999) recognized that the constructive approach presupposes the existence of a good problem that needs solving by the learner. They define a good problem as one that:

- requires students to make and test at least one prediction;
- can be solved using only equipment and facilities that are available;
- is realistically complex;
- benefits from a group effort; and
- is seen as relevant and interesting by students.

The questions associated with designing problems that are suitable for encouraging learning in particular topics will be discussed in more detail using examples that relate to diversity.

Another way of viewing the constructivist learning environment is to see it as one that encourages sharing between students and between educators and students. The educator ceases to be the source of all wisdom and knowledge and, instead takes on more the role of mentor than instructor. Also the success of the outcome moves from being the responsibility of the educator to being a shared responsibility between the students and the educator. In this context, Copley (1992) suggested that constructivism expects the teacher to act as a facilitator "whose main function is to help students become active participants in their learning and make meaningful connections between prior knowledge,

new knowledge, and the processes involved in learning." This also has the effect of changing the learning experience for the teacher from one of treading a single, well-known path to, at the very least, that of helping each group find a suitable route to the destination and, sometimes (such as when a specific diversity issue affects the group), it may require a new path to be created (i.e., research). In conventional teaching/learning environments, although much of the material students meet is new to them, this is not (usually) the case for the teacher. An OEGP, as advocated in this chapter, may often be a way of creating a much more exciting and fulfilling environment for the teacher too. With an OEGP, both students and teacher are carrying out a piece of work, the result of which may be wholly or partially unknown. Even with an educationally and culturally homogeneous cohort of students, the differing prior life experiences and personalities of the students will inevitably mean that each group will tackle the task in differing ways, focusing on different aspects at any one moment. As the groups become more diverse, or as diversity issues are explicitly introduced, the approach taken by the groups is likely to diverge further, increasing the interest for the staff and students alike, and encouraging each group to find their own way of tackling the task (plagiarism, which is typically a serious concern for coursework exercises, has not been a problem for any of the authors when using the OEGP approach).

As noted in the list above, Brooks and Brooks (1999) identified the need to utilize group working as an important aspect of choosing a suitable problem. The following sub-section amplifies the discussion of the concepts underlying the OEGP approach. In the context of this sub-section, an OEGP offers a form of constructivist/problem-based education that uses group project work as a primary catalyst for learning, which should be particularly suitable for encouraging students to think about diversity issues.

## Open Ended Group Projects

The authors have been using a development of the constructivist/PBL method, that they call the OEGP (Open Ended Group Project) approach, in their separate universities for a considerable time (in one case the 2003/4 academic year marked the 25th anniversary of its original introduction into the curriculum). The approach has proved extremely successful in each of the institutions and is credited by students and by industrial contacts alike as being a major factor in ensuring that students can be "up and running" quickly when they join an employer, either on an internship while they are at university, or after they have

completed their degree. The perceived value of the approach is illustrated by the fact that major employers (e.g., Accenture, Citigroup, IBM) offer prizes for the most successful group performances, since this gives them the opportunity to come and talk with all the students and encourage them to consider employment at their organizations as interns or full employees. The details of the OEGP approach vary considerably, not just between the authors/institutions, but also from year to year within an institution, since they are dependent on many factors, the most important of which are:

1. Position within the academic program—which year and, possibly, where within the year (e.g., first or second semester);
2. Size of the student cohort—a cohort of 25 may offer opportunities which are very different from a cohort of 250 (however, the approach has been used successfully at both these levels);
3. Length of time the OEGP will run—this can be anything from one or two weeks to a full academic year—and the number of simultaneous activities (is the OEGP the only thing the students will be doing or is it just a "part time" occupation);
4. Academic credit offered for the work (e.g., as a fraction of the credit required to pass the year)—although the amount of credit is generally related to the amount of time and effort the students are expected to spend, there have been occasions when the approach has been used successfully with no credit at all being offered (the students are expected, and do, use it to gain feedback and as an opportunity for very low risk experimentation) and, quite frequently, the students have to be actively discouraged from putting in a disproportionate amount of effort compared to the credit involved;
5. Method by which groups are formed and managed—in some cases both the composition of the student groups and the management structures that are to be used will be prescribed by the educators, in others, it may be advantageous to allow the students to form their own groups and decide how to manage the process for themselves (in part, this depends on the educational objectives but also, asking students to form their own groups and decide on their own management structures transfers the responsibility for the success of the group to the students themselves, which may increase motivation and group cohesion);

6. Type of task chosen as the problem—as implied by the name given to the approach, the task has to be open ended (i.e., to have several different aspects which the students might choose to focus on, with no obvious, clear, single, solution) but this still leaves a very large number of possibilities even when combined with the need, in this case, for it to be related to IT (e.g., it may vary from evaluating existing systems to designing and/or constructing new systems, and the systems could be almost anything—robot footballers playing as a team, support systems for improving patient care in hospitals, project management support systems);
7. Interrelationship between the groups—this can be collaborative or competitive since in some cases the groups are all asked to work together to achieve the task that has been set, while in others every group is set the same basic task (because the tasks are open ended, this does not mean that they all do the same thing; each group forms its own perception of what is needed); the groups "compete" to achieve the best outcome, in at least one case it has been both collaborative within the groups at the institution and competitive with groups working at different institutions; and
8. Educational "objectives" or "intended learning outcomes"—the focus may be quite restricted, such as reinforcing a particular aspect of previously taught material, to very broad, such as: gaining confidence, encouraging reflection and forming frameworks to integrate existing knowledge. However, there are usually multiple objectives which include elements of both the narrow and the broad and the acquisition of new knowledge and skills.

Of course, all of the factors are closely interrelated, although any one of them could be preeminent in a particular case. If, for example, it was decided to use the OEGP approach to introduce a particular diversity issue (say user interfaces for the blind and partially sighted) to a cohort of first year students where only a fortnight of time was available for the exercise, the educational objectives would probably be more limited and more strictly drawn, than if the task were to get final year students to think about a range of diversity issues and a full academic year was available. Similarly, given the same educational objective, the task is likely to be specific to the chosen issue (e.g., design or evaluate interfaces to assist a person with a specific disability to accomplish something).

This section has identified the challenge of including diversity in the curriculum and has explained the potential of the OEGP approach to overcome the

challenge. The section has also provided the pedagogic background for the OEGP approach, relating it to the educational philosophy of constructivism and the well-established, problem-based learning approach.

The following section of the chapter introduces a number of examples of the OEGP approach in action, illustrating how various aspects of diversity have been tackled by groups of students working on tasks that the authors have set.

## Using the OEGP Approach to Accommodate Diversity: Some Examples

The previous section explained the difficulties of using conventional educational techniques for getting students at university to consider the wide range of diversity issues. It also explained why the OEGP approach, with its emphasis on getting students to take shared responsibility for their education, might be an appropriate way of including diversity in the IT curriculum.

This section uses examples of OEGP based coursework undertaken by the authors in their separate universities to show how various aspects of diversity have been addressed in practice. The examples are also used to explain some of the benefits that the OEGP approach offers for educators who adopt it.

The following uses further exemplar scenarios to examine some possible ways in which the OEGP approach could be used to address other diversity issues.

## Examples of How the OEGP has Addressed Diversity Issues

Before introducing the actual examples, it should be noted that in none of these cases was "learning about a particular diversity issue," a specific educational objective for the educators concerned. In each case, the diversity issue arose naturally because of the inherent diversity in the student cohort that was being educated. The examples do, however, show that:

- The OEGP approach does accommodate potential problems caused by student diversity;
- Some learning/understanding was achieved by the students concerned, i.e., OEGP may be an effective approach for encouraging student learning for at least some diversity issues;

- In at least some cases, the learning was not limited to the group that was coping with the diversity issue, i.e., there is transferability of learning/understanding between groups; and
- There is some evidence of transferability from one diversity issue to another.

The examples are grouped into three subsections:

1. Cultural, color and ethnic differences (religious differences would almost certainly also have been covered but no data was collected) related to other examples involving students with different educational (knowledge, skill) and motivational backgrounds;
2. Disability (two examples: one involving deaf students and one involving blind students are chosen as representative); and
3. Gender—more specifically, overcoming differences in confidence and leadership qualities between the genders (interestingly, sexual preference/orientation has never been an issue in practice even though there have been gay, lesbian and transsexual students in some of the cohorts).

## Examples of Cultural, Color and Ethnic differences

The first group of examples under this heading focuses on "cultural" differences as being simply differences in the background and skill sets of the students involved and show the different sorts of approaches that have been taken by the authors. This is intended to help the reader obtain some feeling for what the OEGP approach is and the sorts of projects it may cover. This is followed by some specific examples of projects where cultural, color or ethnic differences between the individuals could potentially have caused difficulties but where these difficulties did not materialize in practice. Evidence that the students gained insights into the diversity issues involved is reported in the examples.

The first example was designed to enthuse and challenge the students, requiring them to use a wide range of skills and to collaborate amongst themselves and with other students taking a different program of study at the same institution, but to compete against teams from other organizations. The task was to build a team of soccer playing robots to take part in the Robocup world championships. For about one third of the year this was the only task the students were

expected to undertake, and for part of that time they were working with students on a mechanical engineering program who assisted them in building the robots (Daniels & Asplund, 2000). This project was run for several years and, in the later years, the team of robots which the group built that year (there were, of course, different students undertaking the task each year) did take part in the championships, and even win some of its matches. The project achieved its objectives of motivating the students and of getting them to be both industrious and inventive. It also helped them appreciate the need to understand the "culture" in which they were expected to work. In this case the culture was the set of rules and restrictions governing the competition which evolved each year and set new challenges for each cohort undertaking the task. Interestingly, in the context of this chapter, the project has now been replaced by one involving the design and construction of rescue robots since that was perceived to be more gender neutral. Observations that the nature of an assignment can affect the engagement students display towards a subject have also been noted by other educators (Wilson, 2004).

A second example also involves all of the students involved cooperating to achieve a shared goal. In this case the students are studying either Human Factors, Human Computer Interaction or Usability Engineering as one of several modules that they are taking at the same time. The cohort is split into teams and they are expected to produce a single "product" between them. This usually consists in developing a piece of software with different interfaces, and then carrying out a joint evaluation with volunteer subjects. The students have to work in teams to produce their subset of the piece of software, and then they have to cooperate between the teams in order to develop the evaluation material and carry out the survey. (Faulkner & Culwin, 2000). The task, involving both building software and running a survey, makes them address questions of their own skill base—which students are skilled at solving software problems or at arranging schedules or are "good" at approaching potential volunteers. The breadth of tasks means that a wide mix of abilities is needed, and all kinds of student backgrounds are catered for. The OEGP approach thus allows the strengths of the student body to be used to the best advantage by providing very diverse opportunities. It also encourages the students to identify potential weaknesses so that these can be avoided.

In contrast to the first two, in the third example the cohort undertaking the coursework is itself diverse, consisting (in 2004/5) of students drawn from seven degree programs. The students also come from a very wide range of cultural and ethnic backgrounds. The majority of the approximately 200

students (numbers have varied from 150 to 250 over six years) is White European (mostly UK-based, although with representatives from most of the EU and Scandinavian countries) but there are also substantial numbers of students with Asian, African, Afro-Caribbean and Chinese backgrounds. Here, the primary educational objective is to get each team of students to use the knowledge and skills that they have acquired to work with their "clients" to first understand the clients' requirements, and then to design, build and demonstrate a suitable support system. To assist the students in discovering the requirements, the educators take the roles of departmental administrators preparing timetables, who need to obtain rooms in which lectures, tutorials, seminars and laboratories may take place, and university administrators who allocate the rooms for such. Secondary objectives include getting the students to reflect on what they have learnt from the experience (Newman, Dawson, & Parks, 2000) and to draw on the range of skills that are available within the group to accomplish the overall task without unnecessary effort, since it represents only one sixth of the work that they are expected to undertake. A number of sub-tasks are specified, involving deliverables on which the teams get feedback. The students are advised to form teams with as much diversity as possible, but are actually left to choose their own teams. In the first year this task was set and the advice to form "multi-cultural" teams was given, most students ignored the advice and stayed with other students taking the same degree program. However, as time has passed, the success of the "mixed" teams (in terms of marks achieved against effort required) in one year has encouraged greater mixing in subsequent years. For the last two years, the majority of teams have been mixed and, in the current year, even though they have only completed one of the three deliverables, several of the teams that were drawn from a single degree program are already saying (in their evaluation reports) that they now realize they should have included people with different skills in their teams. As already mentioned, there has always been considerable ethnic and cultural diversity in the cohort but, with the exception of some of the students with Asian backgrounds, they have always tended to integrate into mixed teams anyway, without any pressure from the educators. Generally, the performances of the teams that do have a good cultural mix is better than the performance of teams with a homogeneous structure, probably because the prejudices do not go unchallenged. However, no systematic studies have been carried out, so this represents a qualitative rather than a quantitative assessment.

A fourth example is specifically aimed at getting students to consider, and overcome, cultural differences. The students in this case are placed into teams

which span two countries in different continents, introducing potential problems of physical and temporal separation as well as different natural languages (Swedish & US English). Each group is composed of approximately equal numbers of students from both countries, and they are asked to undertake a task which requires collaboration between the two halves of the team (all of the groups are asked to undertake the same task). This approach forces the students to think about and, as the success of the students shows, cope with the difficulties of talking to people who live in the different countries, are in different time zones and who have different cultural expectations and attitudes, as well as a different language. As reported in the student feedback from the module, the Swedish students have found the experiences very rewarding, and employers are pleased to have graduates who have already had the experience of cultural diversity before they start work (Last, Almstrum, Daniels, Erickson, & Klein, 2000).

## Examples of Disability

Two examples are given in this subsection, one relates to deaf students, the other to blind and partially-sighted students. These examples are representative. In other cases, students with different physical or psychological challenges (e.g., cerebral palsy, paraplegia, acute anxiety) have been successfully incorporated in teams which have subsequently completed the OEGP task. In every case, both the individual and the team appear to have benefited from the experience by gaining confidence and by becoming more open in their approach. However, it should be noted that in all the cases, the students with the disability were fairly determined individuals, otherwise they would probably not have started their respective university programs.

