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Qualitative Assessment in the Chemical Engineering Curriculum

Abstract

Background

Assessment is an important part of student learning. Probably the most important part since the method of assessment has a major influence on the way students accomplish their studies. It is very important to use this fact in order to create the best possible circumstances for student learning. If we want learning to be more qualitative than quantitative, deep oriented and not surface oriented, to focus on the curriculum as a whole - we educate professional chemical engineers - assessment must always be designed with this in mind. Students must be given the opportunities to demonstrate quality, a deep orientation, and comprehensive views on these occasions.

In recent years we have carried out major changes within the chemical engineering curriculum (Bachelor of Science level) at Lund University. The most important changes comprise a comprehensive view of the curriculum, including a deep orientation of teaching and learning, fewer and more comprehensive courses, and a carefully prepared schedule of courses more focused on food and pharmaceutical technology. Furthermore, "non-technical" elements such as written and verbal communication skills, engineering ethics, quality assurance, economics, environmental problems and social psychology have been introduced into our curriculum. These important items are introduced in an introduction course during the first year and are then integrated in different courses throughout the curriculum. Finally, we have introduced carefully prepared and formulated educational objectives - knowledge, skill and attitude - at all levels within the curriculum.

An important and serious problem is that the assessment has not changed very much and in many cases does not correspond to our educational objectives. To put it simply, our students are not assessed against the comprehensive view of the curriculum expressed in the educational objectives. There is an apparent risk that student learning is surface oriented and only aimed at reproducing facts.

In a recently completed project at LTH School of Engineering in Helsingborg, Lund University, current examination forms have been investigated and a test

with qualitative examination has been performed (Olsson, 2000). The results of the project partly confirm the apprehensions about the assessment.

Pedagogical problem

The pedagogical problem is actually very simple - and yet so difficult. How do we design and perform an assessment so that it creates the best possible circumstances for student learning? Naturally, the optimal assessment is a combination of different examination forms with variations between the different parts of a course and between courses within the curriculum. But in general, the assessment should require the students to demonstrate whether the qualitative goals have been achieved.

General project idea

The general project idea is that we must change examination so that it becomes more qualitative than quantitative. An examination must focus on "how well" a subject is mastered rather than "how much" of a subject that has been acquired. The examination should stimulate a deep oriented, holistic learning that focuses on the overall goals of the curriculum.

Our assessment must be more oriented towards the engineering profession. We educate chemical engineers. This could be regarded as a kind of authorization - but it is not included in the examinations. It would be very interesting to perform tests with external examiners with this aspect in mind. Assessment of attitudes should also be included. Professional engineers are of course suitable but why not also use university teachers from other faculties such as medicine and social sciences? In different medical disciplines the attitudes of the students are crucial and experiences from these areas could certainly be used in a modified form for our purposes.

We must assess practical engineering skills. This includes laboratory skills and planning of experimental work. Some kind of proficiency tests could be used for certain practical parts of the educational programme. After passing such an examination the student could receive a licence for the practical skills of that part of the chemical engineering education. Assessment of practical laboratory skills also has many connections with other areas of the university. The Art Academy, the Theatre Academy and the Faculty of Arts and Theology most certainly use many methods and have experiences that could generate new useful ideas for an engineering education. How is a work of art or a poem assessed? Many untraditional contacts will be taken during this project.

We must test a combination of formative and summative examination forms. This is especially important within the Faculty of Engineering. For reasons of history and administration, above all extensive teaching of courses in parallel, a system has evolved where all examinations are concentrated to special examination weeks four times a year. There are many convincing pedagogical arguments for altering this rigid system. Any reform in this direction necessitates the introduction of new assessment methods. This project will facilitate changes in the educational system at the Faculty of Engineering.

In several courses the students work in project groups to solve different assignments. How are individual students assessed when they are part of a group? This teaching method is used throughout most courses at Aalborg University in Denmark and experiences from there could be used in this project.

We must introduce a more comprehensive assessment with examinations that cover several courses. This is especially important towards the end of the education. The educational programme and especially the engineering profession is an entirety.

To sum up we should use a variety of different assessment methods. There is no overall way of assessing that will solve all examination problems. However, taken together the proposed different methods will give us a better assessment than we have today. We expect them to be an improvement because they will better correspond to the educational objectives of the curriculum and, thereby, increase student learning, which is the principal purpose of all pedagogical activities at a university.

Aim of the project

The aim of the project is to develop, test and evaluate various forms of qualitative assessment methods.

Special aspects that will be considered are the influence of assessment methods on students with different ethnical background and on older students with work experience. One fifth of the students that were accepted for the chemical engineering education (1999) do not have Swedish as their native language. In this project we will especially investigate the effects of different examination forms on non-Scandinavian students. Less than 20% of the students have entered the university immediately after completing upper secondary school and about 65% of the students have worked for shorter or longer periods before they started their chemical engineering studies at the university. This means that we have many students that are older than corresponding students at the Master of Science level. Many students also have longer work experiences when they enter the university. These facts will also be given special attention.

A very important objective of the project is an international distribution of the results. This will be guaranteed through publication of all results in pedagogical papers and/or presentations at various conferences.

Theoretical basis

Within this project the SOLO taxonomy will be used to make qualitative judgments during planning and evaluation of different examination methods. The SOLO (Structure of the Observed Learning Outcome) taxonomy is a model for qualitative evaluation of teaching and examination (Biggs and Collis, 1982). It consists of different levels of increasing structural complexity.

Students intellectual development through the curriculum will be investigated using Perry´s Scheme of Intellectual and Ethical Development (Perry, 1970). This scheme consists of different stages characterized in terms of students' attitudes towards knowledge.

Methods and time planning

Different assessment methods will be developed and tested mainly on students from the chemical engineering education (Bachelor of Science level) at Lund University. The length of this programme is three years with a total of 100-120 students. Some of the tests could be extended to the chemical engineering education at Master of Science level and perhaps also to other engineering programmes.

During the first and second year of the project preliminary studies will be performed and different examination ideas will be developed into practically useful examination tasks. Different tests in smaller scales will be performed. Continuous documentation is an important part of the work and some reports and presentations should be ready during the first year.

During the third year the work will be concentrated towards comprehensive tests of various assessment methods. All students and several of the teachers representing different subjects within the curriculum will be involved in these tests. Evaluation, documentation and the presentations of the results are important parts of the work.

Project participants

The Project director is Dr Thomas Olsson, LTH School of Engineering in Helsingborg, Lund University. Thomas Olsson has participated very actively in undergraduate education at LTH, both as examiner for several chemical engineering courses, and as the director of undergraduate studies in chemical engineering at the Bachelor of Science level.

A reference group (project group) has been formed.
Aside from the project director, the other participants are
Dr Jan Hellberg, Centre for Teaching and Learning at Lund University and Department of Occupational Therapy,
Professor Peter Arvidsson, Centre for Teaching and Learning at Lund University and Department of Media and Communication Studies, Professor Anders Axelsson, Department of Chemical Engineering and Jonas Kronkvist, 3rd year student at the chemical engineering curriculum (Bachelor of Science level) at Lund University.

Documentation and evaluation

The main outcome of the project will be the actual examinations developed for the purposes described above. The results will be documented in reports and articles in pedagogical and/or engineering periodicals and presented at national and international conferences.

The project will be continuously evaluated through questionnaires and interviews with students and teachers within the chemical engineering curriculum.

Project activities during the academic year 2000/2001

The project was presented in a lecture at a conference for chemical education, SPUCK XI (Sveriges Pedagogiska Universitetskemisters Centrala Konferens), held at Lund University, Centre for Chemistry and Chemical Engineering, 16th-18th August 2000.

A poster, "Qualitative Assessment in the Chemical Engineering Curriculum", was presented at the 8:th International Improving Student Learning Symposium, Improving Student Learning Stratigically, held at UMIST, Manchester, 4th-6th September 2000.

A paper, "Assessment of Experimental Skills and Creativity Using a Modified OSCE-method - a Summative Performance-Based Examination in Chemical Engineering", was presented at the 9:th International Improving Student Learning Symposium, Improving Student Learning using Learning Technologies, held at Heriot-Watt University, Edinburgh, Scotland, 9th-11th September 2001.

Methods for assessments of skills and creativity have been developed (Olsson, 2002):

Most courses in a chemical engineering curriculum include practical experimental parts. These parts are normally assessed formatively in the laboratory. Students hand in reports and demonstrate their assignments and they get immediate feedback. This is very important and commendable. However, summative assessments of practical engineering skills are of rare occurrence in engineering curricula. An individual summative assessment could be of major importance to influence students to focus on the skill objective of the curriculum.

Medical education all over the world uses a summative performance-based examination called "Objective Structured Clinical Examination, OSCE (Harden et al., 1975). The aim of the OSCE is to test students' clinical and communication skills in a planned and structured way. The examination consists of several stations each presenting a scenario. At each station an examiner is observing the student's performance. The result is decided by judging how well the performance meets a number of stated criteria.

Can these ideas of assessment be used in a chemical engineering curriculum? The OSCE-method takes considerable resources. The paper presents a study of an assessment of experimental skills and creativity in chemical engineering using a modified OSCE-method.

A typical examination will last for 3-4 hours and consists of 6-8 different stations. More than 25 different tasks have so far been constructed. They test students' experimental skills, planning of experimental work, critical and reflective thinking and creativity and they are constructed so that they will require students to combine knowledge and skill to perform a task. It is important that most of the tasks are open-ended to allow students to show different qualitative approaches (Biggs and Collis, 1982). Students will be asked to discuss and explain ideas and procedures formulate and test hypotheses, design experiments etc. - students must perform their understanding.

The results of the examination tests are investigated using both qualitative and quantitative approaches. The qualitative part comprises the use of different focus groups, with students participating in the summative performance-based examination and a reference group. The quantitative studies are performed using a specially designed questionnaire investigating attitudes, intellectual development (Perry, 1970) and approaches to learning.

Some features of the method are:

· a summative performance-based assessment increases the students' awareness of the over-all objectives of the curriculum

· a performance-based assessment allows students to demonstrate a rich array of abilities

· a performance-based assessment allows the examiner to get a more complete picture of a student's abilities - and it facilitates effective feedback on student performance

· there is a positive correlation between summative performance-based assessment and students' deep approaches to learning - especially the occurrence of tasks requiring creativity and planning of experimental work favours a deep approach.

Project activities during the academic year 2001/2002

Assessment methods that foster integration of non-technical skills in a chemical engineering curriculum through experiential learning (Kolb, 1984) have been developed:

The design of the curriculum includes an accurately prepared schedule of integrated courses supporting a deep orientation of teaching and learning and an integration of non-technical skills and competencies such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology. These important items are introduced in an introduction course during the first year and are then integrated throughout the curriculum. Formative performance assessments include rhetorical speeches, case studies, scientific papers, poster presentations, standard operating procedures (SOP), ethical investigations and field observations. Besides written reports all activities are presented orally at seminars with formal opposition from teachers and other students.

A paper, "*A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum*", will be presented at the International Research Conference: *Learning Communities and Assessment Cultures: Connecting Research with Practice* jointly organised by the EARLI Special Interest Group on Assessment and Evaluation and the University of Northumbria, 28th-30th August 2002, University of Northumbria.

The work presented in this paper investigates how a reflective assessment influences the experiential learning promoted by the performance-based assessments and how this affects students' integrative abilities.

The purpose of reflection is to learn from experiences. Students write reflective papers that are personal, self-reflective and focus on knowledge, skills and attitudes acquired during the introduction course. They reflect on how they will use these competencies in engineering courses and in future professional life. They also reflect on learning and how to improve as learners.

The combination of formative and summative assessment methods favours experiential learning as described by Kolb's learning cycle. Formative performance assessments give several concrete experiences that are reflected upon and conceptualised in the summative reflective assessment. An active experimentation occurs when new competencies are integrated and applied in engineering courses that in turn results in new experiences.

Some features of the method are:
· a formative performance assessment of non-technical skills and attitudes allows students to demonstrate different abilities and facilitates feedback on student performance
· the combination of a formative performance and summative reflective assessment increases the quality of the learning process
· many students possess latent integrative abilities and integration of non-technical skills in different engineering courses is favoured by a reflective assessment
· metacognition is favoured by the use of a reflective assessment and metacognitive skills influence the student learning process throughout the curriculum
· the proposed assessment procedure is more oriented towards quality assurance of learning outcomes than just testing of knowledge and skills (quality control)

Planned activities for the academic year 2002/2003

The main ideas for the final year of the project include more comprehensive assessments with examinations that cover several courses. Assessment methods more oriented towards the engineering profession and assessments of attitudes and intellectual and ethical development (Perry, 1970) will also be developed.

References

Biggs, J. B. and Collis, K. F. (1982). Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome), Academic Press, New York

Harden, R. M., Stevenson, M., Wilson Downie, W. and Wilson, G. M. (1975). Assessment of Clinical Competence Using Objective Structured Examination, British Journal of Medical Education, 1, 447-451

Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development, Englewood Cliffs, New Jersey: Prentice-Hall

Olsson, T. (2000). Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum - Applications of the SOLO Taxonomy, Paper presented at the 7th International Improving Student Learning Symposium, University of York, 1999, In Rust, C. (Ed.), pp. 304-324, Improving Student Learning Through the Disciplines, The Oxford Centre for Staff and Learning Development

Olsson, T. (2002). Assessment of Experimental Skills and Creativity Using a Modified OSCE-method - a Summative Performance-Based Examination in Chemical Engineering, Paper presented at the 9th International Improving Student Learning Symposium, Heriot-Watt University, Edinburgh, Scotland, 2001, In Rust, C. (Ed.), pp. 310-323, Improving Student Learning Using Learning Technologies, The Oxford Centre for Staff and Learning Development

Perry, W. (1970). Forms of Intellectual and Ethical Development in the College Years: A Scheme, Holt, Rinehart and Winston, New York

Qualitative Assessment in Engineering Education

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Abstract

Quantitative learning focuses on the amount of a subject that students learn and learning is about adding new pieces of information to what is already known. The nature of the learning outcome is quantitative and the assessment focuses on reproducing knowledge.

Qualitative learning focuses on changing and developing students' understanding of a subject and learning is a question of combining, relating and interpreting new material with what is already known. The nature of the learning outcome is qualitative and the assessment focuses on the level of qualitative understanding of a subject.

This project is about qualitative assessment in engineering education.

Taxonomies are useful for planning and evaluation of teaching and assessment in higher education. The SOLO taxonomy is used throughout this project for evaluating the quality of student learning outcome. Perry's scheme is adopted to investigate and evaluate students' intellectual and ethical development in relation to different forms of qualitative assessments.

A biotechnology curriculum derived from research-based knowledge about teaching and student learning using the principle of constructive alignment is presented and discussed. A curriculum is a framework implying values and priorities and it deals with philosophical as well as practical issues. It should emphasize knowledge and skills but also foster intellectual development, social interaction and student diversity. Constructive alignment is a way of aligning a curriculum to support students' qualitative understanding. The biotechnology curriculum is aligned so that teaching and assessment methods support the overall objectives of the curriculum. Important qualitative aspects of the curriculum such as integration, variation, aims and objectives, generic skills and Core Curriculum are evaluated.

It is widely accepted that the first year of university studies is crucial for the success of the students. An introduction programme that introduces novel approaches to enhance students' learning abilities and awareness is presented. The combination of interactive and student-centred activities and assessment methods forms the basis for this first year action learning programme. An important dimension of the programme is student diversity—an opportunity and a challenge at universities today. The different actions are even more important among non-traditional students with varying ethnical background, age, educational basis and work experience. The prospect of improving students' learning strategies through activity and social interaction is a challenge.

A summative performance-based assessment of experimental skills and creativity in chemical engineering using a modified OSCE (Objective Structured Clinical Examination)-method is presented. The assessment tests students' experimental skills, planning of experimental work, critical and reflective thinking and creativity and it is constructed so that it will require students to combine knowledge and skill to perform a task. The tasks are open-ended to allow students to show different qualitative approaches. Students will be asked to discuss and explain ideas and procedures, formulate and test hypotheses, design experiments etc.—students must perform their understanding.

Generic skills are common to all engineers and not specific for a particular field of the engineering profession. The combination of technical and generic skills is closely related to students' employability and the ability to handle changing skill requirements and take personal responsibility for professional development is crucial. The proposed assessment methods foster integration of generic skills in a chemical engineering curriculum through experiential learning. The combination of formative and summative assessment methods favours experiential learning as described by Kolb's learning cycle. Formative performance assessments give several concrete experiences that are reflected upon and conceptualised in a summative reflective assessment. An active experimentation occurs when new competencies are integrated and applied in engineering courses that in turn results in new experiences.

The ability to reflect plays an important role to promote qualitative learning. Students who reflect in a structured and creative way on their own learning activities and achievements are more likely to reach higher qualitative levels of understanding. Reflective writing is used as a summative assessment method in a biotechnology and chemical engineering curriculum. Interesting results show how it also can serve as a complement to traditional course evaluations such as the Course Experience Questionnaire (CEQ). It provides an evaluation of the learning outcome that is detailed and informative. Even more interesting is that students demonstrate excellent learning outcomes and write positively about them in their papers but at the same time give quite modest marks in the CEQ. Results from focus groups and individual interviews indicate that students do not regard course evaluations as measures of the learning outcomes. This is important since the goal of all educational activities at a university is learning at qualitatively high levels.

A new two-dimensional matrix model developed primarily as an important tool for qualitative assessment of teaching competence is presented. The model is based on the following two dimensions: the degree of holistic analysis, varying from atomistic to holistic, and the degree of scholarly approach, varying from un-reflected to reflected. The benefits of the proposed model for qualitative undergraduate assessment—be it assessment of project works, laboratory reports or oral presentations—is of special interest. The model enables teachers to distinguish new dimensions—open up dimensions of variation—in their assessment procedures.

This project on qualitative assessment in engineering education has generated new projects, fruitful collaboration about pedagogical issues and many ideas for future pedagogical research and development.

In a recently started project the aim is to investigate the structure of examination systems and to describe the interplay between the formal classification of assessments and the development of students' and teachers' work in different courses. The work on qualitative assessment of teaching competence focusing on dimensions of variation will be continued. Special attention will be paid to the process of peer review of scholarly approaches to teaching. Subject didactics is another important area for future research and development where phenomenography and the concept of Learning Study have interesting potentials.

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Chapter 1

Introduction

Assessment is an important aspect of student learning. Probably the most important part since the method of assessment has a major influence on the way students accomplish their studies. It is important to use assessment to create the best possible circumstances for student learning. If we want learning to be more qualitative than quantitative, deep oriented and not surface oriented, focus on the curriculum as a whole—we educate professional engineers—the assessment must be designed with this in mind. We have a powerful instrument that we can use to influence student learning outcome throughout the curriculum.

If learning is regarded as *quantitative* focus in the learning process is on learning more. Students continuously add new pieces of information to what they already know and the more they learn the better. The nature of the learning outcome is quantitative and the assessment focuses on reproducing what has been learnt.

If learning is regarded as *qualitative* focus in the learning process is on changing and developing students' understanding. Students' learn by combining, relating and interpreting new material with what they already know. The nature of the learning outcome is qualitative and the assessment focuses on the level of qualitative understanding of a subject.

How do we design and perform the assessment to create the best possible circumstances for student learning? The optimal assessment is a combination of different examination forms with variations between different parts of courses and between courses within the curriculum. The learning objectives are of vital importance regarding what assessment form is best suited in a specific learning situation. But in general the assessment should require students to demonstrate whether the qualitative objectives have been achieved—to present qualitative learning outcomes.

The general idea of this project is that we must assess more qualitatively than quantitatively. Assessment must focus on "how well" a subject is mastered rather than "how much" of a subject that has been acquired. Different examination forms should stimulate a deep oriented, holistic learning that focuses on the overall objectives of the curriculum.

The aim of the project is to create possibilities to develop, test and evaluate different forms of qualitative assessment methods in engineering education.

Qualitative assessment is developed and evaluated at course level, programme level and faculty level. This report contains an extensive summary of the project (Chapter 2-10) and twelve papers (Appendix C) referred to by their Roman numerals in the text.

Chapter 2 summarises important features of commonly used taxonomies and describes how taxonomies can be used to increase the quality of teaching and assessment and influence student learning positively. Taxonomies are frequently used throughout this project.

The design of a biotechnology curriculum derived from research-based knowledge about teaching and student learning using the principle of constructed alignment is presented in Chapter 3. The philosophy underlying the design and a Core Curriculum implemented in the curriculum are discussed focusing on qualitative assessment and learning.

The first year of university studies is crucial for the success of the students. Chapter 4 describes an introduction programme that introduces novel approaches to enhance students' learning abilities and awareness. This first year action learning programme is a combination of interactive and student-centred activities and assessment methods.

"Objective Structured Clinical Examination", or OSCE, is an examination method testing students' clinical and communication skills in a planned and structured way used within medical education all over the world. Chapter 5 presents a summative performance-based assessment of experimental skills and creativity in biotechnology and chemical engineering using a modified OSCE-method.

Chapter 6 summarises assessment methods developed to foster integration of generic skills in an engineering curriculum through experiential learning.

The ability to reflect is important in student learning processes at universities. Chapter 7 describes how reflective writing is used as a qualitative assessment method and also how it can serve as a complement to traditional course evaluations.

In Chapter 8 a new two-dimensional matrix model for qualitative assessment is proposed. The model has been developed as an important qualitative tool to be used in the process of assessing teaching competence. However, it will also be useful in other contexts of higher education, such as teacher appointments committees and qualitative undergraduate assessment. Qualitative assessment of project works, laboratory reports or oral presentations could be mentioned as areas of special interest.

Chapter 9 presents overall conclusions and reflections and introduces plans and ideas for future development and research. Current projects on assessment and action learning and further development of qualitative assessment in connection with peer review and teaching competence are discussed. Subject didactics is another important area for future research and development where phenomenography and the concept of Learning Study have interesting potentials.

The present project on qualitative assessment was financed by the Swedish Council for the Renewal of Higher Education (http://rhu.se/activities/projects/financed_projects/m-p/olsson_thomas_99.htm).

The pedagogical development presented in this report was partly financed from other sources.

Chapter 2

Taxonomies and Qualitative Assessment

Taxonomies can support and strengthen qualitative aspects of teaching and learning. This chapter describes how taxonomies, and especially the SOLO taxonomy (Biggs and Collis, 1982), can be used to increase the quality of teaching and assessment and influence student learning positively.

A taxonomy in pedagogical contexts is a model that can be used for systematisation, valuation and classification. Taxonomies can be used to structure planning and evaluation of teaching and assessment and evaluate the quality of student learning outcome.

The best known taxonomy is probably *Bloom's taxonomy* (Bloom et al., 1956). It consists of six cognitive levels—knowledge, comprehension, application, analysis, synthesis and evaluation where:

- *knowledge* is the simple recall of previously learned facts and information,
- *comprehension* is the ability to understand basic material,
- *application* is the ability to use the material in new and concrete situations and solve simple problems,
- *analysis* is the ability to break down the material into its components and understand its structure to find new conclusions
- *synthesis* is the ability to creatively put the parts together to create something original,
- *evaluation* is the ability to judge the value of the material in relation to certain criteria.

The taxonomy was primarily developed to categorise levels of abstraction of questions and problems of different learning and assessment situations. The levels are increasingly more complex and abstract and they are inclusive (according to Bloom et al., 1956) so that comprehension requires knowledge, application requires comprehension and knowledge and so on. A serious shortcoming of Bloom's taxonomy is that it is not based on studies of learning outcomes but only on theoretical and logical analyses. This taxonomy is used for structuring and planning of educational activities.

Learning involves both quantitative and qualitative aspects. *The SOLO taxonomy* is a model for qualitative evaluation of teaching and learning (Biggs and Collis, 1982).

The development stages that were formulated by Jean Piaget describing the cognitive development from childhood to adulthood form the theoretical basis for the taxonomy. The idea is that different qualitative stages in the cognitive development partly correspond to similar stages of the process of learning a complex material. This makes it possible to distinguish a learning outcome of high quality from a learning outcome of low quality in the same way as it is possible to distinguish mature thoughts from immature thoughts. It is crucial to distinguish between the cognitive level according to Piaget and e.g. the level of an answer of a certain task of an examination paper. Biggs and Collis call this qualitative level *Structure of the Observed Learning Outcome* or SOLO. The cognitive level constitutes the highest possible level of the quality of learning whereas the SOLO level is the actual outcome of a certain learning situation. Which SOLO level a person reaches depends on many circumstances such as teaching, motivation, prior knowledge etc.

