

# Assessing Professional Skills in Engineering Education

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## Abstract<sup>1</sup>

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 professional 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

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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. <b>Analyze</b> user requirements and document them.	Thinking Skills Communication Skills	Analysis
2. <b>Establish</b> 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. <b>Manage</b> on-going project progress, making efficient use of available resources and planning tools.	Thinking skills Technology skills Communication skills	Analysis
4. <b>Provide</b> constructive feedback to other team members	Professional skills Thinking skills Communication skills	Evaluate
5. <b>Reflect</b> 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).**

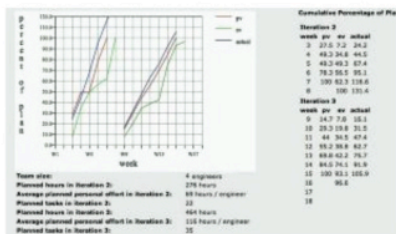
*Curtin University*

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.



	Helpful	Harmful
Internal	<b>STRENGTHS</b> <ul style="list-style-type: none"> <li>Well equipped shops and labs</li> <li>Diverse team skills</li> <li>Enthusiastic volunteers</li> <li>Multiple year levels</li> <li>Learn new skills</li> <li>Reinforce existing skills</li> <li>Work in an interdisciplinary context</li> </ul>	<b>WEAKNESSES</b> <ul style="list-style-type: none"> <li>Different timetables</li> <li>Different assessment due dates</li> <li>Academic advisors not identified</li> <li>Corporate sponsors not identified</li> <li>Interfaculty cooperation issues</li> <li>Lack of funding from Curtin</li> <li>Lack of succession plan for future</li> <li>No communication plan</li> <li>No management plan for design decisions</li> </ul>
External	<b>OPPORTUNITIES</b> <ul style="list-style-type: none"> <li>Work experience</li> <li>Industry exposure</li> <li>Networking</li> <li>Professional development</li> <li>Learn new skills</li> </ul>	<b>THREATS</b> <ul style="list-style-type: none"> <li>Better resourced team at UWA team</li> <li>Lack of external funding</li> <li>Sickness or team members during critical development stages</li> </ul>

SWOT Analysis



Earned Value Report

Click on any piece of evidence to see it larger.

### Curtin Motor Sports Team Engineering Project Management

#### Situation

Each year, the Curtin Motor Sports Team designs and manufactures a high performance motor vehicle for competition.

#### Task

In addition to my role in the shop, I served as the Engineering Project Manager, managing a diverse interdisciplinary engineering team.

#### Action

In this role, I led a series of planning workshops in which a *SWOT analysis* was conducted that identified strengths and skills of the team, potential risks, and a work breakdown structure giving the *significant tasks* to be undertaken. Based on this, I developed a formal project plan, and used it to monitor team progress against key performance indicators.

#### Result

As a result, we delivered our vehicle on-time and under budget, meeting all performance targets.

#### Lessons Learned

I learned that it is necessary to bring resources and people together for mutual team benefit and success, while optimising and co-ordinating individual strengths and skills.

#### Evidence Provided

1. SWOT Analysis
2. Earned Value report showing project progress over time against planned progress and actual effort

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 Daguaid 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 the 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 framework 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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