## Deaf Students

In this example, two deaf students were part of a class of about 30 first-year students carrying out a group project. When the students divided into groups, the two deaf students and their communicator were left unassigned. The deaf students had no hearing friends in the student cohort, and the communicator thought their problems necessitated their working separately. The educator insisted that the two deaf students were assigned to a group. Initially, the group thus formed was nervous: the hearing students were not sure what to expect and

the deaf students were worried about working with their hearing counterparts. However, the deaf students proved to have skills that were very useful to the team, and the hearing students soon learned how to communicate effectively with them. The deaf students, in turn, practised speaking aloud and were not permitted to sign unless they also spoke aloud. In other words ,both deaf and hearing students had to learn "manners" for this situation. The deaf students became more confident about speaking in public since this was something they had never had to do previously. The hearing students learned new communication skills (and some signing) which gave them confidence in tackling unfamiliar situations. The deaf students also made new friends and integrated better with their cohort to the extent that for the second OEGP in which they took part, they wanted to be in different teams from each other. They now knew they could make friends with hearing students and vice versa.

## Blind and Partially-Sighted Students

The experiences in this case relate to four blind students: one totally blind, two with the ability to detect light but very little other visual ability (both of these two had "seeing eye" dogs) and one partially-sighted individual, who can read magnified print. The four students were in different cohorts, but all of them undertook group project work in their second year at university, where the students were in a situation where they were expected to form their own groups, and the group project work contributed one sixth of the work that the students were expected to undertake in a semester.

The two students with seeing eye dogs, one male and one female, were similar in that they were both direct entrants into the second year of the university course, transferring after successfully completing their first year at a different university. They were both determined and bright individuals, the male eventually proved to be one of the three most academically successful students in a cohort of about 50, and the female had transferred universities because her sighted brother was starting the first year at university and their parents were dead so she felt that she needed to support him. Despite having to make friends before they could find a group, both of these individuals used their considerable personal and social skills to first make friends, then find a group, but they both managed it without requiring any help from the educators. From observation and the personal reports written by the students in the groups as part of the assessment process, both of these students made above average contributions to their respective groups. The female student became group leader, as well as

carrying out more than her share of the task, while the male became "chief analyst/programmer" for the group. Both used their abilities to listen to, and understand, what was being said to very good effect, and their groups had fewer misunderstandings of the requirements than most of the other groups.

The partially-sighted student had worked with a totally blind fellow student in the first year, but that individual had not satisfied the first year assessment criteria. These two students had done everything together in their first year, and had not integrated very much with the rest of the cohort. This meant that the partially-blind student was worried, before the module commenced, about how he would be able to find a group and how he would work within the group. At a meeting with the staff managing the module, it was agreed that he would like to find a group of his own, but if he could not do so the educators would find a way to get him placed with a group. This reassurance was sufficient to give him the confidence to find a group. Once in the group, he contributed well, so much so that by the end of the project, other group members were turning to him when they needed support. The final, and most recent, example involved the totally-blind student who has a helper to escort him between lectures and someone to take notes for him during the lectures. He, naturally, was extremely concerned about how he would manage to join and work with a group, since he had not mixed very much with the other students. However, he was reassured when he was told about the successful outcomes for the other blind students, as reported above, and he did, in practice, find a group very early compared with most of the other students. Furthermore, because of his involvement, the group has decided to consider disability issues as part of their project work and have sought, and gained, permission to do this.

## Summary of Experiences with Disabilities

The overall message both from these sets of experience and from experiences with other students with different sorts of physical and mental disabilities (e.g., paraplegic, cerebral palsy, agoraphobia) is that the most important factors in getting a successful outcome are the determination of the student with the disability to contribute to a group and the initial willingness of the other members of the group to accept them. Once these steps are taken, there seem to be fewer difficulties in groups that exhibit significant diversity than in the groups which are apparently homogeneous.

## Gender

The OEGP approach naturally puts greater emphasis on collaboration rather than competition, since the task is intentionally larger than can be accomplished by any individual and, by being open-ended, requires all of the group to work together to agree what is to be done and to contribute to doing it. Underwood (2003) suggests that women fare better and feel more comfortable in a cooperative situation, whereas men prefer to compete and both Yieron and Reinhart (1995) and Underwood argue that a collaborative learning environment may well be more successful at drawing female students into the computing community. If this is correct, then the OEGP approach should naturally provide a more comfortable environment for female students. The experiences of the authors certainly bear this out, although it is also necessary to observe that the female students are quite as diverse as their male counterparts and not all female students are shy, retiring or lack confidence in their technical skills. Some of the female students do, indeed, seem to lack confidence and defer to the male students in the groups. However, some of the female students, particularly those in programs where there is a high percentage of males, seem to relish the competitive element and are very likely to take the lead in their group. Nevertheless, one of the important issues in most university computer science programs is the need to encourage more female students to come into the program and to give the female students who do come a greater confidence in their own ability to contribute effectively. The two examples given below focus on this and report experiences where the situation has been adjusted to successfully encourage the female students.

### *Example 1: Using the Rapporteur Role to Encourage Female Students*

For many years, computing has been very much a male preserve, and many of us teaching in the areas of computing and Information Technology have been accustomed to classes which consisted mostly of male students. With the introduction of courses based in Information Technology, this picture has shifted. Classes in Information Technology, and those which cover the "softer" aspects of computing, may often consist of a 50-50 gender split, or even have a predominance of female students. However, women in these classes quite often show a tendency to let their male colleagues take the lead, and are frequently less confident about their abilities, particularly in software development. Members of a cohort who are lacking in confidence or feel shy about

taking part in whole class discussions usually find that the smaller groups required by the OEGP approach provide a much easier place to air their views and to learn to take a more active part. The OEGP naturally requires communication within the group and with the tutor. Where the OEGP involves the whole cohort working together rather than in competition, teams also need to communicate with other teams. One of the authors has found that appointing a student as the rapporteur for the group encourages that individual to act as an administrator for the team they are a part of. They are then also expected to communicate on behalf of their team with other teams. Female students are quite often encouraged by the teams to take on this administrative role, and they will often accept it because it gives them the opportunity to "care" for their team, only to discover a little way down the road that they have more of a communication and leadership role than they envisaged. Gradually, even the shyest are encouraged to take a more active part and this builds their confidence. Making use of, and enhancing, the collaborative nature of the OEGP approach in this way encourages the female students and, quite often, a female student will emerge as one of the spokespersons and leaders for the cohort, and will manage it, making decisions and delegating as necessary. A subtle use of this tactic may encourage female students to take on technical roles as well, which, sadly, they are often reluctant to do. In one case, where a mixed team involving both males and females was deputed to take on the testing and bug reporting, a young women who initially claimed that she would be technically incapable of carrying out the task ended up taking over responsibility for the leadership and organization of the group, after gaining confidence in the rapporteur role. This illustrates the effectiveness of the OEGP approach in helping the students to discover that they possess skills that they did not anticipate that they possessed. This typically happens when the student recognizes that to complete a task the group will need to deploy a skill, or gain knowledge, that no-one in the group appears to possess. The concern for the success of the group overcomes the confidence barrier and leads to the individual gaining the skill or the knowledge in order to ensure that the required task is completed (Faulkner & Culwin, 1999).

### *Example 2: Using OEGP to Assist in the Recruitment of Female Students*

As noted in the previous example, the OEGP approach emphasizes collaboration rather than competition. One of the authors has also found that a suitable

choice of the task for OEGP project work can be used to attract more female students onto a particular module within a degree program. In this case, the OEGP was based on the idea of providing IT solutions for a hospital. The caring, social responsibility aspects of this project proved to be particularly interesting for a section of the female student population, who felt that their skills were particular needful for that type of project. (Daniels, Jansson, Kavathatzopoulos, & Petre, 2000). The success of this choice of task in attracting more female students also encouraged a change in the choice of the OEGP task on another module. As mentioned earlier, in that case the task was changed from the overtly competitive, and primarily male-oriented, world of Robocup (involving the design, construction and deployment of soccer-playing robots) to the design, construction and deployment of rescue robots.

### *Summary: The OEGP Approach, an Effective Way of Incorporating and Capitalizing on Diversity*

The examples that have been given in this subsection, and the many more that could have been given, all show that the OEGP approach accommodates diversity within groups very effectively. The authors also observe that not only do the individual students within groups benefit by working together, but students within other, less diverse groups ,may also begin to see the advantages that are offered by having diversity within the group.

The next subsection briefly examines some ways in which the OEGP approach might be used to specifically address particular diversity issues within the curriculum. It also identifies some of the research questions associated with the OEGP approach.

## What Next

The previous sections of the chapter have presented a case for the OEGP approach as a very effective way of accommodating issues of diversity that occur naturally amongst students studying in an undergraduate degree program. It has also suggested that there is some evidence that the observed advantages of diversity within a particular group leads at least some of the students in other less-diverse groups to see the advantages of diversity.

This section addresses the question:

*"How might the OEGP approach be used to explicitly include some aspects of diversity in the curriculum?"*

It uses two examples to show how the approach could be used to address specific issues in diversity. It then identifies a number of research questions whose answers might help improve the uptake of the approach (encouraging staff to try the OEGP approach has been, and remains, a major challenge for the authors).

## Designing a Module Based on the OEGP Approach to Help Students Reflect on Particular Aspects of Diversity

As noted earlier in the chapter, the design of a module which will use the OEGP approach to help students gain skills, new knowledge or integrate and reinforce existing knowledge depends on a lot of interrelated factors, many of which will actually be constrained in real situations. This subsection identifies two possible "diversity objectives," and discusses possible module designs that would be likely to achieve the desired educational outcome based on the previous experiences of the authors.

### *Example 1: Getting Students to Consider People with a Visual Impairment When Designing Generally Accessible Web Sites*

Obviously, as described in the title, this would be a partial goal for the module since the task itself could be chosen to meet other educational objectives. Depending on these other educational objectives and the constraints imposed by the existing degree program elements, it might be appropriate to specify a particular subject for the Web site (this could vary from "car sales" to "database design," depending on the students involved) and then add the need to consider people with visual impairments into the constraints. A typical requirement for the groups could be: "demonstrate how the interface would support individuals with, and without, visual impairment" (asking groups to provide a demonstration of what they have done is one effective way of both observing how the group works and of giving a format in which feedback may be given to the group

on what they have done). If it was desirable to encourage the students to give more thought to the issues involved then an additional requirement, a report could be specified (e.g., list the issues that you have considered and describe how each issue has been addressed in your design). If still greater emphasis on the issue was required (and more time was available), then the students could, for example, be asked to design a set of test criteria for the interfaces assess the interfaces provided by other groups and provide a report on their findings.

*Example 2: Accommodating Diversity—Designing for Customers in Different Countries*

This example could address differences in culture and assumptions as well as differences in natural language. Again, the diversity issues would only be one of several aspects which the module would be addressing (this is a very general comment, diversity is only meaningful in a wider context and, the authors would strongly recommend, it should be addressed in this way). Similar examples have actually been used by two of the authors to help students in Sweden, the US and the UK consider these issues. The Swedish and US students were asked to produce and implement appropriate designs, while the students in the UK carried out evaluations on the designs. In this case, the students doing the designing were producing Web sites and were told to produce sites in English, the challenge being to make the sites accessible to the very wide range of cultures represented in the evaluation cohort in the UK university.

## General: Designing for Diversity

More generally, the above two examples will hopefully illustrate the idea that any specific diversity issue could be incorporated in a module which uses the OEGP approach. This can be accomplished quite straightforwardly by adding a deliverable which asks each student group to design for, demonstrate and report on how they had addressed the chosen diversity issue. However, it must be noted that there are limits to the number of issues that may be added to any single OEGP exercise, since it is necessary to ensure that the "reward" (usually marks) for each aspect of the exercise does not become so small that the students can safely omit one or more of the aspects without jeopardizing their overall success.

## Deploying the OEGP Approach: Associated Research Questions

The most important research questions, as far as the authors are concerned are probably: "How can teachers be encouraged to try the approach?" and "Why is uptake so limited if the approach is as successful as our observations lead us to believe?" These questions will be discussed in the conclusion. In this subsection, more limited questions will be posed which might be possible to answer via experimental design.

1. Measuring the skills or knowledge that is obtained and the degree of retention when compared with alternative teaching methods.

   It is a fairly common (anecdotal) observation that students learning for an examination seem to have forgotten what they learned by the time the examination is over. In contrast, experience gained from actually carrying out work for oneself and learning from one's own mistakes tends to be retained. The OEGP approach is intended to provide a safe and supportive environment in which the students may try things out, make mistakes and learn from them. Measuring how much is actually learned and retained and being able to demonstrate this objectively would be very valuable. A longitudinal study of a particular student group to see whether the knowledge and skills are retained over time would be particularly valuable.
2. Time spent by staff and students when undertaking an OEGP.

   This question addresses two different questions that are frequently asked, and also two concerns that are often expressed by staff who have not experienced a module which uses the OEGP approach. The questions are: "How much time do the students spend on a module based on the OEGP approach?" and "How much time do the educators spend on a module based on the OEGP approach?" The concerns that are frequently expressed are that both staff and students will spend a disproportionate time on the module and, conversely, that the approach allows some students to "get away with doing very little." If a suitable experiment could be designed, the results obtained by studying the two questions would ideally be linked with the outcomes from the previous questions to see whether the learning achieved by the students was at least commensurate

with the effort that was put in or, as the authors believe, proportionately greater.

3. Obstacles, real and perceived, in addressing diversity issues using the OEGP approach.
4. Designing experiments to assess these questions in a way to avoid disadvantaging some students.

   The traditional experimental designs require comparable sets of experimental subjects to be "processed" using different techniques. The results would then be compared. However, when the subjects are students studying for a degree and the experimental procedures are different teaching methods intended to help them with that study, the concept of "double blind" testing, such as is used to eliminate bias in drug tests, seems completely impossible to undertake. Even if the students could be split into two (or more) comparable groups and each group could be subjected to different teaching methods, it would not be easy to prevent knowledge and skill transfer between the groups outside the structured teaching environment. Furthermore, if one of the groups performed significantly better than the others then the students in the groups that performed worse would have a prime facie case that they were discriminated against and entitled to compensation.

## Conclusion

Starting from the premise that education should have a role to play in the development of well-adjusted citizens and workforces of the increasingly diverse societies of the future, it would be reasonable to ask how diversity may be incorporated into the educational curriculum. This chapter has suggested that the OEGP approach would be an effective way of including a consideration of some diversity issues in the university curriculum. However, given the claimed success of the OEGP approach for dealing with a variety of educational and social questions, it might seem strange that the use of the OEGP is not more widespread than it apparently is. Several possible concerns are discussed below, but it is also possible to consider that a fear of diversity is one reason for the slowness in the uptake of the OEGP approach. University teaching, particularly in science, has traditionally been based round the lecturing paradigm, and most of the methods of assessing the performance of lecturers are

geared to the lecturing approach. Using the OEGP approach inevitably means that some of the assessment elements which are used to decide whether a lecturer is competent (e.g., was the lecturer well prepared, did they have a plan for the lecture, did the lecture have an appropriate structure, etc.) will not be fulfilled and, therefore, it is inherently risky and may threaten career progression. This worry may only be addressed by overcoming the prejudices and gaining acceptance that using the OEGP approach as a supplement to the more conventional lecturing approach does bring benefits in learning and retention.