This taxonomy, unlike Bloom's taxonomy, is also based on an extensive amount of qualitative data. The structural complexities of answers to problems in subjects as history, mathematics, creative writing, reading, geography and foreign languages from students from elementary school to university form the empirical basis of the taxonomy. Similar structures emerged in the answers from different students in different subjects.

The SOLO taxonomy consists of five levels of increasing structural complexity. These levels are called the prestructural, unistructural, multistructural, relational and extended abstract levels where:

- *prestructural* level means that no understanding is demonstrated,
- *unistructural* level includes a very basic understanding with focus on one component or aspect of a complex problem and all other relevant components or aspects are disregarded,
- *multistructural* level includes understanding of several components or aspects of a complex problem but the different components or aspects are not related to each other or to the whole—lack of system analysis and only discrete understanding,
- *relational* level includes understanding of several components or aspects of a complex problem which are conceptually integrated to a whole structure from which logical conclusions might be drawn—system analysis and integral understanding,
- *extended abstract* level is the level of highest structural complexity and it builds on the relational level but extends beyond the boundaries of the actual problem and generalises into new areas—a general principle might be formulated at a higher level of abstraction and new general conclusions drawn.

The first three levels of the SOLO taxonomy represent quantitative stages of learning—only the amounts of facts and details in the responses increase—whereas the highest two levels represent qualitative stages of learning—the facts and details are integrated into a structural pattern. The SOLO taxonomy is especially valuable for evaluation purposes but can also be used for planning.

The best known taxonomy for attitudes and values is perhaps *Krathwohl's affective domain taxonomy* (Krathwohl et al., 1964). The levels of this taxonomy are organised according to a principle called "internalisation" which means that values and attitudes are gradually incorporated within oneself. It is built up by the levels receiving (attending), responding, valuing, organization and characterization by a value or value complex where:

- *receiving* means being aware of the existence of certain ideas or phenomena and being ready to receive and attend to them,
- *responding* means being committed to certain ideas or phenomena by actively responding to them,
- *valuing* means being motivated to value certain ideas or phenomena,
- *organization* means relating values to each other and bringing together different values into an organised value system,

- *characterization by a value or value complex* means acting consistently in accordance with the values held and integrating these values into a personal philosophy of life.

Perry's scheme of intellectual and ethical development (Perry, 1970) is a model that can be used to characterise students' intellectual development. It has nine stages that describe students' development from a simple right or wrong view of knowledge to a more complex and contextual understanding. The stages of the model can be arranged into four general areas. During the earliest stages, *dualism*, students believe that there is always a right answer to different problems and that the teacher knows these answers. Knowledge is quantitative and atomistic. When students begin to realise that even experts sometimes disagree they slowly move into the next set of stages, *multiplicity*, where they believe that everyone has the right to an opinion. However, at this level all opinions have equal validity since they are regarded as atomistic and no judgement can be made between them. When students recognise that this is not true, that some opinions have a higher validity than others, they are entering the next level of stages, *relativism*. Here knowledge is affected by values, assumptions, different theories and perspectives. Knowledge is qualitative and dependent on the context. Finally, when students are able to commit themselves to a solution of a problem or an explanation of a phenomenon they move into the final stages of Perry's model, *commitment*. Students integrate knowledge with personal experience and reflection in the awareness of relativism.

Perry's scheme was developed some decades ago but its fundamental principles are still applicable to university teaching and student learning. If the scheme is related to modern research on conceptions of learning among students and teachers it is clear that the way teaching is carried out influences students' intellectual development. Entwistle and Walker (2000) argue that student centred approaches to teaching and learning are well suited to encourage a development towards relativism and commitment.

Another model relevant to intellectual development is Baxter Magolda's model (Baxter Magolda, 1992) with four major categories: absolute knowing, transitional knowing, independent knowing, and contextual knowing. A model especially related to women's way of knowing is Belenky's model (Belenky et al., 1986) which includes cognitive characteristics associated with learning and understanding.

Assessment has a most important impact on student learning strategies and qualitative assessment methods could stimulate students' intellectual development. Perry's scheme is used throughout this project to investigate and evaluate students' intellectual and ethical development in relation to different forms of qualitative assessments.

Taxonomies are useful for planning and evaluation of different teaching activities. Sometimes they are just there in the back of your head but still valuable to organise a discussion concerning a difficult problem in mass transfer or to structure a new problem in thermodynamics or to redesign a practice in fluid mechanics etc. The SOLO taxonomy is an excellent help in constructing examination papers or assessing project reports (Olsson, 2000). Reflective teachers' pedagogical awareness could increase due to practical applications of taxonomies. The SOLO taxonomy is frequently used throughout this project on qualitative assessment to make judgements about the quality of learning.

Paper I (Appendix C) – *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy* – was the starting-point for the present project on qualitative assessment and it is included in this report for completeness and as a background. The paper describes how the SOLO taxonomy is applied in the analysis of different aspects of quality in teaching and assessing. It includes an investigation of examination papers within the chemical engineering curriculum with regard to the possibilities of reaching different SOLO levels, furthermore a presentation of an assessment designed especially to measure the qualitative level of learning and finally a discussion of the qualitative features of an experimental teaching method used in the chemical engineering curriculum.

Paper II (Appendix C) – *SOLO taxonomin – en modell för kvalitativ planering och utvärdering av undervisning och examination* – describes (in Swedish) how the SOLO taxonomy can be used for planning and evaluation of teaching activities and especially qualitative assessment. The SOLO taxonomy is used to construct and assess home assignment papers in a course in biotechnology and the significance of the taxonomy for teachers and students is discussed.

Chapter 3

Curriculum Design for Qualitative Learning

Biotechnology is a synthesis of biology, chemistry and engineering. Biotechnology uses living organisms to develop useful products or services especially in the fields of food, agriculture, pharmacy and environmental protection. Biotechnology plays a vital role in the interface between food and pharmacy. Functional Foods are often defined as foods that provide health benefits beyond basic nutrition and new products are developed as a result of the progress of biotechnology.

The biotechnology curriculum presented in this chapter is derived from research-based knowledge about teaching and student learning using the principle of constructive alignment (Biggs, 2003). A curriculum is a framework implying values and priorities and it deals with philosophical as well as practical issues. It should emphasize knowledge and skills but also foster intellectual development, social interaction and student diversity.

The philosophy underlying the design of the curriculum focuses on fostering effective student learning strategies and includes measures to:

- create an integrated curriculum,
- integrate generic skills and attitudes throughout the curriculum,
- use modern technologies and learning systems,
- introduce varying forms of teaching and assessment methods,
- introduce carefully designed and formulated educational objectives—knowledge, skill and attitude—at *all levels* within the curriculum,
- focus the curriculum towards food and pharmaceutical technology.

The curriculum objectives are formulated to promote learning at qualitatively high levels (Biggs and Collis, 1982; Bloom et al., 1956; Krathwohl et al., 1964; Perry, 1970). A very important aspect is that the overall educational aims influence the formulation of learning objectives as well as the design of teaching and learning activities at *all levels* within the curriculum.

The structure and contents of the curriculum are designed to support a student-centred approach to learning. Special attention is paid to student development with respect to skills and attitudes.

The design of the curriculum includes a schedule of integrated courses supporting a deep orientation of teaching and learning and an integration of generic competencies such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology. These important items are introduced during the first year and integrated throughout the curriculum. The procedure is based on Kolb's experiential learning cycle (1984).

A *Core Curriculum* is implemented in the curriculum. It comprises varying aspects of quality assurance (ISO, Standard Operating Procedures, GLP etc.), learning and information resources, computerized systems for information retrieval (databases, reference literature etc.) and for integrated problem solving and visualization (Mathcad), oral and written communication skills (technical writing and presentations etc.), statistical (error analyses and accuracy of measurements), economical, environmental and ethical analyses and use of scientific papers (an easy original paper could be used in most courses).

The methodology used to analyse the curriculum comprises different qualitative approaches:

- Identification of learning needs—knowledge, skill and attitude—using in-dept interviews with academic scholars and teachers, professionals from relevant industries as well as former and present students. Concordance about major curriculum approaches, such as an integrated curriculum, became evident from the interviews and this knowledge is evident in the design of the curriculum.
- A clear development towards teaching and assessing at qualitatively higher levels is demonstrated using the SOLO-taxonomy by Biggs and Collis (1982).
- Integration is a hallmark of the curriculum philosophy. Case studies investigating integrative learning outcomes through open-ended questionnaires are presented. This research investigates if students integrate different aspects of complex problems (technology, ethics, quality, economics, communication etc.) spontaneously or if this ability is passive and specific tasks must be formulated to help students integrate knowledge from different areas. The results show that many students possess latent integrative abilities.
- Questionnaires, focus groups and reflective papers show that students are surprisingly aware of their intellectual and ethical development and this development is well on its way towards the higher levels of Perry's scheme of intellectual and ethical development (Perry, 1970).

The present curriculum is designed to support student understanding and constructing of meaning. It is not designed to cover as many aspects of biotechnology as possible. Extensive coverage only induces surface learning. Constructive alignment is a way of aligning the curriculum to support students' qualitative understanding. The curriculum is aligned so that teaching and assessment methods support the overall objectives of the curriculum. Assessment is crucial and all teaching activities are aligned to support each other and the assessment to support learning.

Paper III (Appendix C) – *A Modern Integrated Curriculum in Biotechnology Designed to Promote Quality Learning* – includes a systematic presentation of the philosophy, alignment and design of the biotechnology curriculum. Important qualitative aspects of the curriculum such as integration, variation, qualitative aspects, aims and objectives, generic skills and Core Curriculum are thoroughly discussed in the paper.

Chapter 4

First Year Experience

It is crucial for the success of the paradigm shift from teaching to learning in higher education (Barr and Tagg, 1995; Bowden and Marton, 1998) that students are familiar with and accept important fundamental concepts of teaching and learning at universities. This chapter presents an introduction programme that fosters important aspects of qualitative learning, qualitative assessment and curriculum design among first year Biotechnology and Chemical Engineering students. Not only lecturers but also especially students should adopt a learning perspective.

The introduction programme introduces some novel approaches to enhance students' learning abilities and awareness. Different strategies have been developed that are grounded in constructivist pedagogy (Brooks and Brooks, 1993) and collaborative learning (Bruffee, 1993).

It is widely accepted that the first year of university studies is crucial for the success of the students. The introduction of a *combination* of interactive and student-centred activities and assessment methods forms the basis for the present first year action learning programme. An important dimension of the programme is student diversity—an opportunity and a challenge at universities today (Biggs, 2003). The different actions are even more important among non-traditional students with varying ethnical background, age, educational basis and work experience. The social dimension of different learning environments is especially influential (Säljö, 2000).

Several actions are taken to increase students' meta-cognitive awareness:

- During the introduction of the curriculum students and lecturers discuss and clarify the mutual responsibilities of students and university regarding the learning process. These responsibilities are formulated in a *pedagogical contract*.
- Students also think about their educational expectations and goals and formulate their own personal *learning contracts*.
- An introduction course, *The Engineering Profession*, runs through the first year. Students work in project groups and focus on fundamental skills and competencies of a professional engineer. Assessment includes oral and written presentations with formal oppositions and extensive discussions (including aspects of learning strategies) among students and with lecturers. Students also write personal, self-reflective papers and they reflect on learning.
- Student-led tutorials provide a natural and informal meeting place for discussions about learning.
- The use of multisource assessment focusing on peer assessment will be introduced with the purpose to help students improve as learners and to develop their meta-cognitive learning skills. They also get opportunities to share their learning strategies with other students and they receive an effective and credible feedback.

The pedagogical results so far, based on interviews, focus groups and self-reflective papers are:

- The pedagogical contract has increased students' awareness of the responsibilities of the participants in the learning process. The meaning of "learning perspective" is important and it is crucial to reach consensus about responsibilities.
- Students realise that learning can be an active social process and they incorporate group dynamics in the learning process. This is especially valuable for non-traditional students.
- Students feel that they are members of an intellectual community. They interact with other students and with lecturers and get involved in the learning process. The involvement of older students as peers highly increases the credibility and feedback of the process.
- Students identify learning as production of knowledge and skills—not reproducing facts. They begin to realise that learning and research are essentially the same process.

The start of the first year programme is a one-day introduction to the curriculum.

This day begins with *presentations* where the students present *each other* before the whole group of students after having interviewed each other in pairs of two. These presentations are always a mixture of serious information, curiosities and humour and it is fun for the students and fun for the participating teachers.

The presentations are followed by *student interviews* where groups of five students interview an older student on the topic: "How to study at the university?" Two recommendations from older students appear every year:

- begin studying in time,
- work together.

The same groups of five students use about a quarter of an hour over a cup of coffee to formulate three to five *questions* in relation to the education they are about to start or university studies in general. Each question is written on a piece of paper and all pieces of paper are collected, the questions are read aloud to the whole group and categorised (clusters of similar questions are created and given titles decided by the participants) and finally pinned to a white-board. The categories of questions seem to be the same every year: future work, further studies, courses and assessment, degree projects and miscellaneous.

The next part of the introduction is *discussions* about curriculum aims and how to achieve relevant learning objectives and expectations at the beginning of several years of studies at the university.

Finally, just before lunch, the work on formulating a *pedagogical contract* is initiated. The contract should contain responsibilities of the university and responsibilities of the student concerning the learning process.

During the afternoon students work in groups and prepare *poster presentations* of the different courses of the biotechnology and chemical engineering curriculum. The posters should give an overview of the different courses of the curriculum and the role of the courses in the curriculum as a whole. Students use several facilities when they prepare their posters including general and technical encyclopaedias, course literature, library and librarians, World Wide Web, interviews, telephone calls etc. Further important aspects of the presentations include industrial or other applications of a subject, different subsections of a subject, research areas of interest, historical development and possible professional careers after graduation. The groups present their posters during a poster session. Each group also makes a brief oral presentation of the poster before the whole group of students. In general, posters and presentations are of very high quality.

Student evaluations concerning their experiences of the one-day introduction always show a very high satisfaction. Students emphasise the social dimension of the introduction as especially valuable.

The prospect of improving students' learning strategies through activity and interaction is a challenge especially in connection with student diversity and approaches to learning.

Chapter 5

Assessment of Experimental Skills and Creativity

Assessment is probably the single most important aspect of student learning in higher education. There is compelling argument presented in the literature that the method of assessment has a major influence on the way students accomplish their studies (e. g. Ramsden, 2003; Biggs, 2003; Prosser and Trigwell, 1999).

Within the biotechnology and chemical engineering curriculum (Bachelor of Science level) at Lund University we have introduced carefully prepared and formulated educational objectives—knowledge, skill and attitude—at all levels within the curriculum. An important and serious problem is that the assessment is still too much focused on knowledge. Learning is a complex holistic process involving many aspects besides knowledge. The assessment should stimulate a deep oriented, holistic learning and focus on all educational objectives of the curriculum.

Most courses in a chemical engineering curriculum include practical experimental parts. These parts are normally assessed formatively in the laboratory. Students hand in reports and demonstrate their assignments and they get immediate feedback. This is very important and commendable. However, summative assessments of practical engineering skills are of rare occurrence in engineering curricula. An individual summative assessment could be of major importance to influence students to focus on the skill objectives of the curriculum.

Medical education all over the world uses a summative performance-based examination called "Objective Structured Clinical Examination", OSCE (Harden et al., 1975). The aim of the OSCE is to test students' clinical and communication skills in a planned and structured way. The examination consists of several stations each presenting a scenario. At each station an examiner is observing the student's performance. The result is decided by judging how well the performance meets a number of stated criteria.

Can these ideas of assessment be used in a chemical engineering curriculum? The OSCE-method takes considerable resources. This chapter presents a method of assessment of experimental skills and creativity in biotechnology and chemical engineering using a modified OSCE-method (Olsson, 2002a). The modifications include the use of learning technologies (video/audio recordings and computerised collection of results) to observe student performance.

A typical examination will last for 3-4 hours and consists of 6-8 different stations. More than 25 different tasks have so far been constructed. They test students' experimental skills, planning of experimental work, critical and reflective thinking and creativity and they are constructed so that they will require students to combine knowledge and skill to perform a task. It is important that most of the tasks are open-ended to allow students to show different qualitative approaches (Biggs and Collis, 1982). Students will be asked to discuss and explain ideas and procedures formulate and test hypotheses, design experiments etc.—students must perform their understanding.

At each station a student's performance is observed by a teacher, video/audio taped or delivered electronically using a computer.

Special attention should be paid to the following areas (when appropriate) during the assessment of experimental skills:

- skills in identifying the problem,
- skills in choosing measurements and observations,
- skills in choosing appropriate experimental procedures,
- implementing skills (handling of apparatus, experimental procedures, observation procedures),
- skills in data analysis (including error analyses, reliability and precision),
- skills in drawing valid conclusions from observations and data,
- skills in evaluating the results.

The evaluation of the assessment method employs both qualitative and quantitative approaches. The qualitative part comprises the use of different focus groups, with students participating in the summative performance-based examination and a reference group. The quantitative studies are performed using a specially designed questionnaire investigating attitudes, intellectual development (Perry, 1970) and approaches to learning.

The main results are:

- a summative performance-based assessment increases the students' awareness of the over-all objectives of the curriculum,
- the introduction of learning technologies facilitates the use of an OSCE-method in chemical engineering—the assessment becomes effective, easily administered and requires less resources,
- a performance-based assessment allows students to demonstrate a rich array of abilities,
- the use of learning technologies together with traditional approaches in assessment allows the examiner to get a more complete picture of a student's abilities—and it facilitates effective feedback on student performance,
- there is a positive correlation between summative performance-based assessment and students' deep approaches to learning—especially the occurrence of tasks requiring creativity and planning of experimental work favours a deep approach,
- preliminary findings indicate a positive correlation between performance-based assessment and intellectual development (Perry, 1970)—this interesting aspect is further investigated.

Paper IV (Appendix C) – *Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – A Summative Performance-based Examination in Chemical Engineering* – includes an outline of student views of laboratory teaching and a presentation of a summative performance-based assessment of experimental skills and creativity. Assessment of skills, attitudes and intellectual development, approaches to learning and learning technologies are discussed and qualitatively evaluated in relation to laboratory work.

Chapter 6

Assessment of Generic Skills

Generic skills are common to all engineers and engineering students and not specific for a particular field of the engineering profession. They include communication and problem-solving skills and the ability to handle information technology and to work successfully in teams.

Generic skills have become increasingly important competencies in the work-life of engineers of all disciplines. Many reasons can be found for this but the shift from an industrial to a knowledge oriented economy and fundamental changes in organisational structures of companies have increased the demand for generic skills. More complex work environments with flatter organisational structures and increased individual responsibilities result in much more flexible professional conditions for the modern engineer. This requires competencies such as communication, team working, management and self-management, customer handling, information technology, problem-solving and learning skills or ability to learn. Flexibility is a key word. Personal qualities such as commitment, integrity, motivation, adaptability and reliability are highly valued.

The combination of technical and generic skills is closely related to students' employability and should be an essential part of an engineering curriculum. The ability to handle changing skill requirements and take personal responsibility for professional development is crucial. Generic skills develop throughout life and constitute an important aspect of life-long learning.

Assessment of generic skills in engineering education is important and if these competencies are not assessed students' will not regard them as an essential part of the curriculum. Interesting and relevant assessment methods could play an important role in fostering positive attitudes to generic skills among engineering students and to provide relevant feedback on their acquisition of these competencies. Assessment in authentic work contexts is preferable. Self-assessment is important especially with regard to life-long learning as engineers must be able to adapt their generic skills to new and different work environments throughout life.

The important question in this chapter is if assessment design can increase students' abilities to integrate generic skills and competencies in an engineering curriculum. Assessment has a major influence on all aspects of student learning in higher education. Using this knowledge we can influence the way students accomplish their studies (Biggs, 2003; Prosser and Trigwell, 1999). The proposed assessment methods foster integration of generic skills in a biotechnology and chemical engineering curriculum through experiential learning (Kolb, 1984).

The design of the curriculum includes an accurately prepared schedule of integrated courses supporting a deep orientation of teaching and learning and an integration of generic skills and competencies such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology. These important items are introduced in an introduction course during the first year and are then integrated throughout the curriculum. Formative performance assessments include rhetorical speeches, case studies, scientific papers, poster presentations, standard operating procedures (SOP), ethical investigations and field observations. Besides written reports all activities are presented orally at seminars with formal opposition from teachers and other students.

The assessment method described in this chapter demonstrates how a reflective assessment influences the experiential learning promoted by the performance-based assessments and how this affects students' integrative abilities (Olsson, 2002b).

The purpose of reflection is to learn from experiences. Students write reflective papers that are personal, self-reflective and focus on knowledge, skills and attitudes acquired during the introduction course. They reflect on how they will use these competencies in engineering courses and in future professional life. They also reflect on learning and how to improve as learners.

The combination of formative and summative assessment methods favours experiential learning as described by Kolb's learning cycle (Kolb, 1984). Formative performance assessments give several concrete experiences that are reflected upon and conceptualised in the summative reflective assessment. An active experimentation occurs when new competencies are integrated and applied in engineering courses that in turn results in new experiences.

The assessment methods are evaluated using several qualitative approaches: Case studies investigating integrative learning outcomes through open-ended questionnaires are presented. This method investigates if students integrate different aspects of complex problems (technology, ethics, quality, economics, communication etc.) spontaneously or if this ability is passive and specific tasks must be formulated to help students integrate knowledge from different areas. Focus group interviews, individual in-dept interviews and a modified Course Experience Questionnaire (Ramsden, 1991) are used to investigate the effects of the combination of different assessment methods. Special attention is paid to the integration of generic skills, evaluation of teaching and learning outcomes and students' reflection on learning (metacognition). The self-reflective papers presented by the students are also analysed using the SOLO-taxonomy (Biggs and Collis, 1982) and Perry's Scheme of Intellectual and Ethical Development (Perry, 1970).

The main outcomes are:

- a formative performance assessment of non-technical skills and attitudes allows students to demonstrate different abilities and facilitates feedback on student performance
- the combination of a formative performance and summative reflective assessment increases the quality of the learning process
- many students possess latent integrative abilities and integration of generic skills in different engineering courses is favoured by a reflective assessment
- metacognition is favoured by the use of a reflective assessment and metacognitive skills influence the student learning process throughout the curriculum
- the proposed assessment procedure is more oriented towards quality assurance of learning outcomes than just testing of knowledge and skills (quality control)
- a modified experiential learning cycle combining assessment, evaluation and integration with Kolb's learning cycle (Kolb, 1984) is presented

Paper V (Appendix C) – *A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum* – presents assessment methods developed to foster integration of generic skills in an engineering curriculum through experiential learning. The study investigates how a summative reflective assessment influences the experiential learning promoted by formative performance-based assessments and how this affects students' integrative abilities. The assessment procedure is focused more on quality assurance of learning outcomes than quality control.

Chapter 7

Reflective Assessment

The ability to reflect plays an important role in the learning process at universities. Students who reflect in a structured and creative way on their own learning activities and achievements are more likely to reach the higher levels of the SOLO taxonomy (Biggs and Collis, 1982) and Bloom's taxonomy (Bloom et al., 1956) and to adopt a deep approach to learning. This chapter presents reflective writing as a qualitative assessment method in a biotechnology and chemical engineering curriculum and an investigation on how reflective writing also can serve as a complement to course evaluation techniques such as the Course Experience Questionnaire, CEQ (Ramsden, 1991).

The evaluation methodology employs several qualitative approaches. Comparative studies of reflective papers, CEQ results and more traditional course evaluation forms were performed and evaluated together with focus group interviews and individual in-dept interviews. The SOLO-taxonomy (Biggs and Collis, 1982) and Perry's Scheme of Intellectual and Ethical Development (Perry, 1970) were also used in the evaluation process.

Three types of reflection that can be associated with experiential learning (Kolb, 1984) are reflection-in-action, reflection-on-action, (Schön, 1983) and reflection-for-action (Cowan, 1998). In the summative papers students mainly reflect "on" and "for" action and they are critically reflective and connect the assessment to their own learning. The papers comprise both a cognitive (students' reflection on knowledge and skills) and a metacognitive (students' reflection on learning) dimension. In most cases there are also clear and distinct course evaluative aspects found in the papers.

The main results of this study imply that a reflective summative assessment provides an evaluation of the learning outcome that is more detailed and informative than the results of the CEQ (Olsson, 2004). Even more interesting is the finding that the CEQ and the papers give diverging results about learning outcomes. Students demonstrate excellent learning outcomes and write positively about them in their papers but at the same time give quite modest marks in the CEQ. Results from the focus groups and the individual interviews indicate that students do not regard traditional course evaluations as measures of the learning outcomes. This is important since the goal of all educational activities at a university is learning at qualitatively high levels.