Other concerns are rather easier to address since they are not institutionalized in the assessment procedures which are prescribed for the educators.

To begin with, one of the biggest reasons for resistance to the use of the OEGP comes from both staff and students, and that is that the OEGP cannot be assessed fairly. Many authors have commented on the seemingly difficult task of deciding who gets what and coping with "free wheelers.". All three authors have addressed these problems in different ways, and although anyone using the OEGP would not deny that there appears to be a problem, it is not insurmountable. One technique that may be used is for the teams to have regular monitoring meetings with the tutor running the OEGP. This allows the tutor to ensure that all students are working consistently and doing their fair share. Logbooks, or minutes, may be kept by the teams in order to ensure a record of each student's contribution. Students may be asked to "pay" their fellow team members, thus allowing them to comment on the effectiveness of their teammates and themselves. These "payments" may then be used to decide how marks might be distributed. The OEGP might of itself contribute very little to the final assessment mark. For example, students might be required to provide a final report on what they did, or the teamwork could be the process by which further work is done. One author uses the OEGP to build software which is then used in a survey. The data available from the survey is then used by the students to write a "conference paper," which forms the majority of the assessment marks. In this way, the OEGP is the process by which the work is done, but it isn't the entirety of the exercise and forms very little of the final marks. It has to be said that in the experience of the three authors, students are very honest about their contributions to the team effort. They are unwilling to let down their fellow teammates in the first place,and, if their effort has been less than 100%, they usually confess to that and agree to having their team mark component reduced. Most teams are quite realistic about what they have accomplished. Again, this very process of addressing the diverse nature of each student's contribution can help students to evaluate and assess their own contribution, and is part of the skill base for cooperative behavior.

There is also resistance to the OEGP because staff are unsure as to how they will manage disputes should they arise. However, if disputes are seen as part of the process of learning cooperation and compromise, then they cease to be negative and become a positive part of the learning process. When disputes occur, students need to be encouraged to find out why they have occurred and to talk through possible solutions. When people work together, there will always be disputes but these do not have to be negative and learning how to deal with them is necessary. It is better to learn in the safe environment of the OEGP than in the workplace. Staff may wish to help this process, but they should not be a substitute for the compromising that will need to occur. Students may sometimes ask for interventions from staff, and these requests will need to be dealt with firmly and kindly, but finally learning to deal with diversity is all about finding solutions that everyone can accept and students have to address that.

OEGP topics may also be problematic. It is easier by far to have a few assignment topics with clear-cut answers which can be used in rotation. Finding a practical and useful topic for an OEGP is not always easy. However, on the positive side the OEGP can be used to introduce exciting new topics which would otherwise not find their way into the educational diet and are perhaps too small for an entire module. Again, this can in its turn be a way of introducing diversity into the curriculum.

The OEGP requires the tutor to cease being an all-knowing guru who answers all questions and shows the way. The tutor engaged with an OEGP acts as a guide and a mentor, offering advice only when he or she needs to. The OEGP is a cooperative environment, not just for the students, but also for the tutor. This is particularly the case when the topic being covered by the OEGP is a research one. Some staff may find this shift from being the font of all wisdom to an adviser or signpost difficult to adjust to. Perhaps the biggest hurdle, though, is one of custom. It is not easy being a teacher. Lecturing is very like starring in a play where there is no real script and the audience is allowed to join in as they wish. For some lecturers, the OEGP seems to take away even more of the script. Thus, shifting to an OEGP approach may be seen by some as letting go of control. This is not always an easy decision to make, but the rewards for both staff and students should not be underestimated. Perhaps the best approach for anyone considering an OEGP is to try one occupying only a few weeks, or to try it first in a team-teaching environment, where there are other lecturers to offer support.

As societies confront the need to ensure the participation of all sections of their communities, so the challenge of coping with diversity will come more to the

forefront. Societies can legislate to ensure that all of its people have the chance to take part in all walks of life and to enjoy the fruits of society equally. However, the real challenge comes when people live with the genuine consequences of the attitudes which such legislation seeks to foster. All people, whatever their racial background, color, creed, sexuality, physical and cognitive abilities, deserve to take their place in society on an equal footing. The challenge for society is to ensure that its people are not weighed down by past prejudices. To a great extent, education can help to foster a spirit of cooperation and positive acceptance of the differences that people exhibit. It is not simply that society needs to offer people with disabilities, for example, the chance to take part in the community, but that society needs to recognize that the very differences betweens its people are the source of much strength. Homogeneity produces fewer novel and exciting solutions than heterogeneity does. When students work alone, they witness only their own backgrounds, assumptions, skills and propensities. By asking them to work with others, educators can show the citizens of the future how differences are the strength of society. The OEGP, by encouraging and fostering a spirit of mutual respect and cooperation, can help shape the workforce and citizens of the future so that the legislation which is now necessary to protect minorities will become unnecessary. The modern workforce needs to be one without harmful prejudices. By subjecting students to the problems and joys of working with diverse people now, we ensure that they are equipped to deal with the increasingly diverse nature of the society they live in and will have to work in. The OEGP can do this in a safe environment so that attitudes and practices may be tried out and evaluated.

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# Paper III

# Experiences from using Constructive Controversy in an Open Ended Group Project

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*Abstract* – **The purpose of this paper is to inspire other educators to aspire to *true collaboration* in student projects by presenting experiences from two course instances where *speed dating* were used in the light of *constructive controversy* ideas. The educational setting is an international student project based on an *open ended group project* framework in which scaffolding is introduced to ensure that essential teamwork skills become part of the learning experience for the students. An *action research* approach has been used by the authors to both develop the course and acquire information about the learning outcomes. The particular focus in this paper is to report findings about if and how constructive controversy can be used in the scaffolding.**

*Index Terms* - Education research, Open Ended Group Project, Constructive Controversy, True collaboration.

## INTRODUCTION

The educational framework Open Ended Group Projects (OEGPs) [1] has been used in order to create an inspiring learning environment in a semester long 4th year project course. This course, IT in Society [2], has been run since 1998. One aspiration has been to open the eyes of the students to the benefits and power of true collaboration [3] in which the students work together rather than merely divide the job. There are many factors that influence how well this is achieved and the success has varied over the years, leading to a desire to find ways to positively influence the project towards true collaboration. The focus in this paper is the true collaboration issue.

During the 2008 instance a form of speed dating was introduced by the students that seemed to be promising for inducing true collaboration. The speed dating technique fit well with ideas behind *Constructive Controversy* [4], [5] and an effort was made during the 2009 instance of the course to build on this theory in order to guide the students towards true collaboration [6]. The basic ideas behind the new structuring of the speed dating event in the 2009 instance is presented, but comparisons with the 2008 instance will be made.

The results of the implementation will be presented as seen through the eyes of the instructors and through written and oral reflections from the students as well as anonymous course evaluations. The results will be contrasted to those of the 2008 instance. Suggestions for further development will be given based on an analysis of the results.

The pedagogical focus for the instructors of this course is to find a balance between the *openness* of OEGP and the guidance some students need in order to not become confused and miss the learning opportunity. The balance in question with regard to the issue of this paper, i.e. true collaboration, is about creating a learning environment where the students fully participate in the OEGP in the sense that they have a well-developed overall understanding of the situation as well as the constituent parts and the skills of the team members. Achieving this provides an important foundation for true collaboration, since a situation where members in a team are confused due to the complexity of the problem addressed they often resort to the, for them, more familiar divide and conquer technique in order to deal with situation and thus miss the *true collaboration* experience. Constructive Controversy is a method that is promising for creating a mutual understanding of a problem area and it is used to help reduce confusion in the OEGP setting.

## RESEARCH METHOD

These research findings are based on participatory observations as we have taken part as reflective practitioners [7] and supervisors in the IT in Society course in an action research approach [8], [9]. This has included written assignments as well as both individual and group meetings. The written reflections were handed in by all students, where one was focused on the experience with the speed dating event and one was a final reflection on the course as a whole. The last individual meeting was held after the project and was done as semi-structured interview based on the final written reflection and lasted typically one hour. Some evidence have been gathered from anonymous course evaluations. Analysis of data has been done through workshop meetings, where memory recall has been supported by the written reflections and statements in the course evaluation.

## EDUCATIONAL SETTING

The educational setting is described elsewhere, e.g. [2], but a short summary might however be useful in reading this paper.

The IT in Society course is run in collaboration with a course in US (Communication in a Global Society) and is

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offered to students taking the first semester of the fourth year. The course accounts for half of the study load for a student during that semester in the IT engineering degree program at Uppsala University, Sweden. A goal of the IT in Society course is that the students should be able to constructively participate in a project dealing with a complex and multifaceted problem set in a real environment.

Since 2002 the setting has been the Uppsala Academic hospital and since 2004 all students have been involved in the same project. The number of students has varied between 20 and 45 over the years.

Based on OEGP ideas they are supposed to organize their work themselves, but some restrictions apply. They must, for instance, all work together in *one* project and there should be subgroups with between four and eight members where no such group should have a single member from either Sweden or the US.

The setting for the 2009 course was to look into the issue of providing online access to health accounts for everyone. The students formed five groups, i.e. Culture & international aspects, Economy, Ethics, System architecture, and Usability, and appointed three students as project coordinators. The Economy and Ethics groups had only Swedish members, all others had a mix of Americans and Swedes.

## THEORETICAL BACKGROUND

### *I. Constructive Controversy*

Johnson and Johnson define constructive controversy as follows:

> *Constructive controversy* exists when one person's ideas, information, conclusions, theories, and opinions are incompatible with those of another and the two seek to reach an agreement [10]

The important aspect in a learning situation is the focus on seeing different aspects of an issue and an ambition to find a solution to the issue from this wider view [4], [5].

The benefit of constructive controversy is that alternative solutions will be presented and adequately considered and efforts will be made to find ways to reconcile the differences in finding a satisfying solution considering the different aspects that has been brought forward in the process. The idea is that the participants needs to have a thorough understanding of the different aspects, including questioning their own solution, in order to be constructive in their seeking of agreement. There is an emphasis on creating new solutions as opposed to sticking to original ones.

Johnson and Johnson presents six stages the students should go through in their examples of how to create an educational setting based on the constructive controversy model [4]. These stages are:

1. Students are assigned problem/decision, initial conclusion
2. Students present and listen, are confronted with opposing position
3. Students experience uncertainty, cognitive conflict, disequilibrium
4. Cooperative controversy
5. Epistemic curiosity, information search
6. Incorporation of new information, adaption to diverse perspectives, new conclusion

### *II. True Collaboration*

True collaboration can have different meanings, here it is related to how it is used in the cognitive psychology domain, e.g. as discussed in [3], [11] regarding the difference between collaboration and cooperation. This is captured by King as follows:

> *Generally the term collaborative learning means that learners are engaged in activities that are intended to introduce socio-cognitive processes. This meaning implies an important distinction between collaborative and cooperative learning. Cooperative learning often involves separate activities by individuals through the distribution of labor or task components, with little of the joint activity that induces socio-cognitive processes so characteristic of true collaborative learning. ([3, p.18])*

This description of collaborative learning fits well with the view on true collaboration in the paper.

### *III. Speed Dating*

Speed dating has developed from being a way for young people meet their future spouse to becoming a general technique for effective meetings. The properties of interest in this context are that each one (group) meets everybody else (all other groups), that there is a time limit on each meeting, and that there is a format for the discussions at the meetings.

## CREATING TRUE COLLABORATION

True collaboration is a natural consequence of a well functioning OEGP and it is closely related to engaging the students, to motivate them. There are however obstacles in the way, not least the inexperience among the students with the OEGP approach. A need to support the students has been identified and a number of efforts have been made over the years. These range from selecting projects from "real life" as well as adding an international cohort of students to explicitly explaining the underlying learning theory. The latest effort has been to use constructive controversy as a guide for how to develop scaffolding for the students.

This was based on the speed dating event introduced in the 2008 version of the course as a student initiative. The students had to do a major restructuring of the report they were working on and needed a way to get the whole cohort up to speed with the new direction as well as identifying concrete examples on what to enter into the new structure. An afternoon was set aside in which each of the seven subgroups meet with all the other subgroups and tried to identify common issues during a quick meeting [12].

This turned out to be a well functioning way to get a large portion of the students aware of the project as a whole and provide useful insights into who could address which issues in the restructuring work. This collaboration was of a depth and genuineness that had a clear sense of true collaboration. The speed dating event was deemed to be a good starting point for introducing constructive controversy as a means to create true collaboration in the 2009 course instance.

The speed dating event in the 2009 instance was set about ¾ of the way into the project and was planned according to constructive controversy ideas. The instructors provided the project coordinators with a "package" consisting of pre and post meeting assignments as well as a description of how the meetings should be conducted. The plan and the outcome is presented in the six stage frame given by Johnson and Johnson [4].

*I. Stage 1- Students are assigned problem/decision, initial conclusion*

This stage can be seen as being composed of two parts in our setting. The first part was the work they did in their respective subgroup. They spent most of their time prior to the speed dating event in becoming "experts" in the domain of their subgroup. The second part was the actual assignment for the speed dating event. Each subgroup was to identify something they wanted from each of the other subgroups that would be beneficial for them.

Each subgroup had a fair understanding of what the other subgroups were supposed to do and actually had done, mainly from the initial discussions about the essential aspects of the project and a mid-term presentation for the client. The subgroups did however not engage with much enthusiasm with regard to identifying what they wanted the other subgroups to contribute with. Several commented on it being unnecessary work that interfered with the work they were doing already and that they had a hard time coming up with valuable things the other subgroups could do to be of direct use to them.

*II. Stage 2 – Students present and listen, are confronted with opposing position*

This was the most active phase of the speed dating "package", where each subgroup had a short meeting with all the other subgroups. The students were not supposed to be confronted with an opposing position as such, but rather confronted with a number of demands on their time and expertise, as well confronting the other subgroups with demands based on their understanding of what the subgroups were supposed to do.

The level of confrontation varied for the subgroups, but each did experience both other views on what they should do and got in a position to have several good ideas to choose among. The conflict was however reduced for most subgroups due to the suggestions deemed as valuable being, according to several students, along lines they had already considered doing themselves.

*III. Stage 3 – Students experience uncertainty, cognitive conflict, disequilibrium*

This stage was supposed to be reached due to each subgroup being exposed to different views on their work and how it best could contribute to the project. The idea was that each subgroup should be faced with several potentially good alternatives, which would create uncertainty about which to choose. The explicit demand to only oblige one of the other subgroups was supposed to increase uncertainty.

The students played along with these rules in the speed dating event, but there was an underlying "understanding" that a subgroup would not do anything unless they did find it essential for the progress of the their work. The uncertainty was thus not as prominent as intended, but there was a different type of uncertainty present. This uncertainty came from the subgroups finding unexpected views on what they were doing.

*IV. Stage 4 – Cooperative controversy*

This stage was in our example somewhat overlapping stage 2 in that the controversy about how to cooperate was raised already at that stage. There were still issues to deal with regarding how to conduct the cooperation. A slightly different controversy in this stage was to get into a situation where different options on cooperation were present and they could not all be followed. It was also not clear how the chosen cooperation should be carried out.

This stage was however not as strongly stressed since the cooperation was mostly done in a serial mode as a suggestion from one subgroup followed by action by another subgroup. It appears that most students did not see it as cooperation at all.

*V. Stage 5 – Epistemic curiosity, information search*

The discussions were supposed to bring many different aspects of what could be done in the project to the surface. The idea was that these aspects would spark a curiosity about what could really make the project better and thus provide incitement to dig for more information.

This occurred, but most students felt at this time pressed to deliver what they already saw as the contribution of their subgroup to the project as such. There were some reports on new insights and a genuine new understanding of what a wider perspective on their work could lead to in terms of improving the project. These were however considered more as good ideas to note rather than something to act on due to not enough incentive to change what they were doing.

*VI. Stage 6 – Incorporation of new information, adaption to diverse perspectives, new conclusion*

This stage consisted of coming up with an agreement with one other subgroup on how to proceed with the suggestion that subgroup had made. The agreement was supposed to be based on a mutual understanding of the value of the time spent with regard to the project as such. This stage was intended to also include carrying out what was agreed on.

This resulted in some creative ideas and discussions about what was essential for the progress of the project. The general aura was however of it being an academic exercise that they could put on hold while doing the things they previously considered important to do. Contributing to this was the low buy-in from the project coordinators in the value of the speed dating "package". The project coordinators arranged the activity and participated as listeners in meetings, but they reported that they did not have their heart in the activity, since they felt it was forced on them by the course instructors.

## ANALYSIS

The speed dating functioned well in the aspect of making the students aware of what the other students really did. In the final reflection almost all students expressed that the speed dating was the occasion when they really understood what the other project subgroups worked with. This was an important aspect of the speed dating event, since there was a clear lack of communication between the groups before the speed dating. The subgroups were content with working on their own problems without really knowing how this fitted into the context of the other subgroups.

The speed dating did however not lead to true collaboration in the project. This is perhaps most visible when looking at the culture & international aspects, economy, and ethics subgroups. These subgroups represented aspects of the project that were seen as peripheral to the result. Statements with the implication that the system architecture and usability subgroups were the important parts of the project were not uncommon, and not least in the other three subgroups.

This could perhaps be explained by relating to the reflective practitioner concept [7], where the students lacked confidence in relying on reflection as a basis for what to work on. It appeared as they did not trust in the value, or rather their ability to contribute anything of value, to the project in a situation where the problem they addressed mostly looked like a swamp in contrast to the safe ground they were used to when working with issues closer to what they saw as IT-work where rigorous methods could be used.

Most students pointed out that the timing of the speed dating event was problematic. They were too focused on finishing the report in the way they already had agreed on at the time of the event. Some suggested that there should have been an event early in the project followed by another one towards the end of the project.

The American students were only part of the preparation and the wrapping up phases. This lead to a situation where the whole event became rather obsolete for them.

The perhaps most interesting insight came from comparing the two course instances. The actual speed dating event was more thought through in the 2009 instance and included ideas from the constructive controversy model, but the 2008 instance was, as seen by the instructors, more successful in reaching the true collaboration goal. The conclusion was that the difference was not due to the speed dating event as such being less efficient in the 2009 instance, but rather in that the 2008 instance had a contributing constructive controversy factor. The 2008 students were faced with the dilemma of what to do with their report, i.e. continue with the direction they already had taken or making a major restructuring. They had a real incentive to truly work together in order to reach their goal, in that the restructuring required them to integrate knowledge from the different subgroups in writing the text.

One ironic observation is that the ambitious leadership provided by the project coordinators probably contributed significantly to the lack of true collaboration. They "paved the way" in such a way that conflicts rarely occurred, and thus also reduced the need for the other students to interact in order to make the project progress. Almost all students reported that they were highly satisfied with the way the project coordinators lead the project. A rare few did however comment on the strong leadership resulting in a lack of collaboration between the groups.

Almost all students realized in the meeting about the final reflection that it would have added an interesting depth to the result if a closer collaboration between the subgroups had occurred. This was partly due to recognizing that the client had many questions relating to the cultural and ethical aspects of the project and partly due to the instructor pointing out that important aspects brought up by the economy subgroup not really influenced the prototype solution they had developed.

## IMPLICATIONS FOR OTHER EDUCATORS

Running courses within non-traditional settings is a challenge and one way to meet the "resistance" among the student cohort is to be explicit about the underpinning educational considerations, such as exemplified in this paper. Our experience is that being explicit and to inform students about the pedagogic reasons for the activities improve their learning experience.

To act as a reflective practitioner [7] can provide important insights into the educational process, both in terms of being able to explain why a learning environment is set up as it is and also to further develop theories and methods.

When working with in an OEGP setting students might feel uncomfortable, and resort to the strategy of creating a set of well defined sub-problems to solve without fully grasping a holistic view of the problem. This strategy does not lead to the kind of learning experience we are aiming for, and the method constructive controversy show promise in making the student abandon this strategy.

The most important reflection about this work is that the constructive controversy model can be used in a less structured manner than suggested in e.g. [4] with good results. The important aspect is to create a situation where the students will get a genuine experience of improvement.

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# Paper IV

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# Engineering Education Research in Practice: Evolving Use of Open Ended Group Projects as a Pedagogical Strategy for Developing Skills in Global Collaboration*

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*Globalization presents engineering educators with new challenges as they face the need for graduates who can function comfortably in an increasingly distributed team context which crosses country and cultural boundaries. Scaffolding learners to acquire professional attributes which transcend the solely technical places stress on traditional curriculum models. This paper analyses an Open Ended Group Project Framework (OEGP) situated in an action research program applied within the IT in Society course at Uppsala University. The approach results in conscious evolution of the course as an integral element of its design. It enables flexible planned educational change informed by a combination of learning theories and stakeholder input. In this paper we discuss the role of the research program in addressing the educational challenges we faced assisting students to develop global collaboration skills. The implications of combining this course with one at a partner institution in the USA and developing a global collaboration are also addressed. The paper concludes by summarizing the benefits of adopting an integrated action research and OEGP framework to support flexible course delivery in a global professional engineering context.*

**Keywords:** Open Ended Group Projects; global collaboration; action research; engineering education research

## 1. INTRODUCTION

This paper argues that educational changes should be soundly informed and based on (engineering) education research findings, in direct contrast to 'folk pedagogy' as critiqued by Lister [1]. We present an evolving learning theory for the *IT in Society* course at Uppsala University [2] based on the Open Ended Group Project Framework (OEGP) [3] over a sequence of course instances. The goal has been to provide an improved learning environment where the students develop essential skills for global collaboration.

Change in curriculum and methods of teaching seem to be endemic for engineering degree programs, but recent drastic declines in applications suggest the need for more radical changes. In Sweden the number of applicants that chose an engineering degree program as their first choice has almost halved from approximately 11,500 in 1999 to just over 6,000 in 2006 [4]. In New Zealand a recent report has identified a severe shortage in computer science graduates [5]. In both the United States and internationally McGettrick [6, 7] has identified the 'crisis' in computer science enrollments as one of the 'grand challenges' for computing educators.

There are many possible reasons for the declining interest in engineering careers, and much effort has been devoted to addressing this issue. While the nature and quality of engineering education itself may be far from the top factor influencing interest, it is fundamentally important for retention of students once enrolled and is especially important for those students that enroll as a result of widening participation efforts. One set of challenges is to adapt engineering education to a more varied cohort of students, but perhaps even more importantly to a changing world, e.g. the globalization of economies, education systems and the workforce. These challenges are closely linked to development of transferable skills while studying at University. The development of these 'soft'

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skills is crucial for the new engineers and their employers, and for stakeholder perceptions of the value and relevance of engineering education.

The importance of transferable skills in the IT industry is apparent in the Association for Computing Machinery (ACM) job migration taskforce report on 'Globalization and Offshoring of Software' [8]. The report advocates a set of educational responses to recognize a fast changing reality, including preparing students for satisfying global careers and for creative and innovative roles that are less likely to be commoditized.

One such educational response is the adoption of an OEGP. Yet a strong counter force to introducing that mode of pedagogy is the simplistic, 'black and white' mode of thinking, often presented in early courses. In their early training engineering students thus become firmly convinced that there is a single 'correct' solution to engineering problems. Rick and Guzdial observe that in engineering education in the USA:

> Students in engineering and mathematics, additionally, tended to see their homework as having only one correct answer, even when faculty stressed that this was not the case. [9]

Furthermore they noted from Cohen's [10] review of the collaborative learning literature, the extent to which such a style of education limits more collaborative modes of pedagogy:

> open-ended, ill-structured problems tend to encourage productive group learning; if the students perceive that there is only one answer, there is not as much need for the group [9]

Such thinking is likely to be obstructive in dealing with issues that have many possible solutions and where the desire is to collaborate to explore many different approaches rather than finding the best solution.

A layered approach to OEGP courses had been implemented at Uppsala University prior to introducing the *IT in Society* course discussed in this paper. This started in 1998 with the international (Sweden—USA) project based Runestone course [11, 12] at the third year level, which was followed up that year with an introductory student collaboration (Sweden— New Zealand) at the first year level [13, 14]. Thus insight into the nature of such courses had been developed over time, with the latter collaboration in particular being developed through an active program of action research [15, 16]. For instance in the NZ collaboration, we had previously noted that the generally tightly structured teaching-learning culture at the NZ site created challenges, when employing a more open course model.

While this work has provided insights, putting the OEGP approach into practice, remains a challenge. This paper outlines the progressive development of the *IT in Society* course, and how this unique international collaboration has been informed by relevant education research. The focus is on efforts to achieve learning outcomes critical to effective global collaboration. Our claim is that OEGPs offer a way to set up interesting learning environments that support development of transferable skills for engineering.

There are two different strands of research to examine in the process of evolving the OEGP based instructional design for the course. One is the meta-view of the process, i.e. using action research [17, 18] both as a methodology by which to guide and plan the research, and as a lens to analyze how the evolution took place. The other strand deals with identifying and using relevant epistemologies, pedagogical theories and methods, which offered insights into the student learning environment and informed the changes implemented in the course.

This paper focuses on changes made to meet the challenges of globalization and evolving professional demands. It should be noted that these changes also are highly relevant for addressing more traditional professional demands [19, 20], much as strategies for making engineering education more relevant to female students, are beneficial for all students irrespective of gender. The *IT in Society* course and its operation in combination with the partner institutions (Uppsala based client and Rose-Hulman Institute of Technology, Indiana, USA) is the main focus of the paper. Attention is also paid to issues related to the IT engineering degree program as a whole. The latter illustrate how the evolution of a course both influences, and is influenced by, the engineering degree program.

In summary, the aim of this paper is to demonstrate how a scholarly approach can been employed to improve engineering education, by the use of OEGPs, in order to help our students to develop global collaboration skills. We hope that this concrete example will encourage others to develop courses on an OEGP model, and follow our example of an informed evolutionary approach based on an action research framework.

## 2. THE ACTION RESEARCH APPROACH

Action Research is a research method intended to support a process of active change. The researcher(s) typically work in a team model with practitioners to effect change in a given problematic situation. The process works in a cyclical fashion with continuing cycles of action and reflection. An illustration of the typical steps within a single action research cycle is given in Fig. 1.

The *IT in Society* course is offered once each academic year, which provides a natural planning window for an action cycle within the research programme. The course of the academic year provides an opportunity for reflection, to take stock of the progress made and learning gained in the previous cycle and acts as a logical planning point for the subsequent cycle. Outcomes and observations arising from an action plan for a

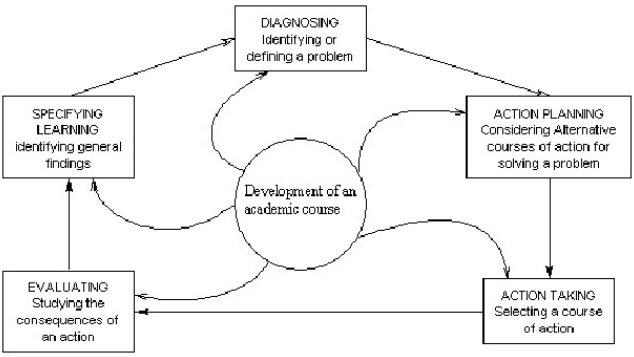


Fig. 1. The Action Research Cycle (adapted from [21]).

course instance naturally feed through into the design of the next.

> Action research activity is said by Carr & Kemmis [18] to have two essential aims, both to *improve* and to *involve*. The focus of this improvement lies in three key areas: improving a practice; improving the *understanding* of a practice by practitioners and improving the *situation* in which the practice takes place [15].

Our research follows the 'dual cycle' action research framework of McKay and Marshall [17]. The progressive addition of different pedagogical and conceptual frameworks are integral to the analysis for each action cycle. Within this variant of action research, the separate components of research and practice are identified and consciously addressed. Five elements are emphasized within their framework, which enable a conscious separation of the practice components from the research elements, and thus enable the research to avoid the trap common to action researchers of having their work described as simply 'consultancy'. The five elements are:

> [F] the research framework or conceptual element informing the research;
> [$M_R$] the research method to be adopted;
> [$M_{PS}$] the problem solving method that will be used in the practice situation;
> [A] the problem situation of interest to the researcher (the research questions);
> [P] the problem situation in which we are intervening (the practice questions of interest to the practitioners).

The application of McKay and Marshall's action research framework to our research is summarized in Table 1. The practitioner interest concerned, among other things, 'improving the global collaboration skills of student teams engaged in international teamwork'. The formal model presented in Table 1 implies a thoroughly thought out, and rigorously documented, research design and process. In practice the process was somewhat looser than indicated. Nonetheless we feel that structuring the informing elements of the research design in this manner provides key information to other researchers seeking to emulate our process.