Paper VI (Appendix C) – *Reflective Assessment – Qualitative Aspects of Evaluation and Learning* – presents an investigation on how reflective writing is used as an assessment method and also how it can serve as a complement to traditional course evaluations.

Chapter 8

Qualitative Assessment — a Two-Dimensional Matrix Model

An important result from this project is a new two-dimensional matrix model developed as an important tool for qualitative assessment (Antman, Olsson *et al.*, 2004). It is primarily intended to be used in the process of assessing scholarly teaching at Lund Institute of Technology (LTH) but has interesting prospects of structuring and facilitating qualitative assessment in many fields of higher education.

The Pedagogical Academy

The Pedagogical Academy was developed to afford status to pedagogical development and to bring about a paradigm shift at LTH, to change the focal point from teaching to learning (Barr and Tagg, 1995; Boyer, 1990; Bowden and Marton, 1998). This is also in line with official staff development strategies and visions for LTH as a faculty with pedagogical development in focus.

The Pedagogical Academy rewards individual teachers and their departments for the contributions they make to the joint scholarly venture of raising the quality of student learning—be it by way of novel initiatives concerning examination, curriculum development or awareness of the first year experience. The knowledge claims made are evidence-based and the examples presented are documented and made public (Boyer, 1990). By encouraging the systematisation of a pool of situated knowledge of how students learn in different subjects, different courses, different learning environments and different years of study, LTH can foster teachers who are not only knowledgeable about learning but who are also competent learners themselves (Bowden and Marton, 1998; Trigwell *et al.*, 2000; Trigwell, 2001; Prosser and Trigwell, 1999).

Application and Assessment

Teachers wishing to apply to the Pedagogical Academy submit a pedagogical portfolio which is assessed against certain criteria and successful applicants are awarded the title *Excellent Teaching Practice* (Hammar Andersson, Olsson *et al.*, 2003). The pedagogical portfolio consists of the teacher's personal reflections regarding teaching and learning—the teacher's pedagogical philosophy—and examples describing the teacher's pedagogical action. The examples (4-5 in number) should be related to the first part of the portfolio in such a way that the portfolio constitutes an integrated overview, from which it is evident that the lecturer has reflected on teaching over a period of time and has made efforts to implement his or her ideas in practical teaching. To this a Curriculum Vitae is added, a CV with a special section dedicated to pedagogical activities.

The present criteria (Hammar Andersson, Olsson *et al.*, 2003) state that the following are to be made clear in the material submitted for assessment:

1. that the applicant bases his/her work on a learning perspective,

2. that the personal philosophy of the applicant constitutes an integrated whole, in which different aspects of teaching are described in such a way that the driving force of the applicant is apparent,
3. that a clear development over time is apparent. The applicant should, preferably, consciously and systematically have striven to develop personally and in pedagogical activities,
4. that the applicant has shared his or her experience with others, with the intention of vitalising the pedagogical debate,
5. that the applicant has cooperated with other lecturers in an effort to develop his or her teaching skills, and
6. that the applicant is looking to the future by discussing his or her future development, and the development of pedagogical activities.

Applicants should describe, analyse and reflect on their pedagogical activities in relation to the criteria. The assessment is based on qualitative considerations and applicants must present examples of qualities they wish to emphasise and they should therefore describe, reflect and motivate their pedagogical actions in relation to student learning within a subject.

The pedagogical portfolio itself, together with a letter of recommendation from the head of department and a letter expressing the considered opinion of an appointed reviewer, form the documents that are put to a group of assessors. The group is made up of roughly five people: previously awarded excellent teachers at LTH, a student representing the student body, and a pedagogical development consultant acting as chairperson. The group of assessors interviews each applicant after having read and discussed their portfolio and eventually accepts or rejects the application, or refers it back to the applicant for supplementation in accordance with the assessment record.

Multidisciplinary Research and Development Project

LTH and the Centre for Learning Lund (a Centre of Lund University charged with the task of establishing and supporting developmentally-oriented research on and about learning, as it manifests itself in the various enterprises of the university) cooperated in a developmentally-oriented research project to investigate the different perspectives on learning that emerged in the process of application, assessment and acceptance to the Pedagogical Academy.

Method

We used a phenomenographic approach (Marton, 1981; Marton and Booth, 1997) to study the phenomenon of rewarding excellent teaching as expressed and experienced by individuals involved in the process of application, assessment and acceptance to the Pedagogical Academy.

In the study we set out to capture this process in all its complexity. By triangulating the analyses of qualitative empirical data—documents, video-recorded observations and in-depth interviews—we could approach the phenomenon from several different angles. Important aspects to study were also the aims of the Pedagogical Academy and how these were reconstructed in the documents, in the criteria for application and in the assessment procedure, respectively. The specific question we set out to answer in this study was: What constitutes excellent teaching, in theory and practice, as expressed in this process?

Studied *documents* included policy documents, the criteria for application, the pedagogical portfolios that all applicants had submitted, letters of recommendation by department heads, reports on each pedagogical portfolio by an appointed reviewer, and the final assessment records. *Video-re-*

cordings were made of the interviews that the group of assessors had with each applicant. The internal discussions that were held among the assessors, both before and after each interview, were also video-recorded. *In-depth interviews* were made with strategically chosen participants who were involved in the process, either as applicants or assessors, individuals we understood as representing different perspectives on learning and different ways of experiencing the process of assessment. All findings are based on the analysis of data obtained in this process.

We started by reading the documents connected to the process, focusing specifically on the submitted pedagogical portfolios. Each member of the research team read the portfolios individually and only after that discussed them with the others in the group. After forming a basic common understanding of the qualities inherent in each portfolio we watched the video footage of the interviews the group of assessors had with each applicant (including the internal discussions they had before and after each interview). The other documents were then analysed in relation to the pedagogical portfolios and the assessment interviews. When the assessment procedure was finalized and the acceptance results made public, in-depth interviews were carried out with strategically chosen actors who were part of the process.

Interpretations Using Didactic Theory and Theories of Higher Education

Our focus in this project is on the assessment procedure and how the qualitative differences in approaching teaching and learning were handled in the process of assessment. In the analysis of the pedagogical portfolios we found qualitatively different ways in which applicants described their pedagogical knowledge and competence, both concerning pedagogical philosophy and pedagogical action. The portfolios were often well written and well structured but they differed in respect to how pedagogical philosophy and pedagogical action were conceptualised and to what extent the two were conceptually integrated.

Theory and practice is a dichotomy that comes to the fore in this process. The double perspective of *knowing* and *doing* which substantiates the format of the pedagogical portfolio seemed to tacitly guide the whole assessment procedure, including how the interviews were conducted. In the assessment procedure the teachers' knowledge and their practice were focused in order to ascertain the extent to which these two aspects of teaching competence were integrated and formed a coherent perspective. The actual assessment though was ultimately based on the quantitative measures of a 1-10 point scale on each criterion. The chair-person would start the discussion by going around the table collecting these numerical data and then start negotiations toward the final combination of allocated points. In cases of extreme numerical discrepancy the group of assessors actually came to discuss qualitative differences in conceptualising teaching and learning in higher education and made the underlying reasoning behind their distribution of points known. In analysing the data we found that this way of handling the assessment procedure opened up *generic* dimensions of variation, i.e. the possibility of tacitly discriminating three hierarchically organised structural levels of academic competence: 1) the ability to *describe* something; 2) the ability to *relate* the things described internally and externally; and 3) the ability to *reflect* upon that which is described and related.

Generic dimensions of academic competence could be considered all and well in the circumstances if it were not for the normative aim of the Pedagogical Academy—that awarded teachers have made the paradigmatic shift to base their work on a learning perspective. The question therefore is how the assessment procedure could be carried out in order to bring qualitative variation in perspectives on teaching and learning to the fore? We propose opening up the generic dimensions of variation (Z-axis in Fig. 8.1) in assessing teaching competence by using didactic theory (Y-axis), on the one hand, and theories of higher education (X-axis), on the other.

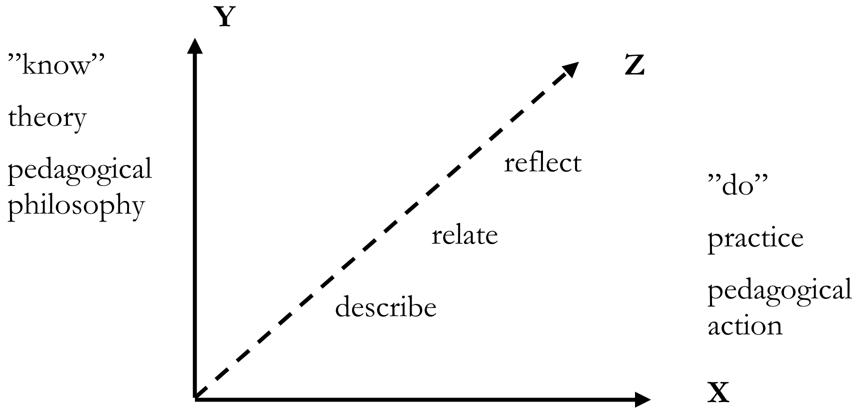

Figure 8.1 Generic dimensions of academic competence

Didactics (the theory of teaching and learning in the German tradition) is sometimes visualised in terms of the didactic triangle in which the student, the teacher and the content form the nodes of a triangle (Figure 8.2). In addition to that, the triangle can be placed inside a circle to indicate that teaching and learning always take place within a context. In this tradition teaching and learning is always seen as the teaching and learning of something.

The didactic triangle can be used at various levels of complexity. At the basic level it is simply used to distinguish between the three *nodes*—student, teacher and content—mainly to support discussions of these nodes separately, as discrete aspects. At the next level the triangle is used to focus on *relations* between the nodes, as interrelated aspects. On this level focus might be on e.g. students' understanding of the subject or the teachers' responsibility to motivate students. At the highest level of complexity the triangle can be used to investigate how all nodes and relations are linked together and constitute an integrated *whole* and how this entirety is influenced by, and in turn influences, the encompassing context. Examples of analyses at this level could concern ways in which assignments prepared by teachers take into account students' prior knowledge or experience within the field of study or how teachers might develop their approach to teaching and learning by conducting investigations into the variety of ways their students comprehend and conceptualise problematic concepts in the curriculum.

In a didactic situation the students approach the subject through the teacher's curriculum design, choice of literature, teaching methods, assessment methods, connection of theory to practice, etc. Using the didactic triangle we can recognise two different perspectives on teaching and learning in higher education based on differences in knowledge views, perspectives on learning and placement of responsibility; a *teaching perspective* and a *learning perspective*.

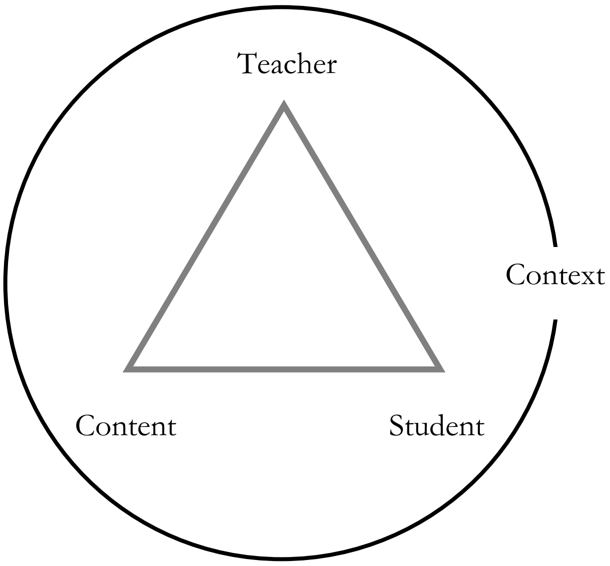

Figure 8.2 The didactic triangle

Within a *teaching perspective* teaching is seen as transmitting pre-defined knowledge to students (Fig. 8.3). This means that content is regarded as something objective and given and the teacher is responsible for planning and carrying out his or her teaching in a methodologically efficient manner. Teaching is organised in a way that allows very limited possibilities for the student to be active in the construction of knowledge. The student is given a passive role as a receiver and the teacher is responsible for the process.

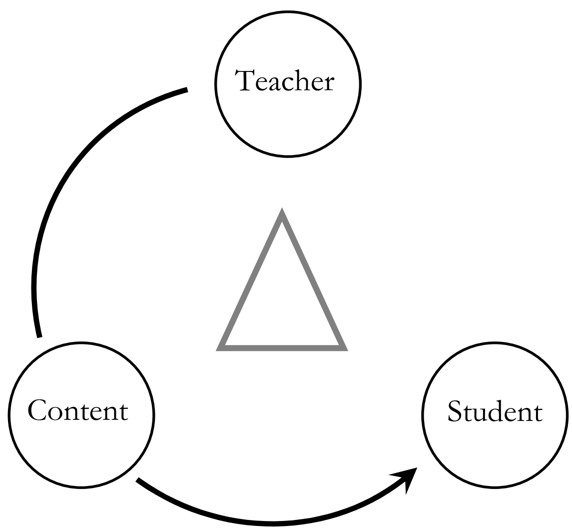

Figure 8.3 A teaching perspective

Within a *learning perspective* the students' active construction of knowledge is fundamental (Fig. 8.4). This means that the teacher is responsible for planning and carrying out his or her teaching so that it meets up with and builds on students' understanding and experiences of content knowledge. The teacher acts as a mediator between the student and the subject knowledge. The student actively constructs knowledge in the subject or field of knowledge and shares joint responsibility for the enacted learning.

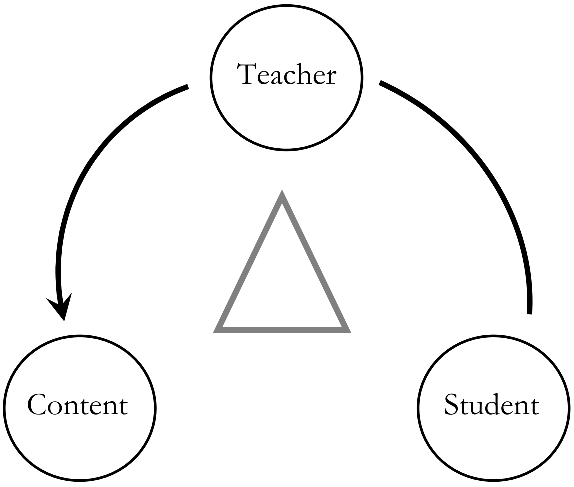

Figure 8.4 A learning perspective

Extensive empirical research within the field of teaching and learning confirms the superiority of a learning perspective in relation to student learning in higher education (Barr and Tagg, 1995; Marton and Booth, 1997; Bowden and Marton, 1998; Biggs, 2003; Prosser and Trigwell, 1999; Trigwell, 2001; Säljö, 2000).

The official position of LTH and of the Pedagogical Academy is *in favour of* the learning perspective. This means that the teacher in the planning, accomplishment and evaluation of his or her teaching should focus on the students encounter with the subject and take an active part in creating conditions for pedagogical resonance within this encounter. Pedagogical resonance (Trigwell and Shale, 2004) can be described as the link between the teacher's knowledge and the students' learning, the mutual understanding achieved in the collaboration between teacher and student, based in students' experiences and the teacher's subject knowledge.

In this project we used didactics in the content analysis of the pedagogical portfolios and in the analysis of the assessment procedure. It was adopted to capture the degree of relevance and complexity in pedagogical reasoning and to distinguish a holistic approach from an atomistic one.

We were, with the help of didactic theory, able to characterize pedagogical portfolios as focusing nodes, relations or wholes and could in the same way characterize the enacted discussions between the panel of assessors and interviewees as focusing either nodes, relations or wholes. In other words we were able to capture the structural aspect—the *how*—of understanding teaching and learning in higher education. By simultaneously focusing the referential aspect—the *what*—in the pedagogical portfolios and in the interview discussions we could effectively discriminate between pedagogical reasoning with student learning in focus, on the one hand, and pedagogical reasoning focusing teaching and teacher activities, on the other. By using didactic theory we could also take normative aspects—the *why*—into consideration and distinguish pedagogical reasoning where didactic content knowledge was focused.

By focusing *what* applicants write about in their pedagogical portfolios and *what* assessors ask about in the interviews, and relating that to *how* they do it, the pedagogical reasoning can be evaluated from the vantage point of both relevance and complexity. As opposed to being able to merely distinguish between descriptive, relational and reflective levels of reasoning the proposed model opens up dimensions of variation (Booth and Hultén, 2003) based on both the referential and the structural aspects of enacted knowledge and world views. This development of the dimension of *knowing* is represented in the y-axis of Figure 8.5.

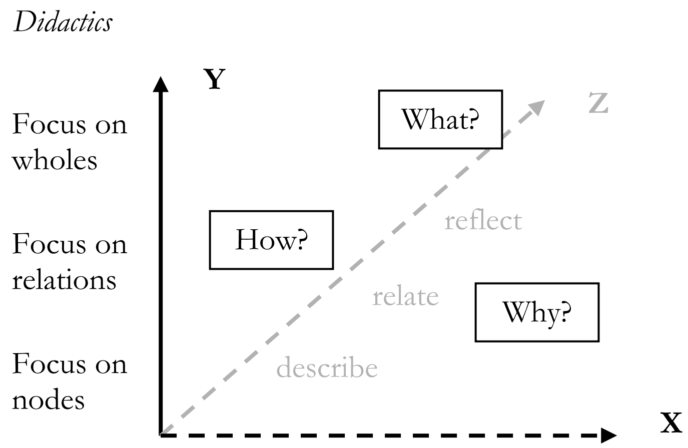

Figure 8.5 Using didactics to analyse dimension of knowing

Academic work at a university includes a continuous problematization of approaches and methods within research and teaching aiming to find improved solutions or explanations to various questions and problems. A scholarly approach is the basis of all academic work—be it teaching, research or service—and it is essential for the idea of the University of Learning (Bowden and Marton, 1998). Research on higher education has paid attention to this as vital also for pedagogical development (Boyer, 1990; Kreber, 2000, 2002; Trigwell *et al.*, 2000; Healey, 2000, 2003; Trigwell and Shale, 2004).

Learning is the common denominator in research as well as in teaching. Bowden and Marton (1998) distinguish between learning on a collective and an individual level. Knowledge is always new for the learner and the important difference between research and teaching in this respect is that in research learning is not only new for the individual but for the entire research community.

Boyer (1990) argued that research and teaching are different aspects of scholarship. He widened the concept of scholarship to embrace all academic work at a university and introduced four aspects of scholarship; *scholarship of discovery* which is close to traditional research, *scholarship of integration* which embraces cross-disciplinary activities, *scholarship of application* which includes academic work directed towards the surrounding community and finally *scholarship of teaching* including pedagogical activities.

Kreber (2002) presented a model for characterising pedagogical activities that has proved to be very useful in the analysis of the process of assessment within the Pedagogical Academy. In this model the teacher's pedagogical activities are differentiated in terms of three hierarchically organised levels. *Teaching Excellence* implies that the teacher's teaching supports student learning in an excellent way but it is un-reflected and without a theoretical frame of reference. *Teaching Expertise* includes the first level concerning the quality of teaching but at this level the teacher also demonstrates considerable reflected knowledge within the area of university pedagogy. *Scholarship of Teaching* builds on the previous levels and at this highest level the teacher in addition goes public and shares his or her experiences and knowledge in form of articles, conference papers, seminars etc. At this level the teacher has a scholarly approach to teaching that includes peer review and contributes actively in the construction of knowledge within the research area of university pedagogy as well as within his or her didactic field of knowledge.

The hierarchical levels of the model are visualised in Figure 8.6 where we have included *teaching* in a general sense, by which we mean teaching activities regardless if they support student learning, a level below Kreber's level of Teaching Excellence. At the level of *Excellence* teaching is performance oriented, experienced based and characterized by reflection-in-action (Schön, 1983). At the level of *Expertise* teaching is learning oriented, competence based and characterized by the pedagogical content knowledge of the teacher. At the highest level, *Scholarship*, teaching is mediation oriented and includes a public account. Sharing our knowledge by making it public is an important and indispensable aspect of scholarship. If teachers do not embrace and practice scholarship within the area of teaching and learning important and innovative work will continue to be private and undocumented, not available for scholarly peer review, scrutiny and feedback, not made public in a form others can build on, and consequently lost to the academic community.

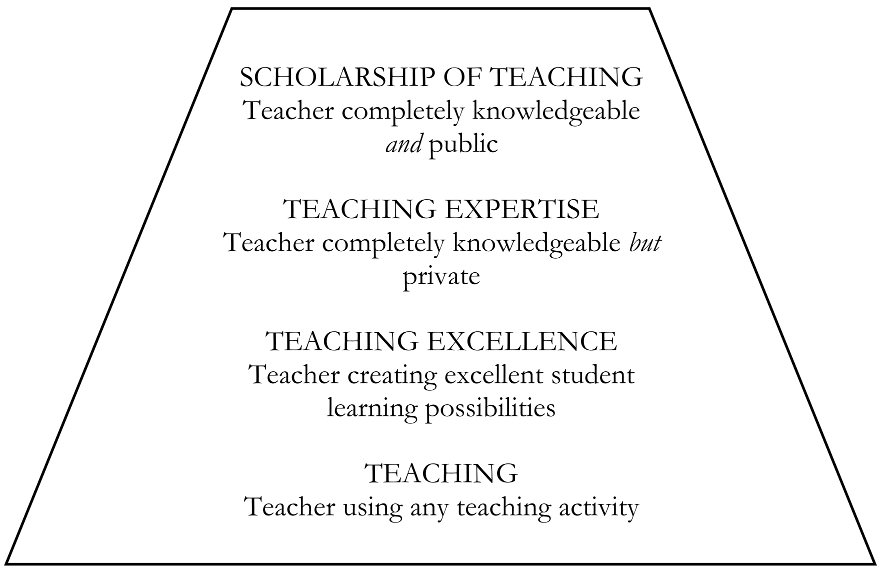

Figure 8.6 Hierarchical model of teaching (Kreber, 2002)

In this project we used theories on scholarship of teaching and learning and Kreber's model to characterise the aims and criteria for the Pedagogical Academy as well as to analyse the individual pedagogical portfolios and the assessment of them. The model was adopted to capture the level of competence and degree of scholarship and to distinguish a reflected approach from an unreflected one.

We were, with the help of theories in higher education, able to characterize pedagogical portfolios and assessment interviews on how teaching was conceptualised as practical and/or theoretical know-how that could be seen as either private or public. Here we were also able to capture the structural aspect—the *how*—of understanding teaching and learning in higher education. By simultaneously focusing the referential aspect—the *what*—in the pedagogical portfolios and in the interview discussions we could effectively discriminate between pedagogical action with student learning in focus, on the one hand, and pedagogical action focusing teaching and teacher activities, on the other. By using theories of higher education we could also take normative aspects—the *why*—into consideration and distinguish pedagogical action aimed at e.g. sharing didactically significant insights with colleagues or extending the parameters of knowledge within the field of university pedagogy.

By focusing *what* applicants commit to—the actions they describe in their pedagogical portfolios—and *what* assessors ask about concerning their actions in the interviews, and relating that to *how* they carry out these acts—what they do to bring them about—the pedagogical actions can be evaluated from the vantage point of both direction and reflectivity. In addition to that the public nature of knowledge and action can be qualitatively assessed by focusing *what kind* of meetings teachers have, *who* they are meeting with and *what* the meetings are about. As opposed to being able to merely distinguish between levels of generic action the proposed model opens up dimensions of variation based on both the referential and the structural aspects of enacted knowledge and world views.

This development of the dimension of *doing* is represented in the x-axis of Figure 8.7 as increasingly reflective and scholarly action. In our analysis we characterise Teaching Excellence as *Intuitive Practice*, Teaching Expertise as *Reflective Practice* and Scholarship of Teaching as *Scholarly Practice*.

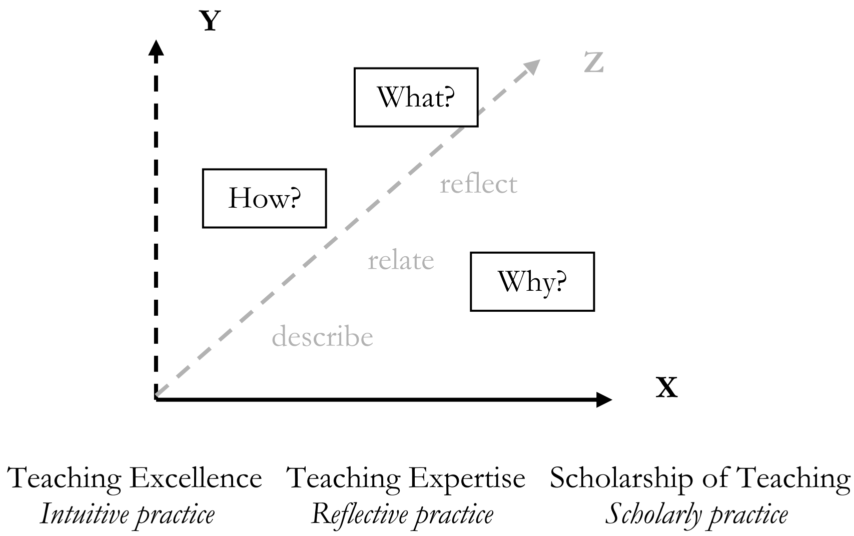

Figure 8.7 Using theories of higher education to analyse dimension of doing

Theories of higher education can also be used to further problematize the notion of *a learning perspective*. In Figure 8.8 another kind of learning perspective is presented where the teacher is the learner and he or she learns from researching student learning of subject knowledge. This is an aspect of the Scholarship of Teaching *and* Learning (Hutchings and Shulman, 1999), an elaboration of Boyer's ideas discussed above. Here we can also get inspiration as to how teachers can produce scholarly evidence-based material for a pedagogical portfolio.

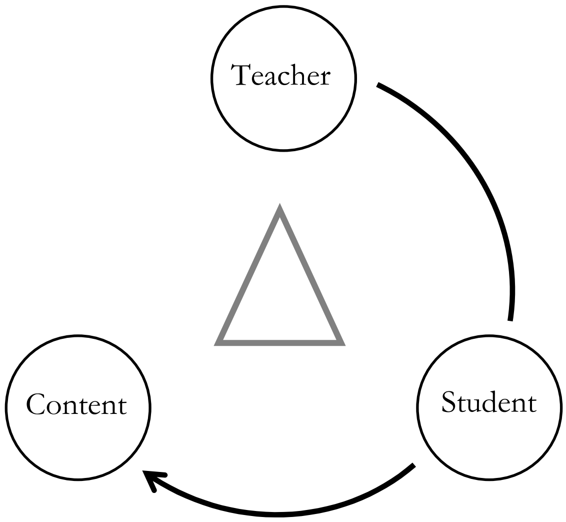

Figure 8.8 Scholarship of Teaching and Learning

Two-Dimensional Matrix Model

Assessment of teaching competence for admission into the Pedagogical Academy should be based on a reworked version of the criteria presented in this chapter and a qualitative analysis of the submitted pedagogical portfolios in relation to these criteria. The overall judgement should emanate from the two fuller dimensions described above where the didactic questions *What*, *How* and *Why* give substance to issues of relevance, level of holistic analysis and degree of scholarly approach. The level of holistic analysis varies from atomistic to holistic and the degree of scholarly approach from un-reflected to reflected as illustrated in Figure 8.9.

With a holistic approach we mean that the applicant presents a comprehensive view where different parts and aspects of his or her pedagogical knowledge and know-how are related to each other and make up a whole. By reflective approach we mean that the applicant has a scholarly approach to his or her pedagogical practice and puts it into action in a reflective way, integrating theory and practice and striving for continuous improvement, and endeavours to communicate both experienced paradoxes and insightful results to the academic community.

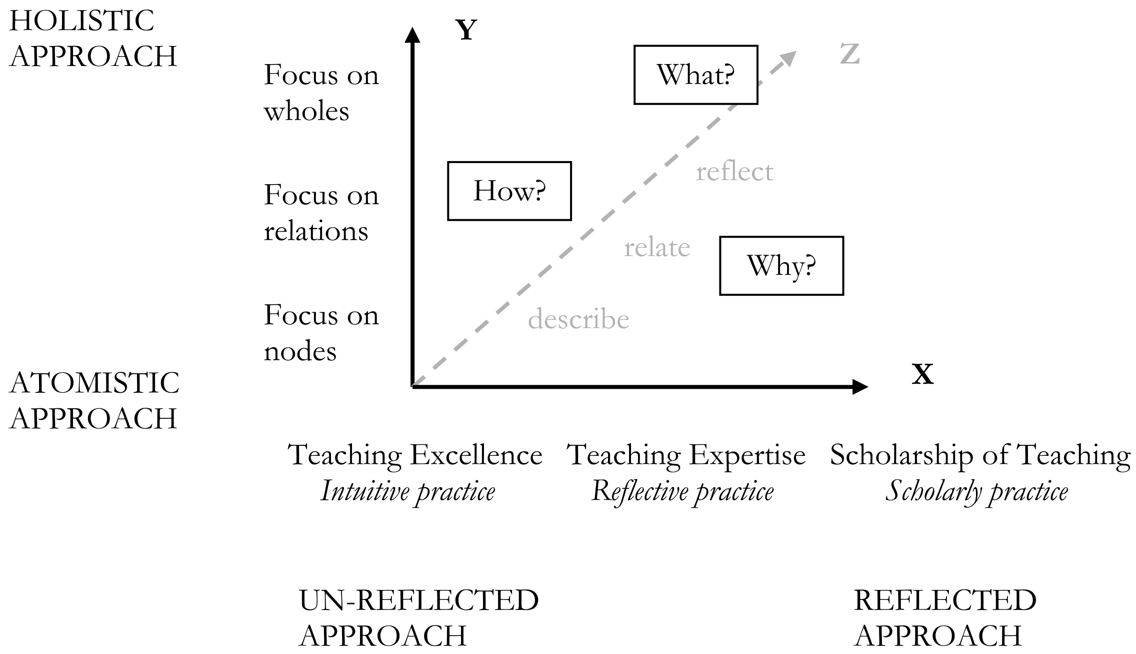

Figure 8.9 Overall assessment dimensions

The model is presented as a two-dimensional matrix in Figure 8.10.

WHAT? HOW? WHY?	**Intuitive practice**	**Reflective practice**	**Scholarly practice**
Focus on nodes			
Focus on relations			
Focus on wholes			

Figure 8.10 Two-dimensional matrix model for qualitative assessment of teaching competence

The model, as a whole, enables us to argue for the Scholarship of Teaching and Learning as an integral part of a true learning perspective. This makes it useful also in other contexts of higher education, such as teacher appointments committees and qualitative undergraduate assessment.

The benefits of the proposed model for qualitative undergraduate assessment—be it assessment of project works, laboratory reports or oral presentations—is of special interest for the present project on qualitative assessment in engineering education. The model enables teachers to distinguish new dimensions—open up dimensions of variation—in their assessment procedures of student reports or presentations.

The discussions in this chapter of the dichotomy of theory and practice in assessing scholarship in teaching and learning are further elaborated in a forthcoming paper, *Assessment of Scholarship in Teaching and Learning*, submitted to Studies in Higher Education (Antman and Olsson, 2005).

Paper VII (Appendix C) – *The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching* – gives the background and the main ideas behind the pedagogical academy, describes the process of application and acceptance and discusses some experiences of the implementation of the pedagogical academy at LTH.

Paper VIII (Appendix C) – *The Pedagogical Academy – Going Public as a Formative Assessment of Scholarship* – discusses scrutiny, peer review and variations in ways and levels of going public. Sharing our knowledge by making it public is an important and indispensable aspect of the scholarship of teaching and learning.

Paper IX (Appendix C) – *Excellent Teaching Practice – ett forskningsprojekt kring LTHs Pedagogiska Akademi* – describes (in Swedish) the developmentally-oriented research project investigating the different perspectives on learning that emerged in the process of application, assessment and acceptance to the Pedagogical Academy.

Paper X (Appendix C) – *Opening Dimensions of Variation: a Two-Dimensional Matrix Model for Analysing Scholarly Approaches to Teaching and Learning* – discusses opening up dimensions of variation, the new two-dimensional model for qualitative assessment and the Scholarship of Teaching and Learning as an integral part of a learning perspective

Chapter 9

Conclusions and Looking to the Future

This report addresses important aspects of qualitative assessment and student learning in engineering education. It deals with various aspects related to assessment in higher education including experimental skills and creativity, generic skills, reflective assessment and experiential learning, performance-based assessment, summative and formative features of assessment, methods useful in the process of assessing the degree of holism and the degree of scholarly approach in project works and presentations, taxonomies and qualitative assessment, first year action learning programme, constructive alignment in curriculum development and design etc.

The present project is primarily a development project. Nevertheless, the interdependence of pedagogical development and pedagogical research in higher education has become evident and indispensable during the course of the project. An important outcome is a fruitful cooperation in research and development ventures between Lund Institute of Technology (LTH), the Centre for Learning Lund, the Department of Education at Lund University and the Centre for Teaching and Learning at Lund University. New and interesting projects that will increase our pedagogical knowledge and awareness and develop student learning at LTH are already in progress.

In a recently started project (Lindberg-Sand and Olsson, 2005) the aim is to investigate the structure of the examination systems in different educational programmes at LTH and to describe the interplay between the formal classification of assessments and the development of students' and teachers' work in the different courses (Giddens, 1991; Bowker and Star, 1999; Wenger, 1998; Trowler and Cooper, 2002). The project consists of three different parts which are mutually dependent on each other and creates an action research design close to practice:

- an initial project consisting of mapping and analysing examination systems in educational programmes at LTH,
- teachers' action learning while exploring their own assessment practices in relation to the examination systems described (framed by a teacher training course),
- research building on the encounter between on the one hand the formal examination system and on the other hand student learning and teachers' experiences of their work in the process of examination.

The Bologna process will change the preconditions for assessment thoroughly and a further future aim is to follow changes induced by the Bologna process.

The work on qualitative assessment of teaching competence especially focusing on dimensions of variation will be continued. Special attention will be paid to the process of peer review of scholarly approaches to teaching.

Subject didactics (the theory of teaching of a subject) is another important area for pedagogical development. It is closely related to the qualitative outcome of student learning. A small-scale investigation in chemical engineering indicates serious shortcomings in the way students understand fundamental aspects of material balances (Grimsberg and Olsson, 2005). Similar investigations in other subjects at LTH would probably show comparable results.

This is a challenging starting point for further research and development. The key word is variation. Constitutionalism and phenomenography (Prosser and Trigwell, 1999; Marton, 1981; Marton and Booth, 1997) could form the theoretical underpinning for a developmental project focusing on subject didactics. Prosser and Trigwell (1999) argue that meaning is constituted through an internal relationship between the individual and the world and that learning is about experiencing a phenomenon (the object of learning) in a different way. Phenomenography discerns qualitatively different ways in which a phenomenon is experienced. It is important to identify and describe this variation in students' understanding. In teaching we should strive at conceptual change in the way students experience the object of learning. This could influence student learning outcome positively.

Learning Study (Pang and Marton, 2003) focuses on the object of learning—not the method of teaching. The starting point is that variations in students' understanding of a particular object of learning should determine how teaching about that object is accomplished. Groups of teachers and educational researchers build innovative learning environments and collaboratively plan teaching activities based on phenomenographic research to help students change their thinking towards qualitatively higher levels of understanding. Further research is performed to identify characteristics of the teaching that have induced conceptual change in students' understanding.

Pang and Marton (2003) write: "What teachers do, how students learn, and the theory about teaching and learning are entangled. An understanding of this entanglement is crucial to attempts to improve learning." It is important that the ideas and actions of the teachers and researchers in a Learning Study are grounded in theory: "The learning study is expected to be a bridge between theory and practice and between basic research and developmental work." Auscultations are essential—the combination of collaborative planning, observation and evaluation based on learning theories is at the focal point. Results from Hong Kong show astonishing differences of learning outcomes between Learning Study groups and control groups. The concept of Learning Study has interesting potentials for the pedagogical development at LTH.

Paper XI (Appendix C) – *Utforskning av undervisning och lärande med vetenskapliga metoder* – describes (in Swedish) different methods of research in higher education and the interdependence of pedagogical development and pedagogical research in higher education.

Paper XII (Appendix C) – *Sustainability and Survival – Analysing Examination Processes as Conditions for Students' and Teachers' Work in Higher Education* – gives an overview of a recently started project on examination systems.

Chapter 10

References

Antman, L. and Olsson, T. (2005). Assessment of Scholarship in Teaching and Learning, submitted to *Studies in Higher Education*

Antman, L., Olsson, T., Hammar Andersson, P. and Booth, S. (2004). Rewarding Excellent Teaching – in Theory and Practice. Characterising the Gap, *12th International Improving Student Learning Symposium*, Diversity and Inclusivity, The Oxford Centre for Staff and Learning Development

Barr, R. B. and Tagg, J. (1995). From Teaching to Learning – A New Paradigm for Undergraduate Education, *Change*, 27 (6), 12-25

Baxter Magolda, M. (1992). *Knowing and Reasoning in College: Gender-Related Patterns in Students' Intellectual Development*, San Francisco: Jossey Bass

Belenky, M., Clinchy, B., Goldberger, N., and Tarule, J. (1986). *Women's Ways of Knowing: The Development of Self, Voice, and Mind*, New York: Basic Books.

Biggs, J. B. (2003). *Teaching for Quality Learning at University*, Second Edition, Society for Research into Higher Education & Open University Press

Biggs, J. B. and Collis, K. F. (1982). *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome)*, Academic Press

Bloom, B. S. (Ed.), Engelhart, M. D., Furst, E. J., Hill, W. H. and Krathwohl, D. R. (1956), *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook I: Cognitive Domain*, David McKay Company

Booth, S. and Hultén, M. (2003). Opening dimensions of variation: An empirical study of learning in a Web-based discussion, *Instructional Science*, Vol. 31, pp 65-86

Bowden, J. and Marton, F. (1998). *The University of Learning: Beyond Quality and Competence in Higher Education,* Kogan Page

Bowker, G. C. and Star, S. L. (1999). *Sorting Things Out. Classifications and its Consequences*, Cambridge Massachusetts: MIT Press

Boyer, E., L (1990). *Scholarship Reconsidered. Priorities of the Professoriate,* The Carnegie foundation

Brooks, J. G. and Brooks, M. G. (1993). *In Search of Understanding: The Case for Constructivist Classrooms*, Association for Supervision and Curriculum Development

Bruffee, K. A. (1993). *Collaborative Learning: Higher Education, Interdependence and the Authority of Knowledge*, Johns Hopkins University Press

Cowan, J. (1998). *On Becoming an Innovative University Teacher. Reflection in Action*, Society for Research into Higher Education & Open University Press

Entwistle, N. and Walker, P. (2000). Strategic alertness and expanded awareness within sophisticated conceptions of teaching, *Instructional Science*, Vol. 28 (5-6)

Giddens, A. (1991). *The Consequences of Modernity*, Cambridge: Polity Press

Grimsberg, M. and Olsson, T. (2005). Teknologers förståelse av centrala begrepp i en kemiteknikkurs, *3:e Pedagogiska inspirationskonferensen*, Lund Institute of Technology (accepted)

Hammar Andersson, P., Olsson, T., Almqvist, M., Zetterqvist, L., Axelsson, A., Olsson, G. and Roxå, T. (2003). The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching, Rust, C. (Ed.), *Improving Student Learning: Theory and Practice -10 years on*, 307-314, The Oxford Centre for Staff and Learning Development

Harden, R. M., Stevenson, M., Wilson Downie, W. and Wilson, G. M. (1975). Assessment of Clinical Competence Using Objective Structured Examination, *British Journal of Medical Education*, 1, 447-451

Healey, M. (2000). Developing the Scholarship of Teaching in Higher Education: a discipline-based approach, *Higher Education Research and Development* 19 (2), 169-189

Healey, M. (2003). The Scholarship of Teaching: Issues Around an Evolving Concept, *Journal of Excellence in College Teaching*, 14 (1/2)

Hutchings, P. and Shulman, L., S. (1999). The Scholarship of Teaching: New Elaborations, New Developments, *Change*, 31 (5), 11-15

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, New Jersey: Prentice-Hall

Krathwohl, D. R., Bloom, B. S. and Masia, B. B. (1964). *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook II: Affective Domain,* David McKay Company

Kreber, C. (2000). How University Teaching Award Winners Conceptualise Academic Work: some further thought on the meaning of scholarship, *Teaching in Higher Education*, 5 (1), 61-78

Kreber, C. (2002). Teaching Excellence, Teaching Expertise, and the Scholarship of Teaching, *Innovative Higher Education*, Vol. 27, No. 1

Lindberg-Sand, Å. and Olsson, T. (2005). Sustainability and survival – analysing examination processes as conditions for students' and teachers' work in higher education, *Improving Student Learning through Assessment*, The Oxford Centre for Staff and Learning Development (accepted)

Marton, F. (1981). Phenomenography – describing conceptions of the world around us, *Instructional Science*, 10, 177-200

Marton, F. and Booth, S. (1997). *Learning and Awareness*, Mahwah NJ: Lawrence Erlbaum Associates

Olsson, T. (2000). Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy, Rust, C. (Ed.), *Improving Student Learning Through the Disciplines*, 304-324, The Oxford Centre for Staff and Learning Development

Olsson, T. (2002a). Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-Based Examination in Chemical Engineering, Rust, C. (Ed.), *Improving Student Learning Using Learning Technologies*, 310-323, The Oxford Centre for Staff and Learning Development

Olsson, T. (2002b). A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum, *Education-line, Brotherton Library*, http://www.leeds.ac.uk/educol/

Olsson, T. (2004). Reflective Assessment – Qualitative Aspects of Evaluation and Learning, *Utvecklingskonferensen för högre utbildning 2003*, Järnefelt, I. (Ed.), Proceedings, 79-82

Pang, M. and Marton, F. (2003). Beyond "Lesson Study": Comparing two ways of facilitating the grasp of some economic concepts, *Instructional Science*, 31, 175-194

Perry, W. G., Jr. (1970). *Forms of Intellectual and Ethical Development in the College Years. A Scheme*, Holt, Rinehart and Winston

Prosser, M. and Trigwell, K. (1999). *Understanding Learning and Teaching. The Experience in Higher Education*, Society for Research into Higher Education & Open University Press

Ramsden, P. (1991). A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire, *Studies in Higher Education*, Vol. 16, No. 2

Ramsden, P. (2003). *Learning to Teach in Higher Education*, Second Edition, Routledge

Schön, D. A. (1983). *The Reflective Practitioner*, Basic Books

Säljö, R. (2000). *Lärande i Praktiken: Ett Sociokulturellt Perspektiv*, Prisma Bokförlag

Trigwell, K. (2001). Judging University Teaching, *International Journal for Academic Development*, 6(1)

Trigwell, K. and Shale, S. (2004). Student Learning and the Scholarship of University Teaching, *Studies in Higher Education*, Vol. 29, No. 4

Trigwell, K., Martin, E., Benjamin, J. and Prosser, M. (2000). Scholarship of Teaching: a Model, *Higher Education Research and Development*, 19 (2)

Trowler, P. and Cooper, A. (2002). Teaching and Learning Regimes: Implicit theories and recurrent practices in the enhancement of teaching and learning through educational development programmes, *Higher Education Research and Development*, 21 (3)

Wenger, E. (1998). *Communities of Practice: Learning, Meaning and Identity*, Cambridge University Press

Appendix A

Project activities – presentations and publications

Presentations

Presentations at conferences, workshops, seminars and visits

- Invited presentation at SPUCK XI (Sveriges Pedagogiska Universitetskemisters Centrala Konferens) national conference, Centre for Chemistry and Chemical Engineering, Lund, August 2000
- Invited presentation at "Kick off", Lund Institute of Technology, Helsingborg, August 2000
- Poster presentation at the 8th International Improving Student Learning Symposium – Improving Student Learning Strategically, UMIST, Manchester, September 2000
- Invited presentation at the Board of Civil Engineering Education (UNV) Seminar, Höör, January 2001
- Paper presentation at the 9th International Improving Student Learning Symposium – Improving Student Learning Using Learning Technologies, Edinburgh, September 2001
- Paper presentation at the International Research Conference – Learning Communities and Assessment Cultures: Connecting Research with Practice, Newcastle, August 2002
- Paper presentation at the 10th International Improving Student Learning Symposium – Improving Student Learning: Theory and Practice – 10 years on, Brussels, September 2002
- Poster/paper presentation at the ASEE/SEFI/TUB International Colloquium – Global Changes in Engineering Education, Berlin, October 2002
- Presentation (short paper) at Pedagogisk Inspirationskonferens, Lund Institute of Technology, May 2003
- Workshop at Pedagogisk Inspirationskonferens, Lund Institute of Technology, May 2003
- Poster presentation at Earli (European Association for Research on Learning and Instruction) 10th Biennial Conference: Improving Learning, Fostering the Will to Learn, Padova, August 2003
- Poster presentation at the 11th International Improving Student Learning Symposium – Improving Student Learning: Theory, Research and Scholarship, Hinckley, September 2003
- Roundtable presentation at Utvecklingskonferensen för högre utbildning, Gävle, November 2003

- Invited presentation at a Workshop on Teaching and Learning, Department of Chemical Engineering, Lund, January 2004
- Presentation for visitors from Learning Lab DTU, Technical University of Denmark, March 2004
- Paper presentation at the 4th International Conference on the Scholarship of Teaching and Learning, London, May 2004
- Presentation (short paper) at 2:a Pedagogiska Inspirationskonferensen, Lund Institute of Technology, May 2004
- Presentation/workshop at the 4th International Workshop on Active Learning in Engineering Education (ALE), Nantes, June 2004
- Presentation for visitors from KTH Learning Lab, Royal Institute of Technology, June 2004
- Paper presentation at the 12th International Improving Student Learning Symposium – Diversity and Inclusivity, Birmingham, September 2004
- Paper presentation at the 2004 SEFI Annual Conference. The XXI Century, The Golden Opportunity for Engineering Education, Valencia, September 2004
- Poster presentations (2) at the 2nd Nordic Symposium on Staff and Faculty Development in Engineering Education, Odense, November 2004
- Invited presentation at a Pedagogical Seminar, "Fattar du?", arranged by the Student Union at Lund Institute of Technology, December 2004
- Invited presentation at Inspiration Course for University Teachers, Lund Institute of Technology, January 2005
- Paper presentation at Forskningskonference: Ingeniørvidenskab, competence og dannelse, Aalborg, March 2005

Planned presentations during spring and autumn 2005

- Presentation at the 2nd CeTUSS Workshop: Teaching and Assessing Engineers, Uppsala, April 2005
- Invited presentation at Uppsala University, Läcker universitetet? Ökad studentgenomströmning – ett mål för alla!, Uppsala, April 2005
- Paper presentation at the 5th International Conference on the Scholarship of Teaching and Learning, London, May 2005
- Invited presentation/workshop on assessment, Idéseminarium at the Centre for Teaching and Learning at Lund University (UCLU), Lund, May 2005
- Presentations (2) (short paper) at 3:e Pedagogiska Inspirationskonferensen, Lund Institute of Technology, May 2005
- Roundtable presentation at 3:e Pedagogiska Inspirationskonferensen, Lund Institute of Technology, May 2005

- Paper presentation (symposium) at the Earli (European Association for Research on Learning and Instruction) 11th Biennial Conference: Integrating Multiple Perspectives on Effective Learning Environments, Nicosia, Cyprus, August 2005
- Paper presentation at the 13th International Improving Student Learning Symposium – Improving Student Learning through Assessment, London, September 2005
- Paper presentation at Utvecklingskonferensen för högre utbildning, Karlstad, November 2005

Publications

Papers relevant as a background to the project

Olsson, T. (1999). *SOLO-taxonomin – en modell för planering och utveckling av utbildning*, UPC-bladet nr 2/1999, Universitetspedagogiskt centrum, Lund University

Olsson, T. (2000). *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy*, 7th International Improving Student Learning Symposium, University of York, 1999, Rust, C. (Ed.), Improving Student Learning Through the Disciplines, pp 304-324, The Oxford Centre for Staff and Learning Development

Papers directly or partly associated with the project

Olsson, T. (2002). *Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-Based Examination in Chemical Engineering*, 9th International Improving Student Learning Symposium, Heriot-Watt University, Edinburgh, 2001, Rust, C. (Ed.), Improving Student Learning Using Learning Technologies, pp 310-323, The Oxford Centre for Staff and Learning Development

Olsson, T. (2002). *A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum*, International Research Conference – Learning Communities and Assessment Cultures: Connecting Research with Practice, University of Northumbria/Earli (European Association for Research on Learning and Instruction) Special Interest Group on Assessment and Evaluation, Newcastle, 2002, Published on: Educati*on-line*, Brotherton Library, University of Leeds, http://www.leeds.ac.uk/educol/

Olsson, T. (2002). *A Modern Integrated Curriculum in Biotechnology Designed to Promote Quality Learning*, 2002 ASEE/SEFI/TUB (American Society for Engineering Education/European Society for Engineering Education/Technische Universität Berlin) International Colloquium – Global Changes in Engineering Education, Berlin