Based on this ongoing program of 'action research' a sequence of course instances has emerged through which we have aimed to progressively develop the capabilities in global collaboration advocated by the ACM task-force. This progression has not been straightforward, and

Table 1. Elements of research investigating Global Collaboration Skills within a 'dual cycle action research' framework

| Element | Description |
|---|---|
| **F** (Framework) | • OEGP Framework, Constructivism, Threshold Concepts, Conceptual Change, Communities of Practice, Cognitive Load, Collaborative Technology Fit, etc. |
| $\mathbf{M_R}$ (Research method) | • Practical Action Research, with some aspects of Emancipatory Action Research. |
| $\mathbf{M_{PS}}$ (Problem solving method) | • *IT in Society* Course and task design, International Collaborations, Local sponsor, Practical Action Research, reflective practitioner model. |
| **A**—(problem situation of interest to the researcher) | • How does OEGP support or hinder the work of global student teams?<br>• How does OEGP develop student skills in global collaboration?<br>• How does OEGP develop student professional skills and ability to cope with ambiguity, complexity and to take responsibility for their own learning? |
| **P**—a problem situation in which we are intervening | • Improving teaching & learning through active learning approaches.<br>• Students as active co-researchers.<br>• Collaborative learning models.<br>• Developing student capabilities in teamwork, cross cultural communication and use of IT.<br>• Providing an interesting & meaningful learning experience.<br>• Improving viability of student or software teams engaged in international teamwork. |

many challenges have been encountered along the way. A number of these initiatives must be acknowledged as still somewhat experimental, and reflect the 'research-linked' teaching and learning experience inherent in the course development framework [11, 13].

## 3. EDUCATIONAL SETTING

Most of the issues presented in this paper draw on the *IT in Society* course, and its relationship with the companion course in the USA [2]. To provide the reader with the necessary background we describe the *IT in Society* course and its educational setting in some detail. The course runs during the first semester of the fourth year and accounts for half of the study load for a student during that semester in the IT engineering degree program at Uppsala University, Sweden.

Since 2005 the course has been intimately linked with the Communication in a Global Society course offered at Rose-Hulman Institute of Technology, Terre Haute, Indiana, USA. The course is an elective for both 3rd and 4th year students. Both courses are OEGP based and are practical examples of dealing with global collaboration.

A goal of the *IT in Society* course is that the students should be able to constructively participate in a project dealing with a complex and multifaceted problem set in a real environment. Since 2002 the setting has been the Uppsala Academic hospital and since 2004 all students have been involved in the same project. The number of students has varied from 20 to 45, depending on the year.

In 2008 the customer at the hospital introduced the teachers to the issue of patients accessing their medical records over the Internet, which was made possible by a change in the Swedish law two months before the course started. Students from both Uppsala and Indiana were initially asked to gather information relevant to this topic. The American students visited Sweden during the 3rd week of the course and at the end of this week the two student cohorts produced a project design (in collaboration with the customer), as well as agreement on how to collaborate. The main course deliverable was initially conceived as a report on the issue, but after discussions with the students and the customer a white paper and a process report were agreed upon as a revised deliverable. The white paper was to be used by the customer as a means to draw attention to the issue at the European Union council in Brussels and the process report was to be a reflection upon the process of engaging in the collaboration itself.

Thus the course assessment included both product and process dimensions. This emphasis on reflection on the process further illustrated the research-linked nature of the course through the students' application of the recently derived research framework of 'Collaborative Technology Fit' [16] and in producing a paper for the IEEE Frontiers in Education Conference 2009 [22].

## 4. THEORETICAL BACKGROUND

A number of key theories have guided the development of the *IT in Society* course. Since the common understanding of the differences between learning theories, methodologies and methods is somewhat blurred in the literature, the definitions given by Crotty [23] are used in this paper.

The view of knowledge, the epistemology, and how learning takes place, upon which the development of the *IT in Society* course is based is constructivism [24]. That is, we take the view that there is no objective truth to discover, rather, that knowledge and meaning is constructed through interactions in a social context. The idea of using constructivism in addressing educational issues was brought to the general computer science education community through work by Ben Ari [25] and subsequent discussions have influenced this work.

Two learning theories that have been useful in contemplating changes and understanding outcomes are conceptual change [26, 27] and threshold concepts [28, 29]. Both of them relate to changes in understanding in a learner and thereby aid in understanding which issues to take into account when attempting to set up a learning environment. Also of importance when considering what is possible in terms of individual learning are limitations identified by the zone of proximal development as introduced by Vygotsky [30] and those stemming from work on cognitive load [31]. The former address which topics can be introduced and the latter the amount of information a learner can take in.

Communities of practice [32] provides a useful model for understanding the mechanisms at work in contexts like the *IT in Society* course. Work by Barab and Duffy [33] ties communities of practice nicely to constructivism and educational settings and similar work on situated cognition by Seely Brown, Collins, and Duguid [34] are also important theoretical influences concerning learning environments for the evolution of the *IT in Society* course. For further reading concerning general aspects of constructivism and design of learning environments consult Duffy and Cunningham [35].

Further notions of an 'Information Technology enabled collaborative pedagogy' [36]; a model of 'research linked teaching and learning' [37] have also been adopted. The model of educational quality adopted has been that of 'transformation of the student' [38] whereby active engagement of the student and a process of personal change through the learning process is taken to indicate a high 'quality' educational experience.

These elements in concert form a rich set of theories which have consistently underpinned the research as noted in Table 1.

## 5. GLOBAL COLLABORATION SKILLS

Engineering has always been an international profession, but the last decade has accelerated this aspect from being something of a choice to becoming more or less a necessity. This change has a high impact on the profession and thus also on the way engineers should be educated. The work of an ACM task force on Globalization and Offshoring reported in [8] is interesting in that it investigate consequences of globalization from an international perspective including both developing and developed countries. The following are listed as general principles to give an effective educational response to globalization:

- Evolve computing curriculum that better embraces the changing nature of IT.
- Ensure computing curricula prepare students for the global economy.
- Teach students to be innovative and creative.
- Evolve curriculum to achieve a balance between foundational knowledge of computing and the business and application domain knowledge.
- Invest to ensure the educational system has good technology, good curriculum, and good teachers.

In addition to this the importance of developing good teamwork and communication skills and becoming familiar with cultures are frequently referred to. These findings resonate well with other reports on consequences of globalization, e.g. in the Newport declaration [39] resulting from a National Science Foundation (NSF) initiative. Another example is work by Del Vitto identifying the crucial element for working in a global environment as possession of collaboration skills, including cultural awareness, where also being innovative and able to work with open problems are identified as important [40].

A further example of the increased awareness of globalization issues is that the following skills have been added to the USA's Accrediting Board for Engineering and Technology (ABET) programs [41]:

- Ability to function in multidisciplinary teams
- Ability to communicate effectively
- The education necessary to understand the impact of engineering solutions in a global and societal context
- Knowledge of contemporary issues

There are thus several influential bodies that flag the need for change in response to the increased globalization of the workforce. There is a reasonable consensus about which skills are needed, but how to implement and, not least, how to create a balanced curriculum where ample space is given to these skills are still open questions.

To summarize, the skills identified here and used as a reference point concerning learning goals are the following:

1. Having general communication and distributed team working skills.
2. Having a cultural awareness including understanding societal impact.
3. Being open minded in a creative and innovative way to solutions.

## 6. EVOLUTION OF THE SEQUENCE OF COURSE INSTANCES

The *IT in Society* course specifications have not changed, but the running of the course instances has evolved substantially as a result of applying an action research approach. This evolution is illuminated here by highlighting actions taken to develop global collaboration skills through one or more loops in the action research cycle (Fig. 1).

Underpinning the course evolution are a series of changes in what might be termed the 'learning theory' for the course (although it is not a singular theory but an amalgam of learning theories combined to support the objectives of the course). These changes have been typically based on observations from the prior instance of the course coupled with studying relevant pedagogical theories. This section highlights six resulting actions that have been taken over the years, all addressing the issue of developing skills for global collaboration, i.e.:

1. American students as partners
2. Cultural awareness expert
3. Reflections
4. Choice of client and project
5. External mentor
6. All students in one project

Before expanding on these six points we note that the observations reported here mostly stem from the course team closely following the process during the project, including weekly meetings with subgroups and several individual meetings with the students. Formal course evaluations and written as well as oral reflections on the project also formed data for these observations. The course team met regularly to discuss these planned and implemented actions and how well they met the intended learning goals for the current course instance. These meetings can be seen as the 'evaluation' and 'specifying learning' boxes in Fig. 1 and led to developing a new version of the 'learning theory' for the course. The discussions were mostly based on the immediate experiences of the course team, but reinforced from time to time by double checking with data gathered, e.g. written reflections and formal course evaluations. It should be pointed out here that the specific method for gathering data differed from year to year, for instance in the 2008 iteration of the course it involved each of the students completing short reflections, the lecturers holding semi structured interviews with the students and the conduct of a formal course evaluation [42].

The new learning theory evolved, as indicated above, in many cases through contemplating the past, by searching for relevant pedagogical theories to explain the observations, especially problems and successes. However, refinement of our approach also involved looking ahead, in that the actions to be introduced were typically based on a specific method and a corresponding underlying pedagogical theory. These pedagogical theories needed to be integrated into the new learning theory for the course. This new learning theory became adopted as a 'theory-in-practice' as opposed to one that was formally elaborated. Thus the evolution of the course has been informed by a spirit of both pragmatism and joint enquiry. Yet, as the decisions were largely based on arguments from pedagogical theories, as mentioned earlier in the paper this 'theory-in-practice' often formed a base for a scientific journal or conference publication [2, 3, 11, 22, 42, 14]. The conferences themselves created meeting opportunities for dispersed partners and were frequently the site of further review and planning sessions [e.g. 16 p. 146.], and sparked further collaborative initiatives such as new courses and models for global collaboration.

*6.1 American students as partners*

This model for global collaboration was introduced 2004 halfway through the semester. The idea was to add a real experience of international collaboration in order to give the students an opportunity to learn skills relevant for future professionals in a global workplace. Past experiences with other international student collaborations, such as the Runestone project [12] and the NZ project [16], at Uppsala indicated that this was both possible and valuable. The extensiveness of studies of both these projects, including examining large corpuses of email messages, online postings, course related documents and selected excerpts from diary notes from researchers also provided confidence in introducing this action. The initial iteration of the collaboration did not function as well as intended, potentially due to it being based on a rather loosely coupled collaboration [43] and thus introducing a higher complexity as compared with the other two projects.

Nonetheless we believed that the potential gain associated with a functioning real international collaboration was high enough to motivate keeping this dimension of the course. There have been several modifications since the first iteration: e.g. running the collaboration through the whole semester, having the American students come to Uppsala for a week early in the course as well as at the final stage, and various forms of scaffolding to strengthen trust between the two cohorts as described below.

The other five actions in this section were all either introduced or modified in order to address complaints, such as 'the international collaboration was more of an hindrance than an incentive', as was prevalent in the individual follow-up meetings at the end of the initial iteration(s) of the course. Resulting changes have engendered smoother collaboration, as reported in the evaluation in [2], where data supporting this conclusion is presented.

*6.2 Cultural awareness expert*

Introducing a session with an expert on cultural awareness is one of the actions taken to help the students build trust between the cohorts. Trust is a key factor in such a collaboration [44, 45, 46] and understanding more about the collaboration partners and their culture is essential as observed earlier. Course evaluations, reflections, and observed behavior all indicate that this action is both popular and functions well [2], e.g. 'The lecture gave me some insight in the cultural differences between Sweden and America. For example, I've never realized that being quiet could be thought of as being stupid'. The first year this session was only held for the Swedish cohort, but based upon the above evaluation it was judged important by the teaching team that both cohorts heard it. Therefore last year the session was integrated in the programme for the first week when the American cohort visited Sweden.

*6.3 Reflections*

It was a common complaint in the course team that the students seldom saw their own role in problematic issues and especially in cases where they viewed the international collaboration as a burden. Reflections were identified as an approach to address this lack of awareness. Fincher and Petre [47] place special emphasis upon the value of reflection in computer science project work: 'reflection on experience underpins the process of successful learning and is essential to the success of education.' Furthermore, not only is reflection on experience educationally valuable, but engaging in reflective practice engenders a mindset that is invaluable for effective professional performance.

The reflective practice model was drawn from the work of Schön [48] in which professional work involves an ongoing process of reflective practice involving self monitoring, continual improvement and action cycles (plan, act, observe, reflect).

> the term 'reflective practitioner' admits a variety of strengths and an openness in terms of beliefs about teaching methodologies. The teacher, as reflective practitioner, is committed to evaluating and re-evaluating performance both individually and collegially in order to sustain the never-ending drive to performance improvement. The more we learn the more there is to learn. [49].

The reflective work assessed in the courses is aimed at developing such professional capabilities.

Reflection is an action that was first introduced as a written and oral individual final report at the end of the course. These reports offered students an opportunity to reflect upon and demonstrate what they had learnt about the process of global

collaboration, the results they had achieved, the problems they had successfully overcome, what they had gained personally and professionally from the experience and where they still had to develop. This report and the follow-up individual meeting was not merely descriptive of the project, but included a broader critical dimension as befits a final year degree course. Many gave insightful descriptions on their performance and learning, e.g. 'I think I took many opportunities to get to learn new things and also to practice what I already know.' This action has been kept with some slight variations in the phasing of the instructions given to the students.

The value derived from the final reflections led to introducing weekly individual reflections throughout the courses. The high volume led to slow responses from the teachers and it was problematic to post issues to reflect on that were relevant for all students. This led to a reduction of the number of reflections as well as using peer feedback in some instances and also using both individual and group reflections. These changes had a positive effect on the quality of the reflections as reported by the course team. The value of the reflections is reported as moderately high, (3.5 out of 5) in the course evaluations. Students have moreover participated in a conscious process of joint reflection upon their learning in a recent conference presentation [22]. In an associated publication [42] their reflections were further enabled through a joint field trial of a newly developed research framework.

*6.4 Choice of client and project*

Since 2002 the projects have all been from the health sector in order to situate the students in an area that has a high social relevance and thus may prove engaging for female students [50]. This area also has many natural connections to ethical issues, which otherwise are often difficult to include in a relevant manner and thus often ignored even though experiences from dealing with ethical issues are both prescribed goals of engineering degree programs and of value in global collaboration situations. It is the opinion of the course team that placing the project in the health sector has inspired the students to perform well, but surprisingly many students have in their final reports stated that they were not influenced by the setting of the project.

*6.5 External mentor*

This action was introduced in 2008 for some of the key students in the project. Prior observations had indicated that the demands on the team leaders in such a course are high and some form of support other than that from the course supervisors was warranted. The mentor role was introduced to address this need. The students reported in their final reflections that their confidence was boosted. The external mentor stated that being aware of theories such as threshold concepts [28, 29] and conceptual change [26, 27] helped in determining how to pace the involvement as well as at which level. The latter is an excellent example of the usefulness of knowing relevant pedagogical theories, and of providing just-in-time scaffolding through a reasonably sophisticated strategy. This action is further profiled in [42]. Subsequently one of the mentees has told the students of this year's course instance that this action was valuable in terms of learning how to address issues related to the global collaboration aspects of the course. We are now experimenting with a remote mentoring model this year, and hope that will prove equally useful.

*6.6 All students in one project*

This action was introduced in order to enable all students to interact with persons in the work force as well as with non-local students and to add complexity to the interactions between the students. The rationale for having one single project meant that it could be large enough not to be too dependent on a few key persons in the work force, and to be able to deal with an unbalanced number of students in the two cohorts.

How the projects have been managed, and the mix of American and Swedish students in a subgroup have varied over the years based on previous experiences and the actual composition of the student cohorts. The basic idea of one project has been kept as it has been deemed to provide an excellent opportunity to learn how to function in such a complex situation. Handling complexity and ambiguity are important skills for global collaboration as noted above.

Reflection after the final individual meetings with the students in the 2008 instance indicated that there is a tendency to assign tasks that are seen as non-critical for the project to the American students. This action will be modified for the 2009 instance by influencing, if necessary, the sub-groups to which the American students are allocated, and the initial tasks which these students will be assigned, so that their work is inherently more interdependent and becomes more critical to the progress of the project.

## 7. SEQUENCE OF OEGP WITHIN AN EDUCATION DEGREE PROGRAM

The main focus of this paper is on the evolution of courses near the end of a degree program, but it is worth mentioning that a side effect of these efforts is an insight into how the previous stages of the students' education have prepared them for working in an OEGP. There are some students who quickly adapt, but most have significant difficulties with the educational format. Most are unfamiliar with not being told what to do and become quite insecure about the value and relevance of their ideas and opinions.

There is thus a perceived need to prepare the

students better for partaking in such courses and one approach would be to use OEGP in a sequence of earlier courses. Whilst that probably would lead to students being better prepared it is not without controversy. There is a debate about the danger of OEGP type methods in that the cognitive load of the students becomes too high and no real learning may take place [51, 52]. The claim is specifically about education at an early stage in a degree program and thus it is a call for being quite careful in the design of courses using OEGP early. The value for the courses discussed here, and especially for the personal development of the students, in our opinion warrant introducing a sequence of OEGP type courses, particularly if the effect is evaluated through an educational research study.

Further support for introducing a sequence of OEGP based courses is found in work by Bidois et. al. [53] where they point out the need for a progression in developing capabilities and that it is unrealistic to expect one course to remedy the deficiencies in student development over a whole degree program. They also, somewhat cynically, point out that the key insight was the immense value of the capstone course as a diagnostic tool in identifying deficiencies in the overall degree program to help students achieve the desired graduate profile.

## 8. DISCUSSION

Action research can be seen as a never ending story in that each loop through the cycle depicted in Fig. 1 leads to development of the situation studied. This is illustrated here by describing and motivating the plans for the 2009 instances when it comes to setting up a learning environment that will lead to skills relevant to a career as an engineer in a global workplace. The skills are the ones listed in the Global Collaboration Skills section, i.e. (slightly rephrased) to be able to communicate and collaborate effectively in a multicultural setting, both in terms of team mates and societal setting of the problem addressed, and to be innovative in the face of open ended problems.

The collaboration between the American and Swedish students is a context where developing these skills is highly relevant and where a call for improvement has been identified. Creating a learning environment enabling effective collaboration between the two student cohorts will here be used as the 'goal' in an action research approach to improve the course. In terms of Table 1 this goal encompasses both research and practice dimensions. The following factors are identified as being problems to address based on our current learning theory for running the courses:

- the cohorts are taking different courses
- the cohorts have different competencies
- there are differences in language and culture
- inter-cohort communication about the course is affecting trust, values, and student attitude over time
- there are unequal motivations among the students to solve the problem at hand in the project

These problems in turn pose a set of questions for both practitioners and researchers to address, but the ability to explore the issues in a practice setting is a vital element in progressing the research.

That the cohorts are taking different courses, including expecting to spend different amounts of time, is an example of complexity that the students must learn how to deal with and is perhaps not a major problem. It is however a good example of where some scaffolding is beneficial in that a short and clear message stating this fact at an early stage can prove important in reducing frustration related to differences in time spent in the project.

That the cohorts have different competencies is another example of a problem the students are expected to learn to deal with, e.g. how to identify the available competencies and how best apply them in the project. The same goes for having to deal with different native languages and being from similar but different cultures. Concrete examples are that the communication between the cohorts has to be in English and that much of the documentation is in Swedish and thus not directly accessible for the American cohort. Learning how to deal with these issues is an essential global collaboration skill. The approach will be to make these problems explicit as learning goals to the students and to be aware of occasions when scaffolding is called for to avoid serious mistakes.

International collaboration in a real-life setting is not easy, nor is assessing individuals in group projects [54, 55]. Add to this that an inherent aspect of an OEGP requires the students to experience frustration and we have a course that will raise questions and be talked about within the student body. Incoming students are thus likely to have a wide variety of visions and misperceptions about the course. This is addressed by spending time on explaining the pedagogical underpinnings of OEGP and engaging in open discussions with the students about their expectations as well as being explicit about other commitments.

These first four problems are more in the nature of issues to 'keep an eye on' rather than serious problems. Uneven motivation however, seems to be a more serious issue. Increasing motivation through the students 'owning' both the problem and the solution is a key ingredient in OEGP, but there is no guarantee that it will happen. The selection of task for the project is deemed to be a key consideration. As observed by Clear & Kassabova [14] patterns of student motivation in global virtual collaboration can differ quite markedly, and the poorly understood distinctions between individual and group motivation add further to the unpredictability. Working on an international collaboration for a real world client is an opportunity to learn skills seen as useful for their future

careers [3] and this will be emphasized to the students to give them an incentive to work hard. Meetings with former students and several opportunities to meet with the client will be facilitated. The actions described earlier in the paper are all partly aimed at increasing motivation and will be adopted in 2009 in order to provide scaffolding, especially for the students with less exposure to this style of learning [56, 2].

The American cohort has a language advantage in terms of the language of collaboration, but has otherwise been seriously disadvantaged in the past projects. Since the course on the American side is smaller in terms of credits there have been some difficulties in prior collaborations, leading to a level of distrust about working with the American cohort on the Swedish side. The action to address this for the coming course instance will be to ensure that there is a stronger incentive for the American students to contribute to the project in terms of the delivery to the client. There are pitfalls with having a too strong emphasis on delivering to an external client [56, 57], but being aware of them is one step towards dealing with that concern.

### *8.1 Recommendations for research and practice*

For others wishing to apply action research to their own educational practice in a manner similar to that outlined here, we recommend a sustained and cyclical process of joint engagement, conscious design and evaluation. The academic literature [e.g. 15, 17, 18, 21, 58] proposes several methodological aspects that need to be considered in designing rigorous programmes of action research, and space precludes a full discussion here. However there are some key distinctions that should be noted. The definitions of rigour in action research for instance, are contested. Melrose for instance has noted that in some schools of action research it is thought more important that the project brings about:

> a process of change and improvement in the real world than to produce a singular theory which fights for attention amongst existing theories in academia [59].

Under such a criterion, the impact and degree of institutionalisation of an action research intervention is more important than the formalism of the research design. Less extreme models for rigour in action research design and implementation have been proposed however. In one example, McKay & Marshall [60] have proposed a useful set of criteria against which to assess the quality of action research. The dimensions they have considered important include: (a) the conduct of the research (i.e. is it credible and dependable); (b) the conceptual significance of the research (does it have a theoretical grounding); (c) the practical significance (would practitioners agree that some improvement in the problem situation had been achieved); (d) the presentation of the research (has the audience been considered and is the form of publication well tailored to the conventions of that audience) [60].

These general guidelines have been applied more concretely in this study, through the following set of practices, which we recommend to those wishing to implement similar approaches.

It is imperative to consciously identify the five separate elements of action research identified in Table 1, in order to distinguish both the research and the practice elements of the initiative.

It is useful to explicitly identify the theoretical underpinnings which inform each iteration.

Arranging for student reflection and evaluations of the experience (whether summative or formative) is a key element, which serves both to focus students on the process of their learning and to provide meaningful data to assess the effectiveness of the intervention.

It is essential for the action research team to observe actively and analyse data as it develops (for instance online artefacts—email, wiki, discussion forum postings etc.—formal and informal, communication and task related, are of value). Accompanying this activity is a need to select methods for analysis of the rich data that arises from such studies [cf. 12, 13, 15, 16, 22, 43, 55].

Regular reflections on progress and debriefings within the teaching team are worthwhile, both during and after each course iteration. These sessions should be informed by multiple sources of data, such as that generated through critical incidents, puzzling situations, notable failures and successes. These meetings of the research team may be a combination of face to face during site visits; virtual via teleconference sessions or videoconferences or at common external venues such as research conferences. Informing these meetings should be a continuous scanning of the research literature relating to the puzzles and challenges raised in this work. Not only does this provide insight, but it identifies gaps in the literature and may serve to inform subsequent cycles with a new 'theory of the course' for the subsequent iteration.

This process of continually intertwined action and thought should generate publications sharing the insights into research and practice gained from the joint learning and reflection during and after each cycle.

Thus a key purpose of the action research approach to OEGP courses is to feed the learning from action as a member of a practitioner/researcher team into the design of the next course iteration. Each action cycle thereby helps to embed and institutionalise the intervention on a sustained basis, and the degree to which this succeeds is in turn a measure of the impact of the research. As recommended by Bain [61] the evaluation process therefore needs to seek measures for the degree of institutionalisation of the educational intervention. Through this means, either the lack of progress, or, the impact of the work in bringing about 'change and improvement in the real world' [59] can be tangibly demonstrated.

## 9. CONCLUSIONS

The challenges of addressing needs arising from the increased globalization in a highly dynamic and complex learning environment, including a real international collaboration, in the *IT in Society* course have been managed through use of a combination of action research and an Open Ended Group Project framework (OEGP). This approach has aided us in applying several educational theories relating to OEGPs [55]; collaborative IT enabled pedagogy [36]; 'transformative pedagogy' [38]; and the 'teaching-research nexus' [37], and are based on a broadly constructivist view of learning [24]. The approach described here is similar in spirit to the use of design tools for developing courses advocated by Ruthven et al. [62].

The progress of these OEGP courses in tandem with an action research approach has enabled specific issues to be addressed as they have arisen in the field, and generated diagnostic insights. The progressive application of a combination of pedagogical theories to the practice problems encountered in OEGP settings has helped develop the courses to their current level of maturity. For example: *threshold concepts* include an understanding of group dynamics and ability to write a joint report in a large project; a *conceptual change* is needed for the joint project to be genuinely collaborative in nature. A supporting terminology for reasoning is required to monitor the progression in student development. For instance using concepts reported in [27] the aim is to move from students *assimilating* a change, to them *accommodating* the concepts needed for a genuine collaboration. Developing the scaffolding to support this transformation also draws from work by Vygotsky about the *zone of proximal development* [30]. Since some concepts may be beyond the zone of understanding for some students, we must devise approaches to prepare students not yet ready for the intended conceptual change. Individual students differ substantially both in their needs and their views about scaffolding.

Nonetheless there remain several open questions, both practical and theoretical, in the conduct of these globally linked course models. Challenges include: building and sustaining common motivation across student cohorts; managing differing courses and outcomes; managing perceptions about the course; providing meaningful learning experiences to groups of students with differing competencies; and accommodating linguistic and cultural differences. For instance, while the collaborations reported in [14] have included some cultural diversity in the student body, we have still to assess the effectiveness of our action research approach to educational development with a non western institutional partner. We intend applying our approach to the next stage in this work, namely an extension of the Runestone project [11, 12] to a collaboration with Tongji University in Shanghai.

The OEGP model adopted here, with an active action research program running alongside the educational change and development process, is one we recommend as a strategy for developing and implementing global courses. We encourage readers to take up this new challenge for global engineering education.

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# Paper V

# Assessing Professional Skills in Engineering Education

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## Abstract[1]

This paper addresses the issue of developing and assessing professional skills in higher education programs. This includes defining and assessing these skills, in the contexts of an individual course unit and for an entire degree program. Identifying forms of assessment that are seen as authentic, meaningful and understandable by the students, teaching staff and curriculum developers are of utmost importance if professional skills are to be accepted and included in the formal curriculum. This can be particularly important in programs that aim to offer students a truly collaborative learning experience in a culturally diverse team. Reflections are presented as one example of an assessment method that fits this requirement. Building assessment based on the notion of threshold concepts is introduced in the context of an open ended group project course unit at Uppsala University.

*Keywords*: Professional skills, assessment, reflections, open ended group problems, threshold concepts

## 1 Introduction

There is general agreement that university students should develop professional skills and be able to demonstrate them as they enter the work force as emerging professionals in their discipline. These are typically described in the learning goals of tertiary educational programs, particularly in professional disciplines like engineering. This is often driven at a national level by accreditation requirements such as those of the Accreditation Board for Engineering and Technology (ABET 2009) in the United States, the Australian Computer Society in Australia, and the British Computer Society in the United Kingdom (2010).

Often, however, teaching teams are more comfortable placing emphasis on the development of technical skills. Limited room in the curricula, the view that professional skills are not core to e.g. the discipline of computer science, or that instructors lack experience with these topics are sometimes cited as reasons for reduced or limited emphasis on these important skills (Spradling et al., 2009).



Another problem is that many educators have an intuitive grasp of what professional skills are, but struggle to give a clear definition of them and to define rubrics for their assessment. This can be further complicated by the plethora of names for professional skills, e.g. soft skills, transferable skills, and employable skills.

The authors believe that the relative reluctance to deal with professional skills at the individual course unit level is strongly related to an uncertainty among teachers on how to integrate, teach, and assess professionals skills in the curriculum as expressed in e.g. (McKenzie et al. 2004).

Large projects unit are an obvious place to develop and assess professional skills, particularly in those cases where the project is run as an open ended group project (Faulkner, Daniels, and Newman 2006, von Konsky and Ivins 2008). This paper provides a case study describing such a unit at Uppsala University.

This paper will also address an approach for holistically integrating professional skills into the curriculum, while simultaneously highlighting their importance to stakeholders. These include educational designers, instructors, project supervisors, and students.