Olsson, T. (2003). *Utforskning av undervisning och lärande med vetenskapliga metoder*, Pedagogisk inspirationskonferens, Proceedings, pp 60-61, Lund Institute of Technology

Olsson, T. and Sivik, B. (2003). *SOLO taxonomin – en modell för kvalitativ planering och utvärdering av undervisning och examination*, Pedagogisk inspirationskonferens, Proceedings, pp 72-73, Lund Institute of Technology

Olsson, T. (2003). *Evaluative Aspects of a Reflective Summative Assessment*, Earli (European Association for Research on Learning and Instruction) 10th Biennial Conference, Padova, 2003, Mason, L., Andreuzza, S., Arfè, B. and Del Favero, L. (Eds), Improving Learning, Fostering the Will to Learn, p 586, Università degli Studi di Padova

Hammar Andersson, P., Olsson, T., Almqvist, M., Zetterqvist, L., Axelsson, A., Olsson, G. and Roxå, T. (2003). *The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching*, 10th International Improving Student Learning Symposium, Bryssel, 2002, Rust, C. (Ed.), Improving Student Learning: Theory and Practice -10 years on, pp 307-314, The Oxford Centre for Staff and Learning Development

Olsson, T. (2004). *Reflective Assessment – Qualitative Aspects of Evaluation and Learning*, Utvecklingskonferensen för högre utbildning, Gävle, 2003, Järnefelt, I. (Red.), Proceedings 2003, pp 79-82, University College of Gävle/The Swedish Council for the Renewal of Higher Education

Antman, L., Booth, S., Hammar Andersson, P. and Olsson, T. (2004). *Excellent Teaching Practice – ett forskningsprojekt kring LTHs pedagogiska akademi*, 2:a Pedagogiska inspirationskonferensen, Proceedings, pp 14-16, Lund Institute of Technology

Olsson, T., Antman, L., Roxå, T., Hammar Andersson, P. and Booth, S. (2004), *The Pedagogical Academy – Going Public as a Formative Assessment of Scholarship*, 4th International Conference on the Scholarship of Teaching and Learning, London, 2004, Conference Abstracts, pp 7-8, City University

Andersson, P., Andersson, R. and Olsson, T. (2004). *The Pedagogical Academy – a Model for Rewarding Scholarly Teaching,* 4th International Workshop on Active Learning in Engineering Education (ALE), Nantes, 2004, Proceedings pp 100-101, Ecole des Mines de Nantes

Antman, L., Olsson, T., Hammar Andersson, P. and Booth, S. (2004). *Rewarding Excellent Teaching – in Theory and Practice. Characterising the Gap*, 12th International Improving Student Learning Symposium, Birmingham, 2004, Diversity and Inclusivity, The Oxford Centre for Staff and Learning Development

Antman, L., Booth, S., Hammar Andersson, P. and Olsson, T. (2004). *The Pedagogical Academy – Qualitative Research on the Process of Rewarding Scholarly Teaching*, SEFI 2004 Annual Conference. The XXI Century, The Golden Opportunity for Engineering Education, Valencia, 2004, Proceedings, pp 55-59, Universidad Politecnica de Valencia

Olsson, T., Antman, L., Hammar Andersson, P. and Booth, S. (2004). *Qualitative Assessment of Teaching Competence – a Two-Dimensional Model for Assessing Knowledge, Expertise and Scholarship in Teaching*, 2nd Nordic Symposium on Staff and Faculty Development in Engineering Education, Odense, 2004, University of Southern Denmark

Lindberg-Sand, Å. and Olsson, T. (2004). *Assessment in Higher Education – a Project Combining Pedagogical Research, Renewal of Assessment Systems and Competence Development in Teacher Action-Learning Groups*, 2nd Nordic Symposium on Staff and Faculty Development in Engineering Education, Odense, 2004, University of Southern Denmark

Lindberg-Sand, Å. and Olsson, T. (2005). *Utformning av examinationssystem - konsekvenser för studenternas studier och lärares arbete*, Forskningskonference: Ingeniørvidenskab, competence og dannelse, Aalborg 2005, Aalborg University

Antman, L. and Olsson, T. (2005). *Opening Dimensions of Variation: a Two-Dimensional Matrix Model for Analysing Scholarly Approaches to Teaching and Learning*, 5th International Conference on the Scholarship of Teaching and Learning, London, 2005, City University (accepted)

Lindberg-Sand, Å. and Olsson, T. (2005). *Analysing Examination Processes as Conditions for Students' and Teachers' Work in Higher Education*, 2nd CeTUSS Workshop, Uppsala 2005, Teaching and Examining Engineers, Uppsala University (accepted)

Lindberg-Sand, Å. and Olsson, T. (2005). *Utformning av examinationssystem – konsekvenser för studenternas studier och lärares arbete*, 3:e Pedagogiska inspirationskonferensen, Lund Institute of Technology (accepted)

Olsson, T., Antman, L., Hammar Andersson, P. and Booth, S. (2005). *Kvalitativ bedömning av pedagogisk kompetens – en tvådimensionell matrismodell*, 3:e Pedagogiska inspirationskonferensen, Lund Institute of Technology (accepted)

Grimsberg, M. and Olsson, T. (2005). *Teknologers förståelse av centrala begrepp i en kemiteknikkurs*, 3:e Pedagogiska inspirationskonferensen, Lund Institute of Technology (accepted)

Antman, L. and Olsson, T. (2005). *The Scholarship of Research and Scholarship of Teaching in Science and Engineering (symposium): Peer Review of Scholarly Approaches to Teaching – The Case of the Pedagogical Academy*, Earli (European Association for Research on Learning and Instruction) 11th Biennial Conference, Nicosia, 2005, Integrating Multiple Perspectives on Effective Learning Environments, The University of Cyprus (accepted)

Lindberg-Sand, Å. and Olsson, T. (2005). *Sustainability and Survival – Analysing Examination Processes as Conditions for Students' and Teachers' Work in Higher Education*, 13th International Improving Student Learning Symposium, London, 2005, Improving Student Learning through Assessment, Imperial College (accepted)

Lindberg-Sand, Å. and Olsson, T. (2005). *Examinationsprocesser i högre utbildning – brytpunkter i mötet mellan studenters lärande, lärares bedömningsarbete och det formella examinationssystemet*, Utvecklingskonferensen för högre utbildning, 2005, Karlstad University/The Swedish Council for the Renewal of Higher Education (submitted)

Antman, L and Olsson, T. (2005). *Assessment of Scholarship in Teaching and Learning,* submitted to Studies in Higher Education

Appendix B

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assessment of pedagogical competence

Björn Sivik, senior lecturer in Food Technology, Lund Institute of Technology

SOLO taxonomy

Appendix C

Papers

This report contains a summary of the project on qualitative assessment (Chapter 1-10) and the following papers referred to by their Roman numerals in the previous text:

Chapter 2

I **Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy**

Thomas Olsson

In Rust, C. (Ed.), Improving Student Learning Through the Disciplines, pp 304-324, The Oxford Centre for Staff and Learning Development, 2000

II **SOLO taxonomin – en modell för kvalitativ planering och utvärdering av undervisning och examination**

Thomas Olsson and Björn Sivik

Pedagogisk inspirationskonferens, Proceedings pp 72-73, Lund Institute of Technology, 2003

Chapter 3

III **A Modern Integrated Curriculum in Biotechnology Designed to Promote Quality Learning**

Thomas Olsson

ASEE/SEFI/TUB (American Society for Engineering Education/European Society for Engineering Education/Technische Universität Berlin) International Colloquium, 2002

Chapter 5

IV **Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-based Examination in Chemical Engineering**

Thomas Olsson

In Rust, C. (Ed.), Improving Student Learning Using Learning Technologies, pp 310-323, The Oxford Centre for Staff and Learning Development, 2002

Chapter 6

V **A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum**

Thomas Olsson

Published on: Educati*on-line*, Brotherton Library, University of Leeds, http://www.leeds.ac.uk/educol/, International Research Conference – Learning Communities and Assessment Cultures: Connecting Research with Practice, 2002

Chapter 7

VI **Reflective Assessment – Qualitative Aspects of Evaluation and Learning**

Thomas Olsson

In Mason, L., Andreuzza, S., Arfè, B. and Del Favero, L. (Eds), Improving Learning, Fostering the Will to Learn, p 586, Earli 10th Biennial Conference, 2003

In Järnefelt, I. (Ed.), Proceedings 2003, pp 79-82, Utvecklingskonferensen för högre utbildning, 2004

Chapter 8

VII **The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching**

Pernille Hammar Andersson, Thomas Olsson, Monica Almqvist, Lena Zetterqvist, Anders Axelsson, Gustaf Olsson and Torgny Roxå

In Rust, C. (Ed.), Improving Student Learning: Theory and Practice – 10 years on, pp 307-314, The Oxford Centre for Staff and Learning Development, 2003

VIII **The Pedagogical Academy – Going Public as a Formative Assessment of Scholarship**

Thomas Olsson, Lotta Antman, Torgny Roxå, Pernille Hammar Andersson and Shirley Booth

4th International Conference on the Scholarship of Teaching and Learning, Conference Abstracts, pp 7-8, London, 2004

IX **Excellent Teaching Practice – ett forskningsprojekt kring LTHs pedagogiska akademi**

Lotta Antman, Shirley Booth, Pernille Hammar Andersson and Thomas Olsson

2:a Pedagogiska inspirationskonferensen, Proceedings pp 14-16, Lund Institute of Technology, 2004

X **Opening Dimensions of Variation: a Two-Dimensional Matrix Model for Analysing Scholarly Approaches to Teaching and Learning**

Lotta Antman and Thomas Olsson

5th International Conference on the Scholarship of Teaching and Learning, Conference Abstracts, London, 2005

XI **Utforskning av undervisning och lärande med vetenskapliga metoder**

Thomas Olsson

Pedagogisk inspirationskonferens, Proceedings pp 60-61, Lund Institute of Technology, 2003

XII **Sustainability and Survival – Analysing Examination Processes as Conditions for Students' and Teachers' Work in Higher Education**

Åsa Lindberg Sand and Thomas Olsson

In Rust, C. (Ed.), Improving Student Learning through Assessment, The Oxford Centre for Staff and Learning Development, (paper to be published 2006)

I

Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum
-
Applications of the SOLO Taxonomy

Paper presented at the
7th International Improving Student Learning Symposium
University of York
6th-8th September 1999

Published in Rust C. (Ed.), Improving Student Learning Through the Disciplines, pp 304-324, The Oxford Centre for Staff and Learning Development, 2000

(published with permission from OCSLD, Oxford)

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1 INTRODUCTION

Learning in higher education involves both quantitative and qualitative aspects. Traditionally, especially in science and technology, quantitative aspects of teaching and assessing have been emphasised at the expense of qualitative aspects. Some important questions raised in this paper deals with this problem.

What do existing examination papers from the different courses within the curriculum look like? Do they make it possible for the students to demonstrate learning at qualitatively high levels? Chapter 2 presents an investigation of examination papers within the chemical engineering curriculum.

What happens if students are presented with an assessment designed especially to measure the qualitative level of learning? Is it important if the examination is written or oral? Do the students show a deep, holistic approach or a surface, atomistic approach to learning? Chapter 3 presents a qualitative examination in chemical engineering.

What characteristics of a teaching method are important if you want to enhance the quality of learning? This question is discussed in connection with a presentation of a special teaching method used in chemical engineering called ”Solving Practical Problems”. Chapter 4 presents the method and its qualitative features.

The SOLO (Structure of the Observed Learning Outcome) taxonomy is a model for qualitative evaluation of teaching and assessing (Biggs and Collis, 1982). It consists of five levels of increasing structural complexity. These levels are called the prestructural, unistructural, multistructural, relational and extended abstract levels. The SOLO taxonomy is applied in the analysis of the different aspects of quality in teaching and assessing presented in this study.

2 A SOLO ANALYSIS OF EXAMINATION PAPERS WITHIN THE CURRICULUM

2.1 Overview of the investigation

What kind of assignments you present to your students are crucial to the answers you get. Not only the content of the questions but also how they are formulated can result in quite different answers at qualitatively very different levels. You get what you ask for and nothing more. This is especially true regarding the answers you receive from students studying only to pass an examination.

This study presents a thorough investigation of 80 examination papers within the Chemical Engineering Curriculum (Bachelor of Science level) at Lund University. The papers represent the following subjects: food engineering, food technology, applied nutrition, analytical chemistry, biochemistry, general chemistry, microbiology and chemical engineering. Of the papers investigated about 60 percent were given during the years 1991-1994 and 40 percent from 1997-1999. Major revisions of the curriculum were performed between the two periods investigated.

In the study all relevant questions were categorised according to the possibility of reaching and identifying different SOLO levels when answering the questions.

2.2 Examples of questions inviting answers at different SOLO levels

A representative selection from the more than 1050 analysed questions and tasks is listed below. It gives a good picture of the various questions of the examination papers and the maximal SOLO levels that can be expected from the corresponding answers.

Questions inviting unistructural responses

- Which are the Latin names of the families' wheat, barley, maize and oats? (Food Technology)
- What factors are important to consider in connection with cold storage of foodstuff? (Food Technology)
- What is gluten? (Food Technology)
- Which membrane processes would you suggest if you should
  (a) separate fat from wastewater?
  (b) recover proteins from whey?
  (c) desalinate seawater? (Food Engineering)
- Many of our choices of different foodstuffs have changed during the 20th century. Give two examples of foodstuffs that we have increased and decreased our consumption of respectively. (Applied Nutrition)
- Give two examples of metabolic fibres. (Applied Nutrition)
- Which two rules for the solvents are important to consider in LSC-separations (adsorption chromatography)? (Analytical Chemistry)
- Explain the following terms
  (a) primary structure of a protein
  (b) transcription
  (c) translation
  (d) feed-back inhibition

(e) induced-fit theory
(f) essential amino-acid (Biochemistry)

- State six important differences between procaryotic and eucaryotic organisms. (Microbiology)
- Explain the following terms
  (a) D-number
  (b) pasteurisation
  (c) BOD
  (d) restriction enzyme
  (e) secondary metabolite (Microbiology)
- Name five different bacteria that can be found in milk. (Microbiology)

Questions inviting multistructural responses

- Explain why bread baked with rye flour is more compact than bread baked with wheat flour. (Food Technology)
- Describe the manufacturing of soured milk. (Food Technology)
- What purpose has selenium in the body? (Applied Nutrition)
- What is the characteristic of the composition of olive oil, maize oil and coconut butter respectively? (Applied nutrition)
- Describe the construction and the characterisation of the different sources of light that are used in UV-VIS-spectrophotometers. (Analytical Chemistry)
- Describe two different principles of building up a mobile phase gradient in HPLC. State advantages and disadvantages. (Analytical Chemistry)
- Describe the different RNA-types of a cell and their tasks in the protein synthesis. (Biochemistry)
- Describe schematically the cycling of carbon in nature. (Microbiology)
- There are three distinct mechanisms for DNA-transfer. Describe them briefly. (Microbiology)

Questions inviting relational and extended abstract responses

- What is food quality? Discuss the question from the point of view of the consumer, authorities, distribution system, processing industry and food security. (Food Technology)
- A company that exports pharmaceuticals to tropical countries has received several complaints that the tablets absorb moisture and therefore cannot be used. As a newly employed engineer you are asked if you know anything about ”sorption isotherms”. The product development department claims that the problem might be better understood if you know something about sorption isotherms. Can you help them? (Food Engineering)
- You can nowadays find several fermented milk products sold in ordinary grocer’s shops with health promotive arguments published in scientific journals. The products contain living cultures that are good for your health and stomach. Make a proposal of how you should best quality-secure a fermented milk product. Follow the production line from the milk entering the Pasteur to the packed milk product in the refrigerated display case in the shop. (Food Technology)

- You are working with product development within a large food company. The market department has received information about a possible market for products promoting the blood lipids. There is already a proposal to introduce a cholesterol-free oil on the market. Answer this and make other proposals. (Applied Nutrition)
- ”Line spectral sources of light must be used in AAS-instruments.” Discuss this statement. (Analytical Chemistry)
- ”Using AAS with a flame the sample is used ineffectively.” Analyse this statement. (Analytical Chemistry)
- You work in a food laboratory where an optimal pasteurisation process for a foodstuff is to be designed. Your task is to propose an experiment for this purpose. How would you design the experiment? State what you think is especially important to consider. (Microbiology)
- There are several different methods that can be used to identify and classify micro-organisms. You receive a completely unknown micro-organism that you should try to characterise. How would you proceed? What characteristics would you consider to be most important to determine? The investigations are to be conducted in a normally equipped microbiological laboratory. (Microbiology)
- A chemical engineer performs a batch distillation using a glass tube filled with crushed glass connected as a column directly above a boiler. All vapour that leaves the column is condensed and withdrawn as a distillate. The condenser is connected in such a way that there is no reflux. Despite this the engineer succeeds in concentrating the volatile component much more than would be expected from an ideal tray (the boiler). Try to explain this. (Chemical Engineering)

2.3 Results

2.3.1 Tables with a complete presentation of the results

Only relevant questions were analysed with regard to possible answers at different SOLO levels. Relevant questions are theoretical and explorative problems. Questions testing methods of calculation and design were regarded as non-relevant for a SOLO analysis.

The sizes of the different courses are given as credits. In the Swedish higher educational system one credit represents one week of full time studies.

Examination papers from different food (and drug) technology courses are presented in Tables 2.1 and 2.2. Before the revision of the curriculum these courses comprised a total of 11 credits (Table 2.1). After the revision a single course in food and drug technology (20 credits) was introduced (Table 2.2). Except for applied nutrition the same teachers were responsible for the courses both before and after the revision of the curriculum.

Table 2.1 Food Technology Courses, 1991-1994

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Food Engineering, 5 credits								
fall '92	72	36	18	**50**	14	**39**	4	**11**
spring '93	61	29	13	**45**	14	**48**	2	**7**
summer '93	68	38	15	**39**	23	**61**	0	**0**
fall '93	56	25	0	**0**	21	**84**	4	**16**
spring '94	58	31	4	**13**	27	**87**	0	**0**
Food Technology, 3 credits								
summer '91	50	36	16	**44**	17	**47**	3	**9**
spring '92	107	72	20	**28**	52	**72**	0	**0**
summer '92	87	58	22	**38**	32	**55**	4	**7**
fall '92	32	32	15	**47**	14	**44**	3	**9**
spring '93	59	38	8	**21**	24	**63**	6	**16**
summer '93	61	38	13	**34**	23	**61**	2	**5**
Applied Nutrition, 3 credits								
fall '92	108	104	66	**63**	38	**37**	0	**0**
fall '93	112	112	72	**64**	40	**36**	0	**0**

Table 2.2 Food and Drug Technology Courses, 1997-1999

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Unit Operations, 4 credits								
fall '97	49	17	4	**24**	8	**47**	5	**29**
spring '99	58	29	10	**34**	9	**32**	10	**34**
Production Technology, 4 credits								
spring '98	46	46	0	**0**	31	**67**	15	**33**
spring '99	46	46	0	**0**	23	**50**	23	**50**
Raw Materials, 2 credits								
fall '98	97	97	36	**37**	54	**56**	7	**7**
Applied Nutrition, 5 credits								
spring '98	75	75	15	**20**	24	**32**	36	**48**
Final examination, 20 credits								
spring '98	--	--	--	**0**	--	**0**	--	**100**
spring '99	--	--	--	**0**	--	**0**	--	**100**

Analytical chemistry is presented in Table 2.3. New courses were introduced and different teachers were responsible for the courses before and after the revision of the curriculum. The course "modern separation methods" was exchanged for "food and drug analysis - quality assurance" in 1998.

Table 2.3 Analytical Chemistry, 1992-1998

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Analytical Chemistry, 3 credits								
fall '92	40	10	0	**0**	10	**100**	0	**0**
spring '93	35	12	3	**25**	9	**75**	0	**0**
Analytical Chemistry with Food Analysis, 4 credits								
fall '92	27	16	0	**0**	16	**100**	0	**0**
fall '93	25	16	5	**31**	8	**50**	3	**19**
fall '94	28	21	2	**10**	6	**28**	13	**62**
spring '94	28	24	4	**17**	9	**37**	11	**46**
fall '94	30	16	3	**19**	10	**62**	3	**19**
fall '95	30	16	0	**0**	12	**75**	4	**25**
Instrumental Analytical Chemistry, 5 credits								
spring '97	80	50	3	**6**	19	**38**	28	**56**
summer '97	70	54	2	**4**	20	**37**	32	**59**
fall '97	70	42	4	**10**	24	**57**	14	**33**
Analytical Chemistry - Modern Separation Methods, 5 credits								
fall '96(1)	80	80	6	**8**	62	**77**	12	**15**
fall '96(2)	80	80	0	**0**	51	**64**	29	**36**
fall '97	80	80	15	**19**	48	**60**	17	**21**
spring '98	80	77	18	**24**	49	**64**	9	**12**
summer '98	80	80	8	**10**	38	**47**	34	**43**
Food and Drug Analysis - Quality Assurance, 5 credits								
fall '98(1)	60	60	4	**7**	17	**28**	39	**65**
fall '98(2)	60	60	0	**0**	26	**43**	34	**57**

Biochemistry and general chemistry are presented in Tables 2.4 and 2.5. The same teachers were responsible for the courses during the entire period investigated.

Table 2.4 Biochemistry, 1993-1999

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Biochemistry, 5 credits								
spring '93	49	49	32	**65**	17	**35**	0	**0**
summer '93	49	49	32	**65**	17	**35**	0	**0**
fall '93	49	37	31	**84**	6	**16**	0	**0**
spring '94	48	43	27	**63**	16	**37**	0	**0**
summer '94	50	40	20	**50**	20	**50**	0	**0**
Biochemistry and Physiology, 10 credits								
summer '98	87	77	27	**35**	50	**65**	0	**0**
fall '98(1)	86	78	38	**49**	40	**51**	0	**0**
fall '98(2)	92	82	34	**41**	48	**59**	0	**0**
spring '99	81	63	23	**37**	40	**63**	0	**0**

Table 2.5 General Chemistry, 1992-1997

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
General Chemistry, 5 credits								
fall '92(1)	80	28	12	**42**	8	**29**	8	**29**
fall '92(2)	80	30	10	**33**	10	**33**	10	**33**
fall '93	100	16	4	**25**	8	**50**	4	**25**
General and Inorganic Chemistry, 10 credits								
fall '97(1)	108	32	0	**0**	13	**41**	19	**59**
fall '97(2)	108	31	0	**0**	10	**32**	21	**68**

Table 2.6 presents different courses of microbiology. The content of the courses is the same before and after the revision of the curriculum. Different teachers were responsible for each of the courses analysed.

Table 2.6 Microbiology, 1990-1998

Examination paper	**Total of points**	**Relevant points**	**SOLO levels**					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Microbiology, 2 credits								
fall '90(1)	44	40	16	**40**	24	**60**	0	**0**
fall '90(2)	46	42	8	**19**	34	**81**	0	**0**
spring '91	48	48	20	**42**	18	**38**	10	**20**
fall '91	42	42	25	**60**	17	**40**	0	**0**
fall '92	41	41	20	**49**	21	**51**	0	**0**
fall '93	45	45	26	**58**	19	**42**	0	**0**
Food Microbiology with Hygiene, 3 credits								
spring '93	60	60	23	**38**	29	**49**	8	**13**
summer '93	60	60	25	**42**	27	**45**	8	**13**
fall '93	60	60	21	**35**	17	**28**	22	**37**
spring '94	60	60	20	**33**	32	**54**	8	**13**
General Microbiology, 5 credits								
spring '98(1)	100	95	28	**29**	57	**60**	10	**11**
spring '98(2)	100	98	17	**17**	44	**45**	37	**38**

The courses of industrial chemistry and chemical engineering had all the same responsible teacher (Table 2.7).

Table 2.7 Chemical Engineering, 1992-1999

Examination paper	Total of points	Relevant points	SOLO levels					
			unistructural		*multistructural*		*relational and extended abstract*	
			points	*%*	*points*	*%*	*points*	*%*
Industrial Chemistry, 2 credits								
fall '92(1)	60	60	34	**57**	18	**30**	8	**13**
fall '92(2)	60	60	31	**52**	27	**45**	2	**3**
Chemical Engineering, 4 credits								
fall '92	60	27	4	**15**	12	**44**	11	**41**
spring '93(1)	60	16	0	**0**	12	**75**	4	**25**
spring '93(2)	60	23	10	**43**	8	**35**	5	**22**
spring '93(3)	60	19	4	**21**	6	**32**	9	**47**
summer '93	60	21	4	**19**	10	**48**	7	**33**
fall '93(1)	60	22	8	**36**	10	**46**	4	**18**
fall '93(2)	60	16	4	**25**	10	**62**	2	**13**
fall '93(3)	60	22	8	**36**	9	**41**	5	**23**
Chemical Engineering, 5 credits								
fall '96	60	15	0	**0**	7	**47**	8	**53**
fall '97	60	16	0	**0**	2	**13**	14	**87**
spring '98	60	29	2	**7**	12	**41**	15	**52**
fall '98	60	13	0	**0**	6	**46**	7	**54**
spring '99	60	14	0	**0**	8	**57**	6	**43**

2.3.2 Analysis of the reported results and some concluding reflections

An analysis of the reported results shows that the number of questions inviting answers at the relational and higher levels have increased considerably in recent years for many of the subjects investigated.

A comparison of papers from the first half of the 1990's with those from the second half of the decade illustrates this increase. This can be exemplified by general chemistry with an increase from an average of 30 to about 60 percent questions at the relational level, chemical engineering from 30 to 60 percent, food technology courses from less than 10 to 40 percent, applied nutrition from 0 to 50 percent and analytical chemistry from 20 to 40 percent questions at the relational level.

Correspondingly questions at the unistructural level have decreased and for some subjects, such as applied nutrition, general chemistry and chemical engineering, there are no longer any examination tasks that only require answers at the unistructural level.

Examination papers of microbiology show the same tendency and in biochemistry the questions at the multistructural level have increased from 35 to 60 percent although still no questions requiring answers at the relational level can be found.

The reason for this positive development is probably to be found in the major revisions of the curriculum performed in 1996-1997. This stimulated the pedagogical discussions among the teachers at several departments who take part in the teaching within the curriculum. Another aspect of the revision is the new structure of the curriculum. It comprises a total of only 14 courses, which favours a deep holistic approach in teaching as well as learning.

Another important factor is most certainly the increased pedagogical activities at the university. Many teachers have participated in advanced pedagogical courses in recent years.

2.4 Design of examination papers that measure more advanced SOLO levels

What should be tested in an examination paper? Is it important to ask about definitions, Latin names of cereals or names of vitamins and bacteria? It may very well be of importance but then why not broaden the questions so that names and definitions must be understood to be able to answer the wider questions (at more advanced SOLO levels)?

An example from Chapter 2.2 illustrates this:

Instead of asking, "What is gluten?" at the unistructural level ask the question "Explain why bread baked with rye flour is more compact than bread baked with wheat flour" at the multistructural level. The last question cannot be answered if you do not have any knowledge about gluten.

How questions are formulated can be crucial to the SOLO levels of the answers you get. If you use words like *exemplify*, *describe* and *explain* you invite answers at the unistructural or multistructural levels. Whereas words like *discuss*, *compare*, *relate*, *analyse* and *judge* invite answers at the relational or extended abstract levels.

More examples from Chapter 2.2 illustrate this last and very important aspect:

"What factors are important to consider in connection with cold storage of foodstuff?"

This unistructural question can easily be reformulated by adding

"and discuss their relative importance". Now you have a question requiring at least a multistructural, probably a relational, response.

Another unistructural question is:

”What membrane processes would you suggest if you should
(a) separate fat from waste water?
(b) recover proteins from whey?
(c) desalinate sea-water?”

Add words like *discuss*, *motivate* or *argue* and the expected responses will be at the relational level.

”Which two rules for the solvents are important to consider in LSC-separations (adsorption chromatography)?” is a unistructural question that becomes multistructural by adding, ”explain why”.

Several of the multistructural questions presented in Chapter 2.2 begin with the word *describe*:

”Describe the manufacturing of soured milk”.

”Describe the construction and the characterisation of the different sources of light that are used in UV-VIS-spectrophotometers”.

”Describe the different RNA-types of a cell and their tasks in the protein synthesis”.

”Describe schematically the cycling of carbon in nature”.

If you use words like discuss, compare and analyse in the questions the expected SOLO levels of the responses is raised to at least the relational level.

2.5 Conclusions and comments - based on interviews with university teachers responsible for the different courses

The investigation shows that many of the theoretical and explorative problems in the examination papers only require answers at the unistructural or multistructural levels. Examination problems in higher education should normally be of such a quality that it is possible to demonstrate at least the relational level. At this level students are able to integrate the task components into a coherent structure and this should be a desirable level of outcome for learning at a university. Extended abstract responses are not likely to be found if the students have not been given specific instructions about the SOLO taxonomy and qualitative examination.

Interviews with some of the university teachers responsible for the different courses lead to three major conclusions relative the reported results.

- Some teachers perform their assessment of students as they always have done. They have never reflected about what kind of questions they give in their examination papers. This is hopefully a rapidly diminishing category of teachers.
- Some, especially inexperienced university teachers, feel that they must cover the whole course by asking many unistructural and multistructural questions. They also feel more insecure in marking answers at the higher levels. This is a problem easily solved by professional training and advice.
- Many teachers are quite aware of the problem but feel that they are prisoners of the higher educational system. It is quite easy to alter the examination papers so that they require more answers at higher SOLO levels but then the time for marking the papers increase considerably. And they just do not have that time. Because a university teacher not only has to teach but also develop the teaching, develop courses and the curriculum, perform own research, participate in the administration etc. There are no simple solutions to this problem....

The third and last conclusion is of course very serious and a solution would require appropriate measures to be taken from the university management.

3 QUALITATIVE EXAMINATION IN CHEMICAL ENGINEERING

3.1 Introduction

This part of the study deals with methods of qualitative examination in chemical engineering. Criteria for different SOLO levels have been set up and a task analysis is presented in Chapter 3.3.

A combined oral and written examination is presented. The 28 participating students have studied basic fluid mechanics, engineering thermodynamics, heat engineering and mass transfer separation processes. The students have also been given some information about qualitative assessment and the different qualitative levels of the SOLO taxonomy.

3.2 Assessment design

The qualitative examination is presented in Figure 3.1. Each student was given six out of the nine questions presented. They worked with the assignment for about four hours.

Qualitative examination in Chemical Engineering

February 1999

Answer the following questions. Your written answers will be analysed qualitatively using the SOLO taxonomy. This means an evaluation of structural complexity according to the written and oral directions you have received. Have this in mind when you work with the questions.

For all questions you should:

- describe
- explain
- discuss
- exemplify
- compare
- relate
- generalise
- hypothesise
- conclude
- analyse
- judge

1. The equation of continuity
2. Flow measurement using flow meters based on the principle of variable head
3. Methods to separate particles from a gas or a liquid
4. Mechanisms of heat transfer
5. Heat transfer by convection
6. Heat engine (from a general point of view)
7. The first law of thermodynamics
8. Refrigeration process
9. Diffusion and separation processes based on diffusion

Figure 3.1 Qualitative examination in Chemical Engineering

3.3 Criteria for different SOLO levels and task analysis

At the prestructural level students show that they do not understand the context of the problem. At the unistructural level at least one relevant aspect of the problem must be discussed and a correct explanation or conclusion presented. The multistructural level requires several relevant aspects of the problem to be treated although independent of each other. At the relational level these aspects are integrated into a coherent structure. Finally extended abstract responses introduce a general principle from which deductive conclusions can be drawn. The two highest levels of the SOLO taxonomy are qualitatively different from the lower levels since students must integrate their knowledge and skills into a coherent structure (Biggs and Collis, 1982). This should always be the aim of higher education.

A task analysis has been made for the qualitative examination and three examples are presented below:

Flow measurement using flow meters based on the principle of variable head

This kind of flow meters comprise orifice meters, venturi meters, flow nozzles, elbow meters etc. Answers at the unistructural level discuss only one method correctly. Multistructural responses include several methods but they are treated independently. At the relational level these methods are compared and analysed with respect to pressure differences, accuracy, flows, energy losses, costs etc. An extended abstract discussion might introduce a general equation valid for all flow meters based on the principle of variable head.

Mechanisms of heat transfer

The mechanisms of heat transfer are conduction, convection and radiation. Unistructural responses treat one and multistructural responses all mechanisms correctly. At the relational level the mechanisms are compared and analysed with respect to magnitudes, temperature levels, interactions etc. Extended abstract responses might introduce general discussions including the second law of thermodynamics.

Heat engine (from a general point of view)

Examples of heat engines are the steam process, the Otto and the Diesel processes (internal combustion engine processes), the refrigeration process and the gas turbine process. One or several treated correctly result in unistructural or multistructural responses. Discussions and comparisons of thermal efficiencies, temperature levels and working media are necessary for a relational answer and extended abstract responses could introduce a general principle for all heat engines and discussions with respect to the first and second laws of thermodynamics.

Similar task analysis must be set up for all questions (written or oral) in a qualitative examination that is evaluated using the SOLO taxonomy.

3.4 Results

3.4.1 Presentation of results focusing on either students or questions

Figure 3.2 shows the average SOLO levels of each of the 28 participating students and Table 3.1 shows the average SOLO level for each question of the qualitative examination. The result in the second column is based on the entire student group whereas the third column is based only on students with an average SOLO level above 2.0.

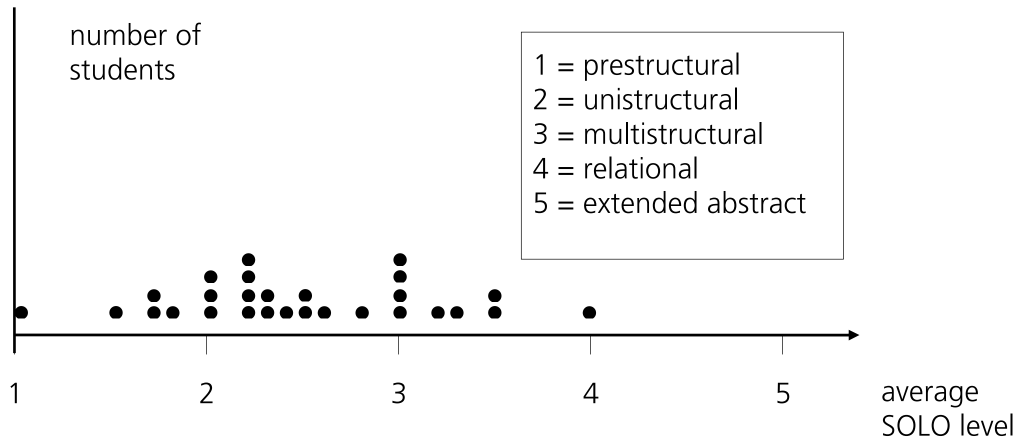

Figure 3.2 SOLO levels of participating students

Table 3.1 SOLO levels for different questions

Question number (1-9) (Qualitative Examination in Chemical Engineering)	**Average SOLO level for each question** (based on the entire student group)	**Average SOLO level for each question** (based only on students with individual average SOLO levels above 2.0)
1	2.9	3.0
2	3.0	3.4
3	2.7	3.2
4	2.6	2.8
5	1.3	1.5
6	2.4	2.6
7	2.2	2.2
8	1.7	2.0
9	2.2	2.4

3.4.2 Comments and discussion of the results

The SOLO levels reached by this student group are quite low. There are several possible explanations. Students presenting unistructural and prestructural responses are obviously not prepared for the examination. Some of the questions were not very suitable for a qualitative examination (for example 5, 7 and 8). The students were probably not prepared enough for this kind of examination. Results from the oral part of the examination (Chapter 3.5) and interviews with students (Chapter 3.7) indicate this.

3.5 Oral examination

3.5.1 Description

After the written part of the examination followed an oral part. The students were examined individually and in groups of 7 students. The questions of the written examination were discussed again together with new aspects.

3.5.2 Results

Students presenting multistructural responses during the written examination with few exceptions presented discussions at the relational level during the oral examination. They just needed some minor input. Even some positive attempts at the extended abstract level were made. This shows that qualitative assessment is better to perform orally than in written examinations. Many students have the ability to present relational solutions although they do not show it in written examinations.

3.6 Investigation of different approaches to learning within the student group

3.6.1 Procedure

An investigation of the participating students deep or surface approaches to learning (Ramsden, 1992) was performed using parts of the course experience questionnaire presented by Ramsden (Ramsden, 1991 and 1992). A total of 17 statements regarding deep or surface approaches were used. Some examples are shown below:

”I try to relate ideas in this subject to those in others wherever possible.”

”I usually set out to understand thoroughly the meaning of what I study.”

”Although I generally remember facts and details, I find it difficult to fit them together into an overall picture.”

”I usually don´t have time to think about the implications of what I have read.”

The investigation was performed in connection with the oral examination and the following question was asked: ”How do the statements (1-17) correspond with your opinions?” In this investigation only four options were possible: *not at all*, *hardly*, *quite good* and *very good*. This means that for each statement the students had to make a choice between a surface and a deep approach.

3.6.2 Results

The four options were given numbers (1-4) where 4 always indicates a deep approach. The answers were analysed and are presented in Figure 3.3. The result shows that these students neither are very deep oriented nor especially surface oriented in their approaches to learning.

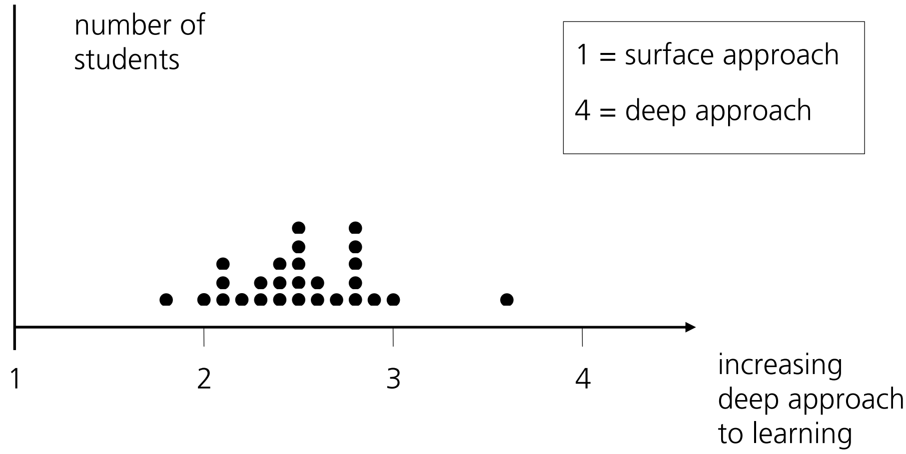

Figure 3.3 Deep or surface approach to learning

3.7 Comments and conclusions - based on the presented results and interviews with students

The written examination shows responses mainly at the multistructural and unistructural levels. Interviews with students resulted in explanations like: ”I was so pleased just to be able to write down all I know about flow meters that I did not think about the relational level.”, ”I just don’t think like that.”, ”I would have needed more experience with this kind of examination.” The last reflection is of course very serious and might explain why some of the students did not reach the relational level.

Oral examinations help the students demonstrate more advanced SOLO levels. Biggs and Collis already stated this when they presented the SOLO taxonomy (Biggs and Collis, 1982).

Interviews with students indicate that they would want to study with a deeper approach to learning and they are surprisingly aware of the problem. The reason why they are not doing so is to be found in the higher educational system. There is just not time enough when you study two or even three subjects in parallel and have to do laboratory experiments, hand in different exercises and projects in time and finally pass the examinations. It is an interesting result worth considering especially if you compare it with the results from the interviews with teachers presented in Chapter 2.5.

4 SOLVING PRACTICAL PROBLEMS - A TEACHING METHOD THAT INCREASES THE QUALITY OF LEARNING

4.1 Presentation of the method

Solving practical problems is a special teaching method used as an alternative in the chemical engineering laboratory. The method introduces problem solving and creative thinking in the undergraduate courses of chemical engineering (Master of Science and Bachelor of Science levels) at Lund University. It has been used since the beginning of the 1980's and it has been further developed in a recent research project funded by the Swedish Council for the Renewal of Undergraduate Education (Axelsson, 1995).

Some of the most important objectives of the method are:

- the problems should illustrate interesting physical phenomena or important engineering problems
- the problems should preferably be able to solve both practically and by using theoretical reasoning
- the problems should enhance the ability to suggest new solutions and ask new questions
- the problems should stimulate students to propose creative ideas

The problem is presented by the teacher together with a brief written description. The students (in groups of four students) discuss and do experiments for about 20 minutes trying to reach a solution. During a final discussion together with the teacher the students present their solutions and new aspects and questions are raised and discussed.

We have long been aware of the qualitative advantages of the method and in this investigation some qualitative aspects of the effects of the method based on a SOLO analysis are presented. Using this method as a complement to lectures, tutorials and traditional laboratory work it is possible to encourage students to reach high SOLO levels. Discussions at the relational and even extended abstract levels are common in the solutions of these problems.

4.2 Examples of practical problems with corresponding solution strategies at different SOLO levels

Manifold

The distribution of flows in manifolds is a challenging problem both theoretically and practically. It is a typical example of a practical problem.
Water flows to a manifold with circular holes as shown in Figure 4.1.

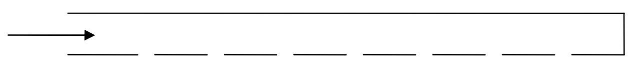

Figure 4.1 Flow in a manifold

From which hole is the flow of water highest? Explain why. Sketch the pressure profile in the figure.

What happens if the holes are smaller?

What happens if the manifold is longer?

What happens if the inner surface of the manifold is rougher?

How can we get a uniform distribution of water?

Solution strategies at the unistructural/multistructural levels lead to a correct answer and possibly a theoretical explanation. At the relational level the students handle different alterations (smaller holes, longer tube, rougher surface) without problems. An extended abstract solution might comprise correct ideas and theoretical explanations for a uniform distribution of water. A mathematical treatment of the problem is very complex and involves difference equations but students that master this are demonstrating the extended abstract level.

Herons fountain.

Heron of Alexandria, a Greek mathematician and physicist, invented this fountain about 2000 years ago. It is a fascinating illustration of fluid statics (Figure 4.2). It might be necessary to think twice to realise why it is not a *perpetuum mobile*.

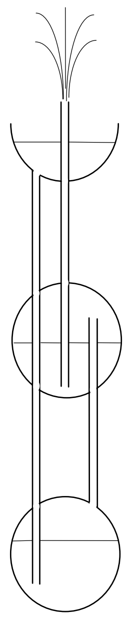

Figure 4.2 Heron's fountain

Water is flowing from level A through a glass tube to a lower level C. As a result water squirts from D to a higher level than A.

Explain how the fountain works.

What is the maximum height the water could squirt? How can you alter this height? Does the actual height differ from the theoretical?

Discussions at the unistructural/multistructural levels lead to a correct explanation. At the relational level different situations and alterations are explained correctly. An extended abstract solution is perhaps not quite applicable in this case but a discussion of other phenomena based on the same principle as Heron's fountain is at least at the upper relational level.

Hydraulic ram

In this water pump, invented in the late 18th century by the Montgolfier brothers, water is pumped from a lower to a higher level without any external supply of energy (Figure 4.3).

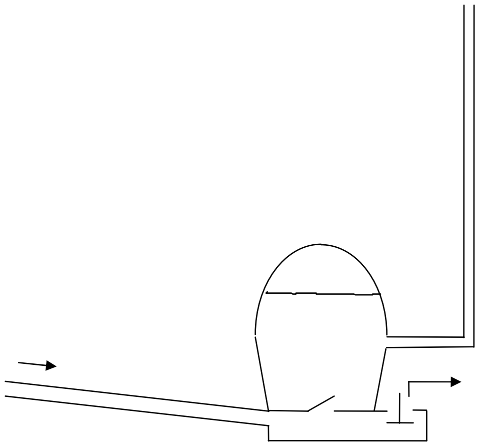

Figure 4.3 Hydraulic ram

Explain how the pump works.

How can you alter the delivery head?

How can you alter the flow of water?

How do you start and stop the pump?

Unistructural/multistructural solutions explain how the pump works. Relational discussions also include correctly how the delivery head and water flow can be altered. At the extended abstract level the students realise that a pressure transient known as water hammer is the reason why the pump works and they are also able to give other examples where and why this phenomenon occurs.

Mariotte's bottle

This useful little device is named after the French monk and physicist Edmé Mariotte (1620-1684). It is used as a practical problem to illustrate basic equations of fluid mechanics (Figure 4.4).

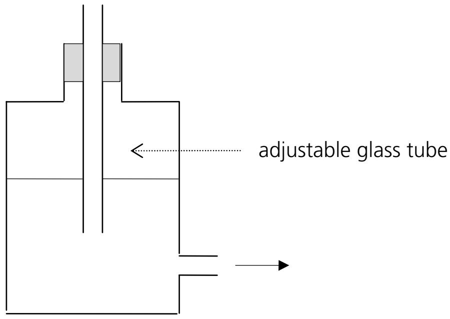

Figure 4.4 Mariotte's bottle

What happens to the flow of water from the bottle when the adjustable tube is held at a constant position?
What happens when the tube is moved upwards or downwards?

Discuss the magnitude of the pressure of air inside the bottle.

Discuss other types of bottles (not shown in Figure 4.4).

Discussions at the unistructural/multistructural levels lead to a correct explanation of the first and second questions above. At the relational/extended abstract levels different situations and alterations are explained. Theoretical explanations and considerations are handled correctly.

Thermos® flasks

Ordinary thermos® flasks are used in a practical problem illustrating fundamentals of conduction and convection at different pressures.

Three flasks are used. One original from the manufacturer, one that is punctured so that the space between the double walls of the flask is filled with air at atmospheric pressure and one that has been provided with a connection to a vacuum pump so that the space between the walls can be evacuated and maintained at different pressures.

The thermos® flasks are filled with boiling water. The temperature of the water and the temperature of the outside walls were measured continually during the cooling of the water.

Why does the water cool at different rates?

Can the heat losses be eliminated?

Why are the surfaces of the walls silver-plated?

Discuss the heat flow at different pressures.

How should the insulation be designed to be as effective as possible?

Unistructural/multistructural solutions explain the experimental results. Relational answers also include discussions of different kinds of insulation, different pressures and different designs of the flasks. At the extended abstract level the students extend their discussions to a more general reasoning about heat transfer in gases at low pressures and the relative importance of conduction, convection and radiation for different thermos® flask designs.

The drinking bird

This toy from the 1970's can be used to illustrate important principles of heat and mass transfer (Figure 4.5).

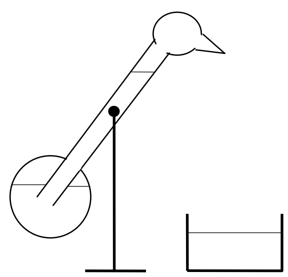

Figure 4.5 The drinking bird

The bird is filled with a volatile organic solvent.

Why does the bird swing up and down so that it appears as if it is drinking from the small cup filled with water beside it?

Unistructural/multistructural solutions explain what happens. Relational discussions also include problems like the use of different solvents in the cup beside the bird and what happens if the bird is enclosed in a glass cover. At the extended abstract level the discussions are extended to a more general reasoning about heat and mass transfer.

The six presented practical problems illustrate the method. More than 40 practical problems have been developed at the Department of Chemical Engineering, Center for Chemistry and Chemical Engineering at Lund University

4.3 Comments and conclusions

This is an interesting teaching method used as a complement to other methods in the chemical engineering undergraduate courses (Axelsson, 1995). It has many advantages and this study has pointed out some qualitative features of the method.

The most important conclusion is that the oral discussions among the students and between teachers and students increase the quality of learning and help students to reach more advanced SOLO levels.

This teaching method is easily transferable to other experimental disciplines of science and technology.

5 FINAL CONCLUSIONS AND RECOMMENDATIONS

Pedagogical discussions, seminars and pedagogical training and advice stimulate teachers to design examination papers that measure more advanced SOLO levels. However, many questions are still inviting answers at the unistructural and multistructural levels and this is to some extent a problem due to the organisation of the higher educational system itself.

Oral teaching and examination methods may help students to reach the relational and extended abstract SOLO levels. It is especially the scientific discussions among students and between students and teachers that are important.

Many students would want to study with a deeper approach to learning. They are surprisingly aware of the problem and their reasons for not doing so is to be found in the educational system.

Finally, and most important, pedagogical discussions within the faculty increase the knowledge of the importance of qualitative aspects of teaching and assessing in higher education.

6 REFERENCES

Axelsson, A., 1995. *Solving Practical Problems - an Alternative in the Chemical Engineering Laboratory*, Proceedings at the Conference on Teaching Science for Technology at Tertiary Level, 7th-9th June 1994, Stockholm

Biggs, J. B. and Collis, K. F., 1982. *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome)*, Academic Press, New York

Ramsden, P., 1992. *Learning to Teach in Higher Education*, Routledge, London

Ramsden, P., 1991. *A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire*, Studies in Higher Education, Volume 16, No 2

II

SOLO taxonomin – en modell för kvalitativ planering och utvärdering av undervisning och examination

Thomas Olsson och Björn Sivik

I. Inledning

En taxonomi i pedagogiska sammanhang är en modell som kan användas för systematisering, värdering och klassificering. Taxonomier används för att strukturera planering och utvärdering av undervisning och examination. Denna workshop visar hur användningen av en taxonomi kan stärka de kvalitativa aspekterna inom såväl undervisning som examination.