The approach described in this paper involves:

- The specification of the professional skills to be developed at different levels of the educational program.
- Ensuring that academic staff and supervisors have the relevant skills to guide students in their development as emerging professionals.
- The provision of authentic learning experiences and environments.
- The implementation of an appropriate framework to assess student learning and the actual attainment of professional skills.

The paper draws on experiences from Curtin University, which implements an institution-wide process for defining, contextualizing and embedding professional skills into the formal curriculum of all degree programs it offers.

The paper also highlight the use of reflections in which students self-assess their attainment of professional skills, which have been a useful tool at the authors' institutions. This will be especially illustrated with work at Robert Gordon University.

The use of reflections at Uppsala University will be presented in the context of a course unit called *IT in Society* (Laxer et al. 2009). This unit will be used to illustrate issues and solutions related to the specification and

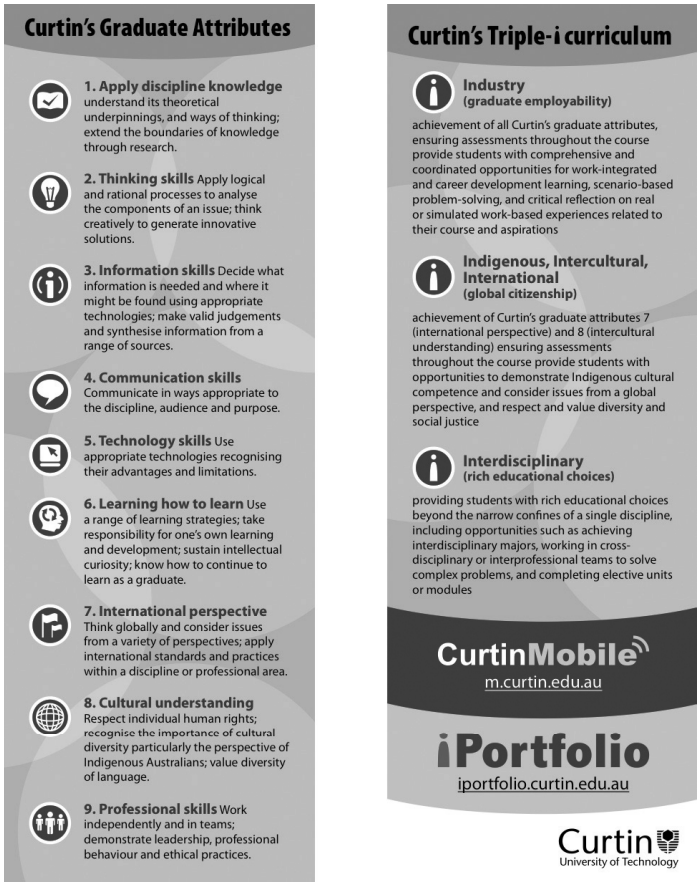


**Figure 1. Bookmark describing Curtin University's Graduate Attributes and the Triple-i curriculum**

assessment of professional skills in an open ended group project. This is discussed in the context of building assessment on the notion of threshold concepts (Meyer and Land 2003, 2005) to differentiate between genuinely possessing the professional skills in question as opposed to merely being able to talk about them.

## 2 Professional Skills in an Educational Setting

A number of recent developments in UK Higher Education have tended to emphasise the development of skills for lifelong learning. This has led to a renewal of interest in issues such as student employability and the role of university curricula in expanding students' capacity to learn.

This is exemplified by the Scottish National Enhancement Themes programme (Lines 2010), which currently has a focus on the development of Graduate Attributes (Barrie 2004), drawing heavily on work done at Australian universities such as Curtin and Sydney. Part of the application of this initiative is the embedding of reflective practice as a major component in the promotion of lifelong learning skills.

The work of Schön (Schön 1983, 1987) proposed a direct link between the use of critical reflection and successful professional practice. Reflection, self-evaluation and self-assessment are characteristics that distinguish expert practitioners from novices and so the development of a capacity to reflect on practice should be an essential element of any preparation for a professional career.

### 2.1 Activities at Curtin University

In conjunction with an institution-wide curriculum renewal project called C2010, Curtin University in Perth, Western Australia implemented a process of Comprehensive Course Review (CCR). The goal was to examine all teaching programs at the University to ensure that each program is of high educational quality, pedagogically sound, and sustainable.

As part of the process, teaching teams map the curriculum for an entire degree program, showing how

Professional Practice 401 Unit Learning Outcomes.

| Unit Learning Outcome (ULO) | Graduate Attributes Developed | Bloom's level |
|---|---|---|
| 1. **Analyze** user requirements and document them. | Thinking Skills<br>Communication Skills | Analysis |
| 2. **Establish** goals and a work plan to track progress with respect to management and technical roles on the team, and including metrics to measure goal attainment. | Thinking skills | Analysis |
| 3. **Manage** on-going project progress, making efficient use of available resources and planning tools. | Thinking skills<br>Technology skills<br>Communication skills | Analysis |
| 4. **Provide** constructive feedback to other team members | Professional skills<br>Thinking skills<br>Communication skills | Evaluate |
| 5. **Reflect** on goal outcomes associated with your assigned management and technical roles. | Thinking skills | Evaluate |

**Table 1: Mapping between subject specific ULO and Graduate Attributes for a hypothetical unit**

Professional practice 402 Assessment Mapping

| Assessment | ULO Assessed | Weighting |
|---|---|---|
| Client interview | ULO# 1 | 10% |
| Requirements document | ULO# 1, 2 | 30% |
| Final management report | ULO # 2, 3, 4, 5 | 60% |

**Table 2. Mapping between associated assessments and ULO for a hypothetical unit**

the University's nine graduate attributes are embedded and contextualized in the context of the given discipline for each subject and for the program as a whole.

A summary of Curtin's graduate attributes and Triple-i curriculum experiences that develop them are shown in Figure 1. The figure is from a bookmark, routinely distributed to both staff and students.

In the Curtin context, the graduate attribute for professional skills includes teamwork and leadership skills, professional behavior and ethical practices. The Curtin CCR process include analysis data that incorporate student evaluations conducted at the end of each semester, results from the Course Evaluation Questionnaire (CEQ) (Wilson et al. 1997), and surveys capturing the perceptions of recent graduates and their employers regarding skills developed during the degree program.

An output of the CCR process is an updated curriculum map. The map shows the relationship between Curtin's graduate attributes and discipline specific professional competencies defined by professional bodies like Engineers Australia. For each unit in the degree program, the curriculum map lists 5 or 6 Unit Learning Outcomes (ULOs) that are intended to clearly define what the students must do to demonstrate learning, the Bloom's Taxonomy Level at which each outcome is demonstrated, the associated graduate attributes developed, and the assessments that measure their attainment.

Bloom's original taxonomy defined six levels of thinking, each requiring increasing levels of cognition. The six levels are knowledge recall, comprehension, application, analysis, synthesis, and evaluation (Bloom 1956).

Tables 1 and 2 show a portion of an abstracted curriculum map for a hypothetical course unit called Professional Practice 401, Table 1 shows the mapping between ULO and graduate attributes. Table 2 shows the associated mappings between assessments and ULOs. Assessment rubrics are also considered as part of the review, although these are not shown in the table nor included in the curriculum map.

Care must be taken when writing ULO statements to ensure that verbs convey the required level of thinking. Selection of verbs is usually based on Bloom's taxonomy. For example, an outcome statement that says "*understand* project management standards" does not convey what the student must do to demonstrate that they have understood these standards. The outcome statement "*describe* project management standards" requires a low level of thinking on Bloom's scale. In contrast, the outcome statement "*implement* project management standards" would require higher order thinking skills. The statement "*evaluate* project risks when selecting and implementing appropriate project management standards" would require even higher order thinking.

The curriculum map describes where teaching teams and curriculum developers *intend* for the graduate attributes to be developed. A new electronic portfolio, called the iPortfolio, closes the loop on curriculum design. That is, the iPortfolio captures what students have *actually* learned, based on self-reflection and evidence provided by students (von Konsky et al. 2010, Oliver et al. 2009, von Konsky et al. 2009).

## 3 Reflection as a Means to Assess Professional Skills

The connection between the development of professional skills and the capacity to reflect on experience is found in work on positive learning dispositions, e.g. Claxton's 'four Rs': resilience, resourcefulness, reflectiveness and reciprocity (Claxton 2002). This is a useful classification

for the development of 'leaning how to learn' and the extension to lifelong learning skills. The disposition of reflectiveness naturally finds counterparts in a network of concepts such as metacognition, self-regulation, self-direction, and self-efficacy (Higgins, 2009).

Further links between the development of professional skills and reflection is found in the work of Nicol and his co-workers (Nicol et al. 2006, 2009) on formative assessment and feedback. Nicol situates his work in the context of the enhancement of self-regulated learning, defined as:

*'an active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features of the environment.' (Pintrich and Zucho 2002)*

This approach was incorporated into the REAP project (REAP 2007) and has been influential in motivating curriculum change in Scottish Higher Education.

Some form of learning journal (whether paper-based, electronic, or simply a set of discrete reflections on learning) is a prime candidate for a vehicle to facilitate the development of self-assessment and reflection (Moon 2006).

While the use of paper-based journals or lab-books may well be more familiar to engineering disciplines, the social features of a blog provide an important additional element that serves to encourage dialogue between tutors and students about the learning process. In particular, the commenting facility plays an important pedagogical role in promoting the development of social and academic support networks and student self-regulation.

A number of pedagogical benefits result.

- Timely feedback allows students to discern the strengths and weaknesses of their performance. It provides an opportunity to make decisions about how they may subsequently modify their own work and so increase learning autonomy.
- The action of supplying commentary on work done by peers provides students with the opportunity to develop the capacity to make objective judgements with reference to externally-set marking criteria.
- This ongoing student-teacher and student-student dialogue also serves to clarify the subtler (and often unstated) characteristics of what counts as "good performance" in the context of a particular assignment.
- Individual students can monitor the relationship between their own understanding of high performance and that of their teacher and also their peers. This is a significant factor in the development by students of appropriate mental models of the learning process.
- On a practical side, advice and academic support from peers may be articulated at a more appropriate level and be perceived as less of a threat to student self-esteem.
- The alternative perspective that such peer feedback may present can serve to motivate perseverance on tasks and provide a degree of mutual support and validation for efforts made.
- The repetitive nature of tasks like blogging also increases time-on-task and allows students to iterate the feedback cycle in a natural way.

This link between successful reflective practice and increased learning autonomy suggests that the narrative structure of blogs may be used profitably to encourage an atmosphere of developmental improvement. Students come to realise that the relationship between their current state of knowledge and the established subject matter does indeed evolve. This understanding that the acquisition of expertise does not happen instantaneously and that their conceptual model of a topic will change, evolve and deepen over time is an important characteristic of mature learners.

Finally, blogs give a useful two-way feedback mechanism that allows students themselves to offer commentary on the provision and suitability of teaching activities. They can therefore be used to provide high quality information to teachers about the nature of the student experience. Such information may go well beyond academic concerns and offer insights into the social, economic and intellectual milieu of the student which may, for example, affect the way in which the course is delivered or simply increase the teacher's appreciation of the (variety of) student experiences.

### 3.1 Use of Reflections at Robert Gordon University

Within this overall context, work done in the School of Computing at the Robert Gordon University has a particular focus on the use of blogs to capture student reflection on their first year experience (McDermott et al. 2010). The activities are embedded into the curriculum within a two-semester course unit investigating professional skills. Each student is required to keep an individual blog and post a minimum of two hundred words per week describing their learning experience on each of the units they study. This forms part of the raw material for an e-portfolio of work that would accompany the student throughout their course of study and could, potentially, form the basis of further reflective activities in later years.

In addition to posting their own reflections, there was a requirement that individual students make a substantive comment on two other posts each week. The academic goals of the blogging activity were carefully explained to students and a default template for the presentation of reflective comments was distributed providing some basic scaffolding for these exercises. This consisted of a number of questions in which the student was asked to identify the major learning objectives covered that week, detail new information or skills assimilated, comment on any learning strategies adopted, and describe any significant affective reactions to the classes the student had experienced.

### 3.2 Assessing Professional Skills Through Reflection

*Robert Gordon University*

While students are identified as driven by assessment (Biggs 1999), there are a number of issues surrounding identification and appraisal of reflection that complicate a straightforward alignment of learning objectives with the desired goal of promoting this kind of activity.

The first of these is that despite widespread agreement in the literature that the development of metacognitive skills is important, there is nevertheless a lack of clarity or precision in the terminology used. Concepts such as reflection, reflective thinking, and critical thinking are defined in different ways by different authors and it is not always apparent how these overlap, or their relationship to other ideas relating to student empowerment (such as self-regulation and self-direction).

This lack of precision in the terminology also manifests itself in the wide variety of theoretical frameworks that underpin schemes to identify and assess reflective work (e.g. Boud et al. 1985, Mezirow 1991, Hatton and Smith 1995, Wong et al. 1995, Scanlon and Chernomas 1997, Kember et al. 1999, Moon 2000, Kember et al. 2008).

A second issue pertains to student engagement with such reflective activities. The majority of students find such activities difficult to practice, and many teachers find them difficult to promote. While this may, in part, be due to a long acquisition time for the capacity to critically reflect, it also appears that activities which are designed to promote the skill lack focus.

For this reason, in addition to requiring students to participate in the reflective blogging exercises, the course unit described above also provided structured opportunities to develop and enhance the graduate attributes mentioned earlier.

The initial exercises were discursive in nature and focussed on the purpose of the course unit and the idea of graduate attributes (over and above subject-based technical competencies). These were then followed by an introduction to the computing infrastructure relevant to the unit, e.g. the blogging environment. Further activities engaged with issues in the psychology of learning. The Hatton-Smith categorisation of reflective writing (Hatton and Smith 1995) was also described. Blogs were reviewed using the Hatton-Smith framework, which classifies writing into four levels of increasing sophistication of reflective activity, see Table 3.