Den kanske mest använda taxonomin är Blooms taxonomi [1] som urskiljer sex kunskapsnivåer – fakta, förståelse, tillämpning, analys, syntes och värdering. De olika nivåerna innefattar varandra så att förståelse kräver fakta, tillämpning kräver förståelse och fakta och så vidare. Denna taxonomi har störst användning vid planeringsarbete.

Lärande omfattar både kvantitativa och kvalitativa aspekter. Två australiensiska pedagoger, John B. Biggs och Kevin F. Collis presenterade 1982 en generell metod för en målrelaterad kvalitativ utvärdering av lärande, SOLO taxonomin [2]. Den är speciellt värdefull vid utvärdering men kan också användas vid planering.

II. Beskrivning av SOLO-taxonomin

Biggs och Collis [2] anser att olika kvalitativa stadier i den kognitiva utvecklingen från barndomen till mogen ålder delvis motsvarar liknande stadier vid inlärningen av ett komplext material. Hur väl något lärts in kan tänkas motsvara hur långt ett barn kommit i sin kognitiva utveckling. Utgångspunkten är de utvecklingsstadier som formulerats av Jean Piaget (schweizisk utvecklingspsykolog och pedagog, 1896-1980). Liknande (men inte identiska!) nivåer framträder om man studerar hur väl ett material lärts in. Detta gör det möjligt att skilja ett väl inlärt från ett dåligt inlärt material på samma sätt som man kan skilja mogna tankar från omogna.

Det är mycket väsentligt att skilja på en individs kognitiva nivå (enligt Piaget) och nivån på de svar individen ger på en viss uppgift vid exempelvis en examination. Biggs och Collis kallar denna kvalitativa nivå ***S**tructure of the **O**bserved **L**earning **O**utcome* eller *SOLO*. Den kognitiva nivån utgör en övre möjlig gräns för inlärningens nivå medan SOLO-nivån är det faktiska utfallet för en viss lärandesituation. Vilken SOLO-nivå man når beror på många faktorer såsom undervisning, motivation, tidigare kunskaper etc.

SOLO-taxonomin består av fem olika nivåer som klassificerar ökande strukturell komplexitet:

Nivå 1 *Prestructural*
Inga relevanta uppgifter i frågeställningen används och ingen logisk slutsats dras.

Nivå 2 *Unistructural*
En relevant uppgift i frågeställningen används och en slutsats dras utifrån denna. Övriga uppgifter bortses ifrån.

Nivå 3 *Multistructural*
Flera relevanta uppgifter i frågeställningen används och en eller flera slutsatser dras utifrån dessa. Använda uppgifter behandlas emellertid oberoende av varandra och inga inbördes relationer analyseras.

Nivå 4 *Relational*
Alla relevanta uppgifter i frågeställningen används och deras inbördes relationer analyseras och integreras till en sammanhängande helhet varefter en logisk slutsats dras.

Nivå 5 *Extended abstract*
Alla relevanta uppgifter i frågeställningen används och deras inbördes relationer analyseras och integreras till en sammanhängande helhet. En generell princip formuleras (på en högre abstraktionsnivå) som även används för att dra slutsatser utanför den ursprungliga frågeställningen.

III. Praktiska exempel på användningen av SOLO-taxonomin

A. *Konstruktion och bedömning av hemtentamen*

För att kunna använda SOLO-taxonomin som arbetsmetod krävs såväl god analysförmåga som kreativitet och helhetssyn. Eftersom många nya begrepp förekommer anser vi att det är nödvändigt för teknologerna att träna konkretisering av innebörden av taxonomin i ett sammanhang de känner till. Det är nämligen inte alldeles självklart hur man i verkligheten tolkar innebörden av t ex nivå 5. Vi har valt att utnyttja en begränsad

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men återkommande hemtentamen eller ”dugga” som hjälpmedel för denna illustration.

Duggan täcker in ett avsnitt av kursen, som bearbetas under två veckor, och är lösningen på ett process- och produktrelaterat problem, vilket formulerats av lärarna. Det är verklighetsanpassat, tydligt beskrivet och omfattar alltid en jämförelse mellan två tänkbara lösningar, varav en är känd och en är okänd för teknologerna. Att karakterisera metoderna är nödvändigt. Vilka är de kritiska punkterna? Vari består svårigheterna? Sammantaget resulterar frågorna i en kritisk problemanalys. Genom denna analys blir det uppenbart på vilken bas problemet vilar. Här kan teknologerna skissa en process som kräver att basfakta kort beskrivs, t ex via ett flödesschema.

För att kunna lösa problemet måste teknologerna lära hur processerna fungerar och förstå samspelet mellan produktens kvalitetsegenskaper och processens parametrar. Detta är enligt SOLO-taxonomin nivå fyra-kunskap. Sambanden mellan t ex processparametrar och produktegenskaper blir ytterligare tydliggjorda genom jämförelsen mellan två tänkbara alternativa metoder. På basis av den information de nu samlat in förväntas de kunna lösa det för dem tidigare okända problemet, vilket efterfrågades i duggan.

Emellertid, utan instruktioner om hur duggan skall struktureras och formuleras blir det svårt att nå målet med duggan och svårt att tydliggöra SOLO-taxonomins budskap. Till stöd har därför utarbetats en ”Mall”.

”Mallen” är ett hjälpmedel som har konstruerats med avsikten att konkretisera SOLO-taxonomin och dess kunskapsnivåer, speciellt nivå tre, fyra och fem. Den används såväl inför bearbetningen av problemet som vid kamratbedömningen av resultatet.

Mallens första punkt är en uppmaning till en kortfattad Problemanalys. Den har visat sig vara helt avgörande för resultatet. Den andra punkten uppmanar till att specifikt begrunda vilka basfakta som ryms inom problemkomplexet. Vad handlar det om? Nästa fråga berör samband mellan dessa basfakta. Vilka är de? Hur kan de kortfattat och kärnfullt beskrivas? Matematiska samband i form av ekvationer kan vara användbara. Den fjärde punkten uppmanar till en analys av hur lösningen av det nya problemet skall ske och hur den blev. Hur ser en bra motivering ut? En femte och sista punkt uppmanar teknologerna till att göra en värdering av hela situationen. Att värdera innebär att kunna sammanväga olika aspekter där även etiska ställningstaganden kan ingå. Problemen är nämligen konstruerade så att där ryms frågor som kan vara kontroversiella, t ex konsumtion av genmodifierade livsmedel, vegetarianism kontra köttätande mm. Det är här fråga om att göra en helhetsbedömning. Och en rimlig helhetsbedömning kan bara göras på ett gott faktaunderlag. Det är inte fråga om enbart tyckande.

En värdering kräver reflektion och helhetssyn. Den yttersta konsekvensen av att nå detta mål är att förstå problemkomplexet. Förståelse leder till djupinlärning. I och med att en dugga blir klar och förståelse uppnåtts kan ytterligare en bit lätt tillgänglig kunskap fogas till den redan befintliga.

B. Examination – formulering av uppgifter

Hur vi utformar tentamensuppgifter påverkar kvaliteten på studenternas lärande. Innehållet i uppgifterna är naturligtvis viktigt men hur uppgifterna formuleras resulterar oftast i olika lösningar på kvalitativt skilda nivåer. Om det skall vara möjligt för studenter att demonstrera lärande på en hög kvalitativ nivå så måste examinationsuppgifter utformas så att de möjliggör just detta. Hur ser det ut i verkligheten? Hur är våra tentamina utformade med avseende på kvalitativa aspekter? Ett antal exempel på uppgifter som leder till lösningar på olika SOLO nivåer presenteras och diskuteras under workshopen.

C. Examination – bedömning av lösningar

SOLO taxonomin kan med fördel användas för att bedöma skriftliga och muntliga lösningar till tentamensuppgifter. Vad händer om man speciellt utformar examinationen för att mäta den kvalitativa nivån? Examinationsförsök visar att det är lättare för studenter att demonstrera lärande på hög kvalitativ nivå vid en muntlig examination än vid en skriftlig. En analys av uppgifterna med avseende på innehållet i förväntade lösningar på olika SOLO nivåer bör göras innan examinationen. Några exempel på denna typ av uppgiftsanalys presenteras och diskuteras under workshopen.

IV. SLUTORD

Att använda taxonomier har blivit ett naturligt inslag när vi planerar och utvärderar olika undervisningsaktiviteter. Ibland kanske de bara finns i bakhuvudet när man ställer en fråga för att få igång en diskussion eller vid formuleringen av en instruktion till en laboration. I andra fall kanske man utgår från SOLO taxonomin för att utforma en tentamen eller kommentera en examensarbetsrapport.

Vår pedagogiska medvetenhet har ökat sedan vi började använda taxonomier i tänkandet kring undervisning och lärande. Studenternas lärande påverkas positivt eftersom kunskapen om hur vi skall organisera studenternas möte med ämnet har blivit mycket större. Vi vågar alltså påstå att en ökad kunskap om pedagogiska modeller direkt kommer studenternas lärande till del.

REFERENSER

[1] Bloom, B. S. (Ed.), Engelhart, M. D., Furst, E. J., Hill, W. H. och Krathwohl, D. R,. *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook I: Cognitive Domain*, David McKay Company, 1956.

[2] Biggs, J. B. och Collis, K. F, *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome),* Academic Press, New York, 1982.

III

A Modern Integrated Curriculum in Biotechnology Designed to Promote Quality Learning

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Introduction

The curriculum presented in this paper is derived from research-based knowledge about teaching and student learning. A curriculum is a framework implying values and priorities and it deals with philosophical as well as practical issues. It should of course emphasise knowledge and skills but also foster intellectual development, social interaction and student diversity. The design of the curriculum presented in this paper is underpinned by current research within the field of learning and teaching [1, 2, 3].

Background

The Swedish educational system at universities includes separate Bachelor of Science and Master of Science programs. The Bachelor of Science curricula are profiled in a few areas whereas the Master of Science curricula are broad and deep with many different alternative courses. Figure 1 shows an overview of the system at the faculty of engineering at Lund University in the area of Biotechnology and Chemical Engineering.

The educational programs at Bachelor of Science level consist since 2001 of a Biotechnology curriculum focused on food and pharmaceutical engineering and a Chemical Engineering curriculum focused on analytical chemistry. The focus on these competencies is mainly based on the demand for engineers in the adjacent region's chemical, pharmaceutical and food industries. The Øresund region of Sweden and Denmark is one of Europe's most important biotechnology-regions with many universities and industrial companies successfully working in this area. The Swedish food technology industry is also to a large proportion located in the south of the country.

The educational programs are run in parallel and several courses are identical in the two curricula. The main advantages are better student recruitment and less sensibility to changes in student recruitment, co-ordination benefits and a more effective use of personnel and laboratories.

The European Federation of Biotechnology (General Assembly in 1989) gives the following definition: ”*Biotechnology is the integration of natural sciences and engineering sciences in order to achieve the application of organisms, cells, parts thereof and molecular analogues for products and services.”* This definition is quite broad and the curriculum discussed in this paper embrace a wide definition of the concept of biotechnology within the area of food and pharmaceutical engineering.

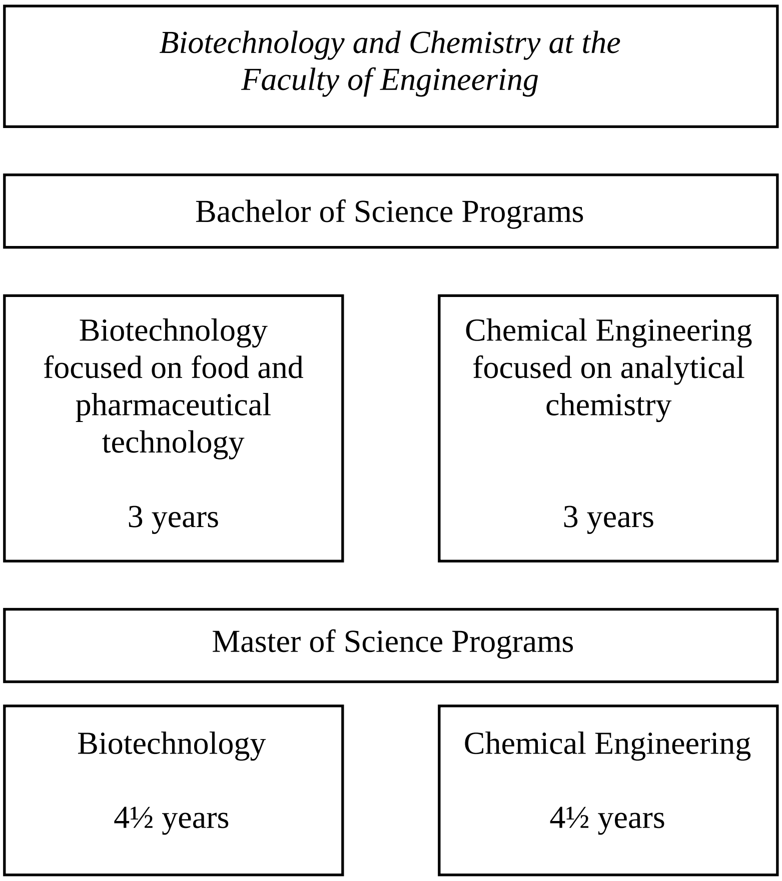

Figure 1 Biotechnology and Chemical Engineering programs

Curriculum Philosophy

The philosophy underlying the design of the curriculum focuses on fostering effective student learning strategies [1, 2, 4] and includes different measures to

- create an integrated curriculum
- integrate non-technical skills and attitudes throughout the curriculum
- use modern technologies and learning systems
- introduce varying forms of teaching and assessment methods
- introduce carefully designed and formulated educational objectives – knowledge, skill and attitude – at *all levels* within the curriculum
- focus the curriculum towards food and pharmaceutical technology

Objectives

The curriculum objectives - knowledge, skill and attitude - are formulated to promote learning at qualitatively high levels [5, 6, 7, 8]. A very important aspect is that the overall educational objectives influence the formulation of learning objectives as well as the design of teaching and learning activities at *all* levels within the curriculum. Overall educational objectives and program objectives as well as objectives at course level or course activity level are formulated and always consistent.

Learning and Teaching

Teaching at universities should be organised to create the best possible opportunities for student learning. This task comprises different measures to motivate, inspire, instruct, tutor and assess students. However, this includes more than just subjects and courses. It also embraces the university as a whole and the educational program, which in turn includes values, ethics, social aspects and intellectual development.

The philosophy of the biotechnology program includes a *comprehensive view* of teaching and learning, an emphasis on *qualitative aspects* of learning and the importance of *varying methods* of teaching and assessing within the program.

It is essential that every course within an educational program contribute to the over-all objectives. Measures will be discussed in this paper that have been implemented to create a modern, integrated curriculum fostering high quality student learning.

Students are different. Methods of teaching and assessing that favour some students may not at all be suitable to other students. Varying teaching and assessment methods increase learning for a group of students as a whole. This is especially important with students of differing age, ethnical and social background.

Qualitative aspects of learning are about focusing on “how well” a subject is mastered rather than “how much”. A simple and important example in chemical engineering is diffusion. The rate at which diffusion occurs depends on a constant (the diffusion coefficient) and a derivative (the concentration gradient). Many students have evident difficulties to physically interpret the derivative. But they can derive complex mathematical functions. Qualitative aspects of learning imply in this example that teaching activities must focus on understanding the relation between mathematics and the physical phenomenon of diffusion. Even if this means that the proficiency in performing complex derivations is less emphasised.

Curriculum Design

A curriculum consists of a number of courses. The challenge is to choose the right courses and arrange them so that the entirety becomes optimal. Furthermore the curriculum should support and encourage students’ intellectual, ethical and social development and pay attention to their varying ages as well as cultural and social background. It is also desirable that overall items that should be included in most courses are identified and form a *Core Curriculum*.

The structure and content of the biotechnology curriculum is designed to support a student-centred approach to learning. Special attention is paid to student development with respect to skills and attitudes. In a current development project, financed by the Swedish Council for the Renewal of Higher Education [9], qualitative assessment methods of skills and attitudes are being developed.

The design of the curriculum includes an accurately prepared schedule of integrated courses supporting a deep orientation of teaching and learning and an integration of non-technical competencies such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology throughout the curriculum.

The development of a curriculum is a continuous process. Current projects include steps for a better integration of mathematics in the curriculum.

Figure 2 gives an overview of the curriculum design.

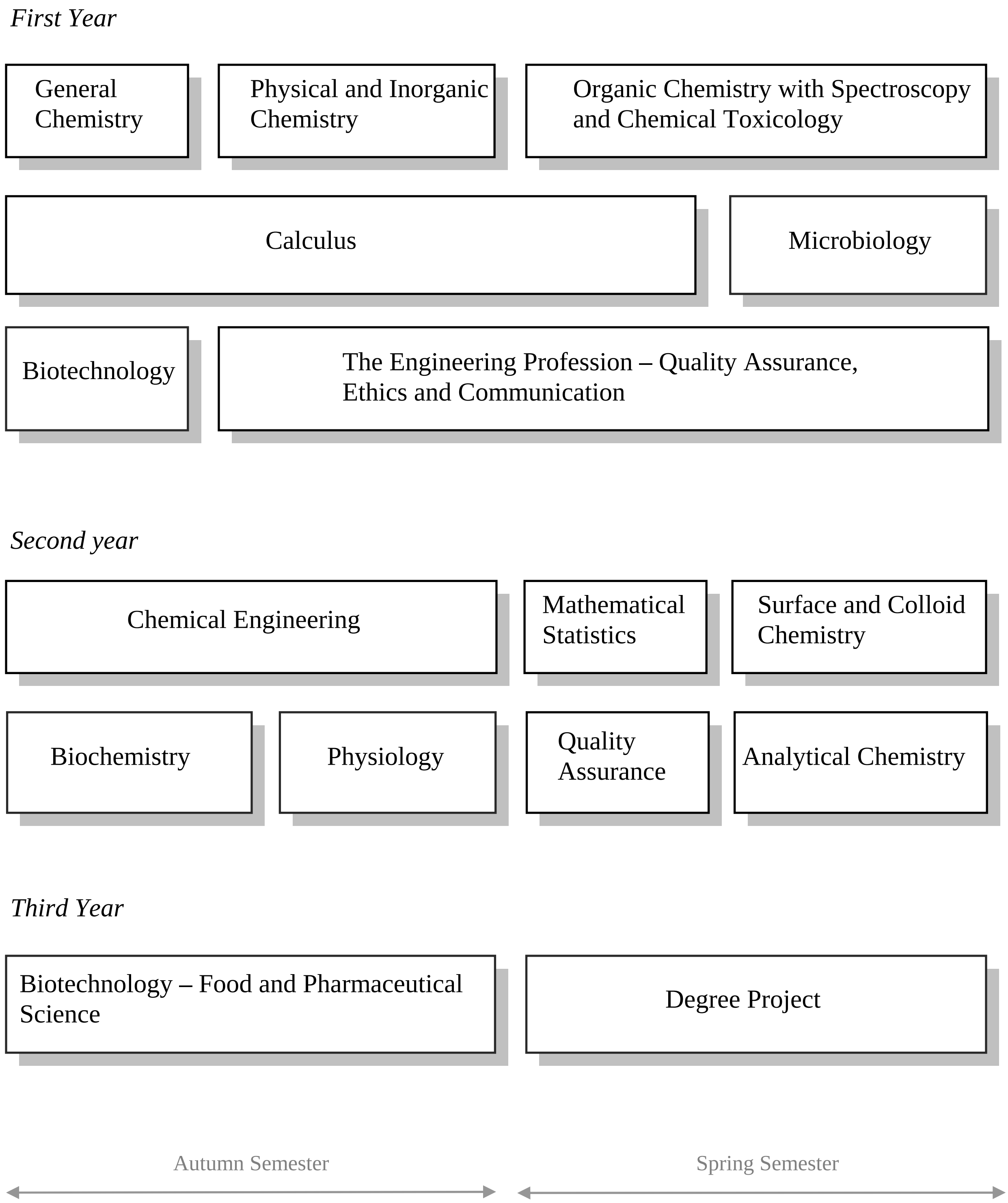

Figure 2 Curriculum Design

Integration

Integration is a hallmark of the curriculum philosophy. This includes integration between consecutive courses and between parallel courses. An illustrative example of both kinds of integration is the courses mathematical statistics, quality assurance and analytical chemistry in the second year of the curriculum. Statistical methods are essential in analytical chemistry and a better understanding of both subjects is achieved through the close integration of the different courses.

Generic skills such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology are introduced in an introduction course, *The Engineering Profession – Quality Assurance, Ethics and Communication*, during the first year and are then integrated throughout the curriculum. The procedure is based on Kolb's experiential learning cycle [10, 11]. The model of integration is shown in Figure 3.

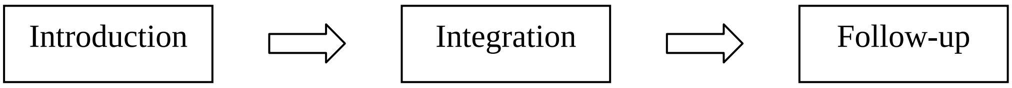

Figure 3 Model of integration

The purpose is to integrate the generic skills in different chemical, biological and engineering courses. The follow-up during the final year of the curriculum includes several project works. The introduction course is delivered in close collaboration with different departments at Lund University and the pharmaceutical industry. The departments include Practical Philosophy, Media- and Communication Studies, Environmental and Energy Systems Studies and Sociology.

Core Curriculum

Several generic competencies and skills essential for a successful career as an engineer can be identified. Many of them should be included as parts of most courses in the curriculum. Together they form a *Core Curriculum* that is implemented in the program. It comprises varying aspects of quality assurance, computerised systems for information retrieval and for integrated problem solving and visualisation, oral and written communication skills, statistical, economical, environmental and ethical analyses and use of scientific papers.

An example from the Core Curriculum is quality assurance where students must keep a laboratory journal and write Standard Operating Procedures (SOP) when appropriate. Technology and Learning Systems comprise computerised systems such as Mathcad used for problem solving and visualisation throughout the curriculum. Other examples include estimations of errors in experimental measurements and calculations, accuracy of measurements and use of reference literature.

The extensive integration together with a carefully prepared Core Curriculum results in an increased focus on the educational program as an entirety and on the future professional life. The professional self-reliance is continuously consolidated throughout the curriculum.

Comments on Courses

Basic chemistry courses during the first year are very important for the rest of the curriculum. Courses at the beginning of a curriculum are influenced by special problems. Everything is new to the students. How to study at a university, responsibilities, literature, assessment etc. All affects the first courses of the curriculum. The design of these courses is crucial for the success of the curriculum.

Mathematics is a foundation for the science of engineering and therefore a central subject in an engineering curriculum. Some arguments for a solid course in mathematics are

- mathematics is a characteristic of an engineering education
- mathematics develops students' problem solving abilities and logical thinking
- mathematics forms a basis for the applied subjects
- mathematics should be used as a tool to solve chemical, biological and engineering problems

It is most important to focus the course in calculus on problem solving skills and to concentrate the pedagogical efforts to increase comprehension and proficiency in basic mathematics.

Problem based learning is used throughout the final year of the curriculum.

The *degree project* has been extended to one semester. It includes a thorough follow-up of the generic skills accomplished during studies at the curriculum.

Qualitative Investigations

The research methodology used to analyse the curriculum comprises different qualitative approaches:

- Identification of learning needs was performed using focus groups and in-dept interviews with academic scholars and teachers, professionals from relevant industries and students.
- The SOLO-taxonomy by Biggs and Collis [5] has been used to investigate qualitative aspects of teaching and assessing.
- Case studies investigating integrative learning outcomes through open-ended questionnaires are presented.
- The course experience questionnaire (CEQ) by Ramsden [12] together with focus groups and reflective papers were used to investigate students' approaches to learning and their intellectual and ethical development.

Identification of Learning Needs

Identification of learning needs – knowledge, skill and attitude – has been performed using focus groups and individual in-dept interviews with academic scholars and teachers, professionals from relevant industries as well as former and present students. Concordance about major curriculum approaches, such as an integrated curriculum, became evident from the interviews and this knowledge is evident in the design of the curriculum.