As may have been anticipated, analysis of the data indicated a natural trajectory for written work throughout the year (McDermott et al. 2010). While most students started at the descriptive writing stage, the vast majority progressed to descriptive reflection, with a number of students regularly engaging in dialogic and even critical reflection. Comments from questionnaires showed that a majority of students felt positively about the need for reflection. Moreover, they also suggested that student satisfaction concerning feedback was also positive, contributing to increased satisfaction measures with course as a whole.

| Level of Reflection | Indicator |
|---|---|
| 1. Descriptive Writing | The student simply describes experience without significant attempts at analysis. Although essentially non-reflective, it can nevertheless serve as a foundation for later, more complex activity. |
| 2. Descriptive Reflection | The student attempts to provide reasons for their learning experiences based upon quasi-reflective personal judgements. |
| 3. Dialogic Reflection | The student enters into a personal discourse to explore possible reasons for observed outcomes. |
| 4. Critical Reflection | In this context, critical reflection was taken to be demonstrated by the elaboration of reasons for personal learning decisions and experiences which takes into account a mature understanding of the psychological and pedagogical factors affecting the learning process. |

**Table 3. Hatton and Smith Framework for Reflective Writing (Hatton and Smith 1995).**

*Curtin University*

Writing critical reflections describing the outcomes associated with a task or learning experience requires higher order thinking; more so than merely reporting on the task or learning experience in a descriptive manner. In Table 1, for example, ULO 5 reads "*reflect* on goal outcomes associated with your project management and technical roles." To demonstrate this outcome, the rubric for the assessment articulates that the student must be able to state whether or not the goal was achieved, how they know this, and what was learned from the experience that can be applied during similar experiences in the future.

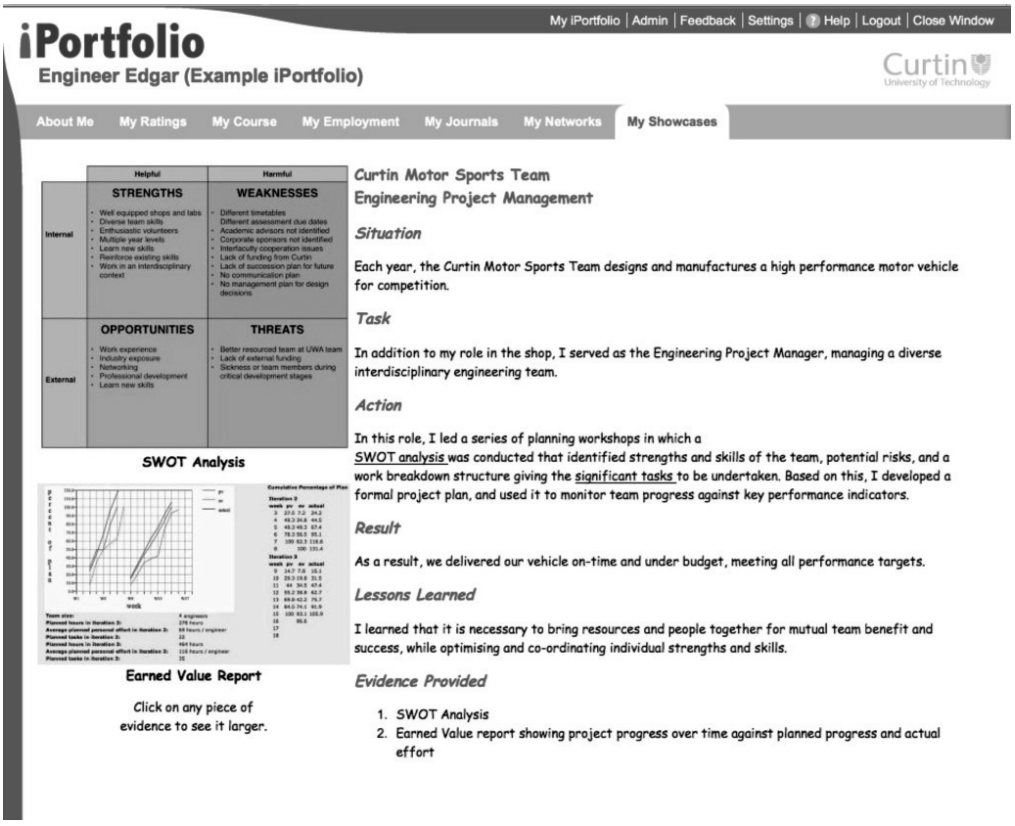


**Figure 2. Example reflection in Curtin University's iPortfolio using the STAR-L template (Curtin University 2010, Queensland University of Technology 2010).**

Curtin's iPortfolio includes a range of optional templates that assist students to write structured reflections. These includes the STAR-L template, in which students write reflections that includes the:

- *Situation*- the event that gave rise to the learning experience;
- *Task*- a description of the learning experience;
- *Action*- the specific action taken by the student in implementing the task;
- *Result*- the outcome of that action; and
- *Lessons learned*- what can be applied from this experience in the future, including what would be done the same, and would be done differently.

An example is shown in Figure 2 for an extracurricular project management learning experience. The reflection in the example is accompanied by artifacts. Note that by themselves, the artifacts only tell part of the story. The reflection is required to put the artifacts into context, and demonstrate what has been learned as a result of the activity.

## 4 Professional Skills in an Open Ended Group Project (OEGP) Course Unit

The Open Ended Group Project (OEGP) framework referred to in this paper is described in (Faulkner, Daniels, and Newman 2006). It is based on a similar view of learning as underpins Problem Based Learning (Kolb 1984, Kolmos and Algreen-Ussing 2001), Situated Cognition (Brown, Collins, and Daguid 1989), Practice fields (Barab and Duffy 2000), and Communities of Practice (Wenger 1998). It is furthermore closely related to ideas concerning use of ill-structured problem solving (Jonassen 1997). This is also discussed in general by for example Rittel and Webber (1973) who call these problems "wicked problems". Schön (1983) describes these wicked problems as belonging to the swampy lowland where predefined methods and techniques are of no use in the problem solving process. Schön describes the different nature of problems like this:

> *"high, hard ground where practitioners can make effective use of research-based theory and technique" as well as "swampy lowland where situations are confusing 'messes' incapable of technical solution"* (Schön, 1983).

The actual implementation of an OEGP can to no surprise vary considerably depending on a number of factors, e.g.:

- Where it occurs in the academic program (i.e. which year/semester).
- Number of students involved.
- Time available for the OEGP.
- Academic credit offered for the work.
- Method by which groups are formed and managed.
- Type of task chosen as the problem.
- Inter-relationship between the groups.
- Educational 'objectives' or 'intended learning outcomes'.

Most variants will however involve use of several professional skills, with limited control over which and to what degree for any given student. This is a natural consequence of the OEGP idea and one that provides a challenge when it comes to assessment. An OEGP course unit, IT in Society (Laxer et al. 2009), will be presented and assessing the ability to truly collaborate in a culturally diverse team will be investigated.

### 4.1 The IT in Society (ITiS) Course Unit

The ITiS course unit at Uppsala University is run in collaboration with a course unit in US (Communication in a Global Society) and is offered to students in the first semester of the fourth year. The unit accounts for half of the study load for a student during that semester in the IT engineering degree program. A goal of the ITiS unit is that the students should be able to constructively participate in a project dealing with a complex and multifaceted problem set in a real environment.

Since 2002, the setting has been the Uppsala Academic hospital, and since 2004 all students have been involved in the same project. The collaboration with the US students at Rose-Hulman Institute of Technology started 2005. The number of students has varied from 20 to 45 over the years.

### 4.2 Using Reflections in Earlier Instances

Assessing student goal achievement regarding ability to function in a culturally diverse team has been collaborative, and involved reflections and direct observation during the project. There was a practical reason for using reflections in that it seemed to be a good candidate to address the problem with students seldom seeing their own role in problematic issues, and especially in cases where they viewed the international collaboration as a burden. This choice was also influenced by the emphasis that Fincher and Petre (2001) put on the value of reflection in computer science project work.

The educational value of being able to reflect has been addressed already in the paper and is clearly described in work on the reflective practice model by Schön (1987). He observes that professional work involves an ongoing process of reflective practice involving self monitoring, continual improvement and action cycles (plan, act, observe, reflect). There was thus an educational benefit to use reflective work to assess professional skills, such as collaboration, in the unit. This can in fact be expressed even stronger in that the ability to reflect is a prerequisite for a professional skill such as the ability to truly collaborate in culturally diverse teams.

Reflection is an action that was first introduced as a written and oral individual final report at the end of the unit. These reports offered students an opportunity to reflect upon and demonstrate what they had learnt about the process of global collaboration, the results they had achieved, the problems they had successfully overcome, what they had gained personally and professionally from the experience and where they still had to develop. This report and the follow-up individual meeting was not merely descriptive of the project, but included a broader critical dimension as befits a final year degree course. Many gave insightful descriptions on their performance and learning, e.g. "*I think I took many opportunities to get to learn new things and also to practice what I already know.*" This action has been kept with some slight variations in the phrasing of the instructions given to the students.

The value derived from the final reflections led to introducing weekly individual reflections throughout the unit. The high volume led to slow responses from the teachers and it was problematic to post issues to reflect on that were relevant for all students. This led to a reduction of the number of reflections as well as using peer feedback in some instances and also using both individual and group reflections. These changes had a positive effect on the quality of the reflections as reported by the teachers. The value of the reflections is reported as moderately high, (3.5 out of 5) in the course evaluations.

Reflection has also been done in thr form of students being active in producing a paper (Cajander et al. 2009) describing their learning experiences in the ITiS unit. The value of a research framwork for understanding the role of technology in collaborations (Clear 2009) in terms of improving ability to reflect is reported in (Cajander, Clear, and Daniels 2009).

### 4.3 Extending the Scope of Assessment in the Next Instance

Assessing using reflections has been valuable, but there is a perceived limit when it comes to assessing the ability to function effectively in a culturally diverse team. The ability to reflect, in the full sense of the word as captured in Table 3, on true collaboration in such a team is not enough to ensure that a student is able to "truly" function in such a setting. This is an example of where there is a difference between knowing the theory related to a professional skill and being able to practice the skill. Both are essential in order to possess the professional skill, i.e. to be a craftsman in the discipline relies on being able to draw upon a mix of theory and practice. Reflections are typically on action, rather than "reflection in action" (Schön 1987), and as such more suited to assess the theory part.

The process of reflection in action is according to Schön (1987) central to the "art" (professional skill) by which practitioners (professionals) deals with situations of uncertainty, instability and value conflict. This seems to indicate that *reflections in action* also would be a suitable means to assess also the actual possession of a professional skill. This is also the basis for our next step

in developing assessment methods in the ITiS course unit. It should however be noted that many aspects of a professional skill is of a tacit type (Polanyi 1958) and thus almost impossible to capture in a reflection.

A suggestion on how to address this issue based on the notion of threshold concepts (Meyer and Land 2003, 2005) is outlined below. The approach will be tried in the upcoming instance of the ITiS unit.

### 4.3.1 View of Learning in an OEGP

The view of how learning take place, the epistemology, in this example is constructivism (Piaget 1970) in which learning is seen as a social process. The immersion of the learner in a complex realistic real world problem is seen as instrumental for creating the context for learning. The need for discussion is paramount in addressing open ended problem and the, for learning vital, social process is a natural component of an OEGP setting. Selecting a real world problem stems from the concern of finding a problem that is relevant for the learner. A good problem is defined in (Brooks and Brooks 1999) as one that:

- Requires students to make and test at least one prediction.
- Can be solved using only equipment and facilities that are available.
- Is realistically complex.
- Benefits from a group effort.
- Is seen as relevant and interesting by students.

### 4.3.2 Threshold Concepts

The notion of threshold concepts has been explained in work by Meyer and Land (2003, 2005). It is a concept that has properties suitable for reasoning about learning and investigation on how to assess professional skills.

A threshold concept is defined in Meyer and Land (2003) in the following way:

> *A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress. As a consequence of comprehending a threshold concept, there may thus be a transformed internal view of subject matter, subject landscape, or even world view.*

Threshold concepts are *integrative* and tie concepts together in new ways and *irreversible* in that they are difficult to unlearn. However, they might also be *troublesome* as they are seen as alien, difficult, or counter-intuitive.

Professional skills can be seen as prime candidates for being identified as threshold concepts and discussions about genuinely possessing a skill, integrating it and transforming thus comes natural. In the context of this paper it is perhaps the difference between mimicry and genuine understanding of the threshold concept that is the most interesting aspect of the notion. The transformation when acquiring a professional skill may be either sudden or take place over a considerable period. This transformative stage of development and learning is named *liminality* by Meyer and Land. Liminality in this context can be understood as the period preceding the actual 'crossing' of the threshold. The liminal state might involve puzzlement and confusion. In the liminal state people may imitate the language and behaviours, prior to full understanding of a discipline or area of expertise. Cousin (2006) describes this confusion in an interesting way:

> *"In short, there is no simple passage in learning from 'easy' to 'difficult'; mastery of a threshold concept often involves messy journeys back, forth and across a conceptual terrain."*

Meyer and Land (2005) point out that scaffolding may create a proxy for the threshold concept that can lead to mimicry or to the student being in the liminal state described above. To capture this difference in a student is the aim of the changed assessment method in the upcoming instance.

### 4.3.3 Plan for Implementation

Experience from previous instances of the ITiS unit suggest that the occurrence of a major shift in direction of the project lead to students obtaining a higher level of professional skills. The instances in question were in the first case when the customer halfway through the project realized the potential of the students and wanted them to change direction and in the second case the teachers wanted the students to take radically different approach to structuring their final report. Both cases resulted in a better product and improved learning in terms of professional skills as seen from the teacher point of view, but it is however unclear to what degree the students realized this.

A form of constructive controversy (Johnson and Johnson 2007, 2009) was introduced in order to try to create a similar learning opportunity (Daniels and Cajander 2010), but with a weaker result as compared to the two instances that inspired the approach. One hypothesis is that the approach needs to be strengthened with a better ability to reflect among the students and furthermore that the motivation to change direction is experienced as genuine among the students.

In short, the idea is that a change of direction will unsettle the students and force them to use professional skills in an intense manner. This increase in intensity will allow a better accessibility to reflecting on these skills. Selection and introduction of suitable threshold concepts, e.g. the skill "ability to genuinely collaborate", will influence the design of the constructive controversy event and will be used as lenses for the students to observe how they use their skills and provide a reference for assessing how well the students understand and master these skills.

That the students master how to write reflections will be crucially important for the success of this approach. Less critical, but still important is that they also have an understanding of the notion of threshold concepts. The same goes for the teachers in order for them to perform assessment, and perhaps especially be able to distinguish between mimicry and genuine transformation.

## 5 Conclusions

The value of reflections as a means to assess professional skills in higher education has been addressed, both at individual course and whole education study program levels. The potential for essential improvements regarding developing and assessing professional skills rely on a raised awareness, and increased capability, among all involved in the educational process. That is, from students, through TA's and teachers, up to coordinators of education programs and education institution boards.

There are many different aspects of professional skills, and careful application of reflection based assessment techniques is found to be promising. An outline of building on the notion of threshold concepts has been presented. There are many aspects of threshold concepts that relate to acquiring professional skills and building on this in developing assessment methods is promising.

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