The most important comments from ten former students graduated between 1991 and 1999 are discussed below. They now work in the pharmaceutical industry, food industry or chemical industry. Areas that all interviewees discuss include:

- Mathematics
- Statistics
- Basic chemistry
- Planning of experimental investigations (factor analysis)
- Information retrieval
- Written reports

Some relevant comments from interviews and focus groups are listed below:

"more time for problem solving in mathematics"
"mathcad is excellent and useful in problem solving"
"amazing how much mathematics we have to learn"
"mathematics is not applied enough"

"more statistics is needed"
"statistics must be relevant for chemistry"
"factor analysis is important"
"processing of experimental results is important"

"a broad educational basis is very important"
"basic chemistry is very important"
"more quality thinking"

"literature retrieval – show the possibilities"
"important to write reports in English"

A meeting attended by most teachers involved in the educational program, the head of the department, a pedagogical expert and representatives from the biotechnology curriculum at Master of Science level and the program administration discussed ways to improve the education. The following question was the basis for the discussions:

"Give suggestions for changes that will lead to a better education"

Each participant should give at least three different suggestions. The Metaplan Technique [13] was used to analyse the results. It is a tool used to make group discussions more effective. It comprises techniques for visualisation, interaction and dramaturgical planning. This study uses a modification of an interaction technique called the "card question technique". The method gives a survey of ideas and priorities of a group of people on a given question. It is an illustrative method where the opinion of each group member is accounted for. The modified technique used in this project is described elsewhere [14].

The different suggestions from the participants comprised some 50 different proposals clustered in 12 different categories. These categories were:

- Mathematics and statistics
- Assessment
- Integration
- Pedagogy
- Projects
- Professional life
- Student recruitment
- Food and pharmaceutical technology
- Literature retrieval
- Communication
- Economical aspects
- Environmental aspects

All participants marked the categories according to the Metaplan Technique [13, 14] and the marks were counted. The result is a measure of the importance of the different categories among the participants. Figure 4 gives the result.

Categories	*Number of proposals*	*Marks (%)*
mathematics and statistics	10	20
assessment	6	17
integration	12	14
pedagogy	8	11
projects	5	11
professional life	3	8
student recruitment	2	7
food and pharmaceutical technology	2	4
literature retrieval	1	3
communication	1	2
economical aspects	1	2
environmental aspects	1	2

Figure 4 Areas and priorities for improvements

Many of the proposals within the category mathematics and statistics deal with more integration with other courses. Integration is also emphasised in connection with assessment, pedagogy and projects.

Each participant has only a limited number of marks and the results must be interpreted with caution. It is *not* correct to say that professional life, literature retrieval and communication are unimportant. However, a correct conclusion is that those categories that receive many marks are regarded as especially important. A reasonable conclusion of the presented results is that integration, mathematics, pedagogy (including projects) and assessment are important areas to focus on in order to improve the education. These areas together with student recruitment are also given the highest priority in the continuing efforts to improve teaching and learning.

Qualitative Aspects of Student Learning

Taxonomies are used to structure planning and evaluation of teaching and assessment. The SOLO taxonomy is used within the curriculum to consolidate qualitative aspects of teaching and assessment. A recent project indicates a clear development within the curriculum towards examination tasks inviting solutions at qualitatively higher levels [15]. Oral teaching and assessment methods help students demonstrate learning at qualitatively higher levels [15].

The use of taxonomies has a positive influence on student learning because it increases teachers' knowledge of the learning process. The SOLO taxonomy is especially valuable when it is used in everyday teaching as a tool to plan and evaluate different teaching activities.

Solving practical problems is a teaching method developed at Lund Institute of Technology [16]. It is used as an alternative in the chemical engineering laboratory and introduces problem solving and creative thinking in chemical engineering. A SOLO analysis emphasises the qualitative features of the method [15].

Integrative Abilities

Integration is a hallmark of the curriculum philosophy. *Case studies* investigating integrative learning outcomes through *open-ended questionnaires* were performed with students in their second year of the educational program. This research investigates if students integrate different aspects of complex problems (technology, ethics, quality, economics, communication etc.) spontaneously or if this ability is passive and specific tasks must be formulated to help students integrate knowledge from different areas [11].

The students discussed different aspects of planning, design, operation, management, maintenance and production of complex engineering problems. Some background information, process diagrams etc. were provided.

The results indicate that many students possess latent integrative abilities [11]. They worked with the problems both without specific instructions to integrate generic skills in their solutions *and* with specific instructions to integrate quality assurance, environmental issues, and aspects of ethics, economics, communication and organisation in their solutions.

The result was analysed both with respect to technical solutions and how generic aspects were integrated [11]. All students presented at least ten different scientific or technical aspects relevant to the problem. Integration of non-technical aspects increased considerably when students were given specific instructions to do so. It is interesting to notice that all students integrate quality assurance in all solutions whereas no students integrate ethics or communication without instructions (50% with instructions). About half of the students spontaneously integrate environmental and economical issues and almost all students integrate these aspects after having received special instructions.

Approaches to Learning

The course experience questionnaire [12] contains twelve statements about students' approaches to learning. An analysis of questionnaire results together with focus group interviews show that students shift between a surface and a deep approach to learning. However, the deep approach dominates and there is no significant difference between students in the first or second year of their studies.

Statements like *"I usually set out to understand thoroughly the meaning of what I study"* receive a high score (students agree) which indicates a deep approach to learning. Many students also agree with statements like *"I usually don't have time to think about the implications of what I study"* which indicates a surface approach. But this could also be a manifestation of a heavy workload.

Intellectual and Ethical Development

New statements about intellectual development were added to the course experience questionnaire [14]. Together with reflective papers [11] the results show that students are surprisingly aware of their intellectual and ethical development and this development is well on its way towards the higher levels of Perry´s scheme [8].

Conclusions and Reflections

Some important key words in the philosophy and design of the biotechnology curriculum include

- Integration
- Variation
- Qualitative aspects
- Objectives
- Generic skills
- Core Curriculum

These different aspects of the curriculum are thoroughly discussed in the paper. Several qualitative tools and methods, such as the SOLO taxonomy [5], the Course Experience Questionnaire [12], case studies, in-dept interviews, focus groups, the Metaplan technique [13] and Perry's scheme of intellectual and ethical development [8], have been used to analyse the curriculum.

The results presented indicate that the curriculum is designed for a student centred approach to teaching and learning and it emphasises qualitative aspects of the learning process.

Bibliographic Information

1. Biggs, J. B. (1999), *Teaching for Quality Learning at University*, Society for Research into Higher Education & Open University Press

2. Prosser, M. and Trigwell, K. (1999), *Understanding Learning and Teaching. The Experience in Higher Education,* Society for Research into Higher Education & Open University Press

3. Marton, F. and Booth S. (1997), *Learning and Awareness*, Lawrence Erlbaum Associates

4. Ramsden, P. (1992), *Learning to Teach in Higher Education*, Routledge

5. Biggs, J. B. and Collis, K. F. (1982), *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome),* Academic Press

6. Bloom, B. S. (Ed.), Engelhart, M. D., Furst, E. J., Hill, W. H. and Krathwohl, D. R. (1956), *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook I: Cognitive Domain,* David McKay Company

7. Krathwohl, D. R., Bloom, B. S. and Masia, B. B. (1964), *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook II: Affective Domain*, David McKay Company

8. Perry, W. G., Jr. (1970), *Forms of Intellectual and Ethical Development in the College Years. A Scheme*, Holt, Rinehart and Winston

9. Olsson, T. (2002), *Qualitative Assessment in the Chemical Engineering Curriculum*, http://hgur.hsv.se/activities/projects/financed_projects/k-s/olsson_thomas_99.htm

10. Kolb, D. A. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, New Jersey: Prentice-Hall

11. Olsson, T. (2002), *A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum*, Paper presented at the International Research Conference - Learning Communities and Assessment Cultures: Connecting Research with Practice, EARLI Special Interest Group on Assessment and Evaluation/University of Northumbria

12. Ramsden, P. (1991), *A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire*, Studies in Higher Education, Volume 16, No 2

13. Metaplan GmbH. (2002), *Primer for the Metaplan Technique*. http://www.metaplan.com

14. Olsson, T. (2002), *Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-Based Examination in Chemical Engineering*, In Rust, C. (Ed.), pp. 310-323, Improving Student Learning Using Learning Technologies, The Oxford Centre for Staff and Learning Development

15. Olsson, T. (2000), *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy,* In Rust, C. (Ed.), pp. 304-324, Improving Student Learning Through the Disciplines, The Oxford Centre for Staff and Learning Development

16. Axelsson, A. (1995), *Solving Practical Problems - an Alternative in the Chemical Engineering Laboratory*, Proceedings at the Conference on Teaching Science for Technology at Tertiary Level, 7th-9th June 1994, Stockholm

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IV

Assessment of Experimental Skills and Creativity Using a Modified OSCE-Method – A Summative Performance-Based Examination in Chemical Engineering

Paper presented at the
9th International Improving Student Learning Symposium
Heriot-Watt University
Edinburgh
9th–11th September 2001

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1 INTRODUCTION

Assessment is probably the single most important aspect of student learning in higher education. There is compelling argument presented in the literature that the method of assessment has a major influence on the way students accomplish their studies (e. g. Ramsden, 1992; Biggs, 1999; Prosser and Trigwell, 1999).

1.1 Background

Within the chemical engineering curriculum (Bachelor of Science level) at Lund University we have introduced carefully prepared and formulated educational objectives – *knowledge, skill and attitude* – at all levels within the curriculum. An important and serious problem is that the assessment is still too much focused on knowledge. Learning is a complex holistic process involving many aspects besides knowledge. The assessment should stimulate a deep oriented, holistic learning and focus on all educational objectives of the curriculum.

Most courses in a chemical engineering curriculum include practical experimental parts. These parts are normally assessed formatively in the laboratory. Students hand in reports and demonstrate their assignments and they get immediate feedback. This is very important and commendable. However, summative assessments of practical engineering skills are of rare occurrence in engineering curricula. An individual summative assessment could be of major importance to influence students to focus on the skill objective of the curriculum.

1.2 Overview of the project

What do chemical engineering students think about laboratory teaching? Which are the most important aspects? Chapter 2 presents an outline of student views of laboratory teaching.

Medical education all over the world uses a summative performance-based examination called *Objective Structured Clinical Examination*, OSCE (Harden et al., 1975). Can these ideas of assessment be used in a chemical engineering curriculum? Chapter 3 presents a summative performance-based assessment of experimental skills and creativity.

Qualitative studies using a modified *Course Experience Questionnaire* (Ramsden, 1991) and different *Focus Groups* are presented in Chapter 4. Assessment of skills, attitudes and intellectual development (Perry, 1970), approaches to learning and learning technologies are discussed in relation to laboratory work.

Evaluation tools used in this project are the SOLO taxonomy (Biggs and Collis, 1982) and Perry´s scheme of ethical and intellectual development (Perry, 1970). The SOLO (Structure of the Observed Learning Outcome) taxonomy is a model for qualitative evaluation of teaching and assessing. It consists of five levels of increasing structural complexity. Perry´s scheme of ethical and intellectual development is used to characterise students' intellectual development from dualism through multiplicity to relativism and commitment.

2 STUDENT VIEWS OF LABORATORY TEACHING

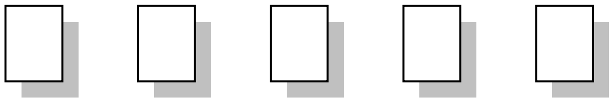
2.1 Methodology

Which are the most important student views on laboratory teaching in chemical engineering? We should know more about this question for many reasons. Teaching in the laboratory is by far the most resource demanding part of an educational programme and it is very important that we reach adequate educational objectives in the laboratory.

The Metaplan Technique (Metaplan GmbH, 2001) is a tool used to make group discussions more effective. It comprises visualisation techniques, interaction techniques and dramaturgical planning techniques. This study uses a modification of an interaction technique called the "card question technique".

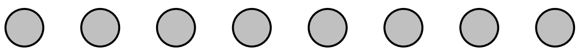
The method gives a survey of ideas and priorities of a group of people on a given question. It is an illustrative and quick method and the opinion of each group member is accounted for. The modified technique used in this project is described below.

Each participant receives 5 pieces of paper.



Each person writes 5 statements that he/she thinks are especially important regarding the question discussed. All pieces of paper are collected, the statements are read to the group and categorised (clusters of similar statements are created and given titles decided by the participants) and finally pinned to a white-board.

Each person now gets 8 marks (self-sticking dots) to distribute among the categories. The more important you think a category is the more marks you give it. A maximum of 4 marks can be given to a single category.



All participants mark the categories (at the same time to make sure that the decisions are made independently from each other) and the marks are counted. The result is a measure of the importance of the different categories among a group of people. Figure 2.1 shows how the results might look like.

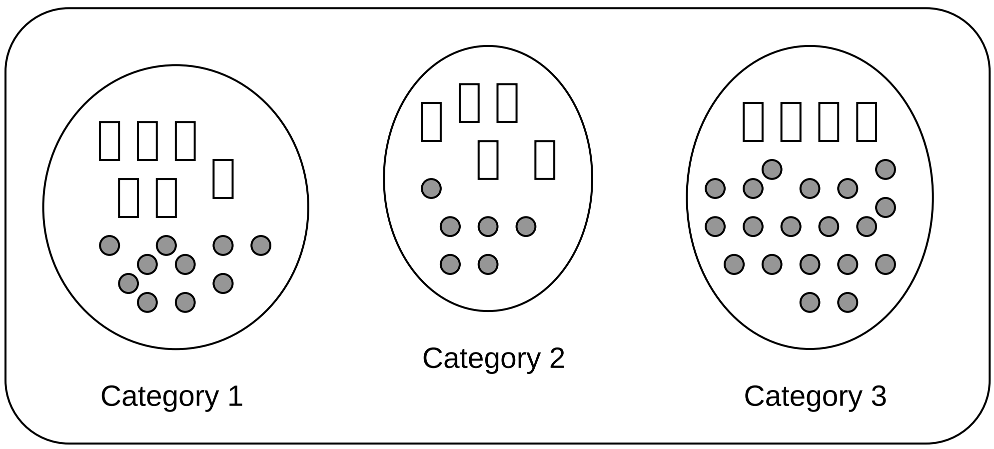


Figure 2.1 Example of a modified "card question technique"

2.2 Findings

The question that the students were asked to answer was:

"Which are the most important aspects of laboratory teaching?"

They were told that the question had no restrictions and that they could write down anything they think is important about laboratory teaching. No other information was given at this point.

The investigation was repeated independently with three different groups of students. The students in two of the groups were in their second year of the chemical engineering curriculum and one group in their third and final year. Each group had 6-8 participants.

Five categories of statements emerged. It is very interesting to observe that the same categories emerged in all three groups of students and that they were given approximately the same relative importance.

The categories were:

Category 1

"Connections between theory and reality"

37% of the marks (by all participating students)

Category 2

"Opportunities to think, plan and design independently"

28%

Category 3

"Instructions and planning"

20%

Category 4

"Educational objectives and future profession"

9%

Category 5

"Reports and assessment"

6%

Figure 2.2 gives a pie chart that shows the different categories and their relative importance for all participating students.

Figure 2.3 gives pie charts that show the different categories and their relative importance for the three groups of students independently. As can be seen from this figure there are only minor differences between the groups.

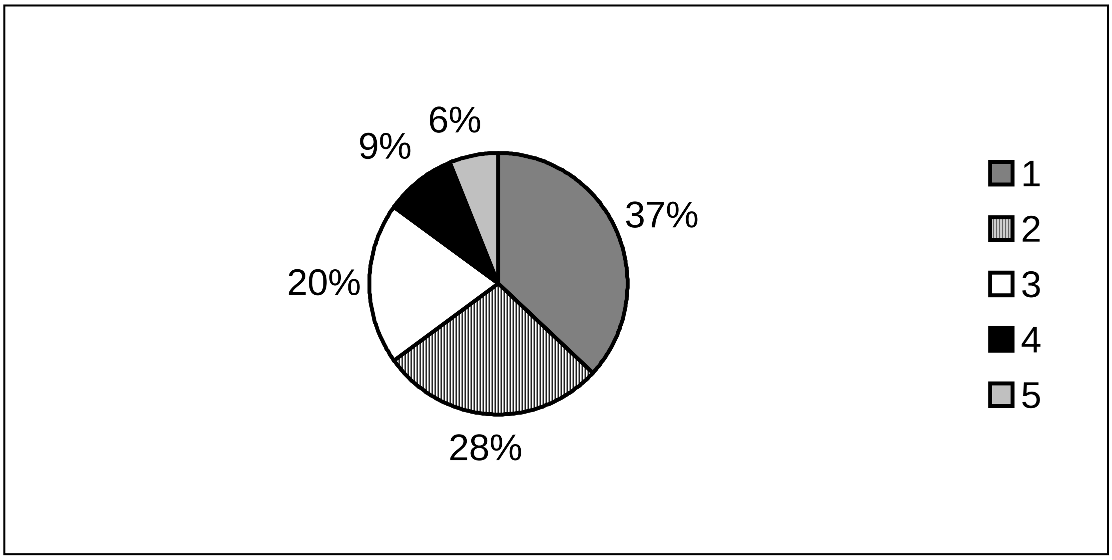


Figure 2.2 Different categories and their relative importance for all participating students

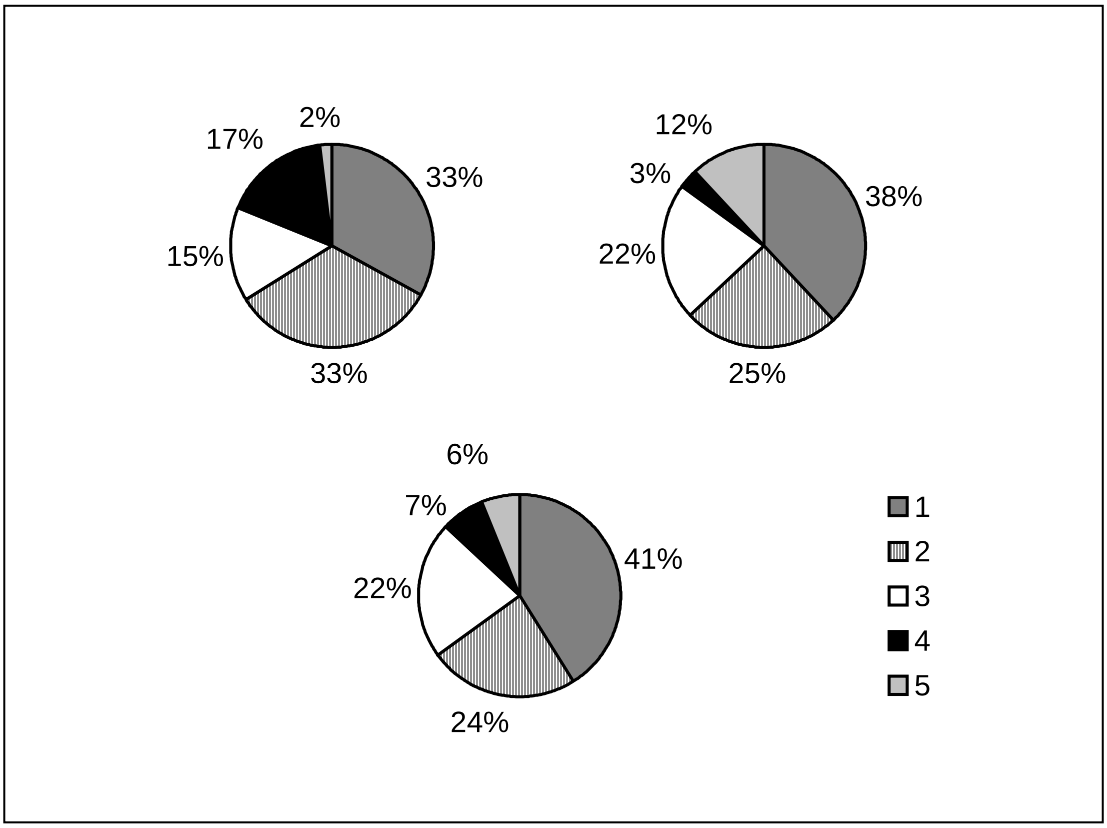


Figure 2.3 Different categories and their relative importance for the three groups of students

Some representative examples of statements given in the different categories are shown below. The total number of statements was 93. The distribution was 30, 19, 30, 10, 2 and 2 statements for category 1, 2, 3, 4 and 5 respectively.

Category 1
Connections between theory and reality

"An opportunity to apply theory in real situations"

"Increase the understanding of theory"

"Connection with reality"

"Discussions. Why? What happens?"

"When you have left the laboratory you should be able to answer questions about the theory that you did not understand before"

Category 2
Opportunities to think, plan and design independently

"I have always wanted to plan and perform experiments without instructions or any other kind of help"

"Give opportunities to think independently"

"…. where you must think for yourself"

"Find out how to perform an experiment"

Category 3
Instructions and planning

"Clear instructions"

"Discuss the theory in advance"

"Learn to plan an experiment – time schedule"

Category 4
Educational objectives and future profession

"Knowledge and skills used in the professional life"

Category 5
Reports and assessment

"Clear instructions about the report"

" Increase report writing skills "

2.3 Comments and discussion

The Metaplan technique with its different visualisation, interaction and planning techniques is very useful in research as well as in evaluation of teaching and learning.

In smaller groups (8-10 persons) it is possible to use the “card question technique” as a starting point for further investigations using other Metaplan techniques (Metaplan, 2001). This procedure makes it possible to find out more about the categories that receive the highest number of marks. Combinations with focus group interviews can also be useful.

It would be very interesting to use the Metaplan Technique as an alternative to traditional evaluations of undergraduate courses.

The results from the present investigation of aspects of laboratory teaching are interesting since the same categories emerged with the same relative importance in all three groups of students. However, the results should not be interpreted quantitatively only as a qualitative measure of student views on the subject.

3 ASSESSMENT OF EXPERIMENTAL SKILLS AND CREATIVITY

3.1 Modified OSCE method

The aim of the OSCE (Objective Structured Clinical Examination) method (Harden et al., 1975) is to test students' clinical and communication skills in a planned and structured way. The examination consists of several stations each presenting a scenario. At each station an examiner is observing the student's performance. The result is decided by judging how well the performance meets a number of stated criteria.

The original OSCE-method takes considerable resources. This paper presents a study of an assessment of experimental skills and creativity in chemical engineering using a modified OSCE-method. The main modifications include:

- stations presenting tasks at different levels of performance – at some stations students only present ideas of performance or constructions of equipment while at other stations a complete performance must be demonstrated.
- stations where groups of students are assessed as well as stations where students demonstrate their abilities individually.
- the use of learning technologies (video/audio recordings and computerised collection of results) to observe student performance.

A typical examination will last for 3-4 hours and consists of 6-8 different stations. More than 25 different tasks have so far been constructed. They test students' experimental skills, planning of experimental work, critical and reflective thinking and creativity and they are constructed so that they will require students to combine knowledge and skill to perform a task. It is important that most of the tasks are open-ended to allow students to show different qualitative approaches (Biggs and Collis, 1982). Students will be asked to discuss and explain ideas and procedures, formulate and test hypotheses, design experiments etc. – students must perform their understanding. Some of the ideas behind the different tasks originate from practical problems developed at the Department of Chemical Engineering, Centre for Chemistry and Chemical Engineering at Lund University (Axelsson, 1995; Olsson, 2000).

3.2 Examination tasks

Determine experimentally the power consumption of a microwave oven

Besides a microwave oven different equipment and materials can be provided to the students. However, the degree of difficulty of the task depends very much on what equipment and materials are provided. A thermometer, a beaker, water, a balance and a stopwatch are needed to solve the task.

This problem will test many abilities. Students must realise that the energy delivered by the microwave oven can be determined by measuring the absorption of the microwaves in a substance (e.g. water) that is placed in the oven. If you know the amount of water (weight), the heat capacity of the water (physical constant) and the increase in temperature of the water you can calculate the amount of energy transferred to the water. Then students must know the difference between energy and power. The energy determined is the energy transferred during the time the microwave oven is turned on. This time must be measured if the power is to be calculated.

The highest level of performance of this examination task is of course a situation where only the microwave oven is provided. If you put a thermometer, a balance, water etc. beside the oven the problem becomes much easier to solve.

Discussions of the reliability of the experimentally determined power consumption should also be required. A discussion of different sources of errors is fundamental in any experimental investigation.

Other substances than water can of course also be used. Do you get different increases in temperature for different substances? Why? What happens if more than one substance is heated at the same time? What physical mechanism explains why a substance is heated? Is it easier to heat liquid water than ice? Many discussions can easily be generated and it is possible for students to demonstrate qualitative learning at high SOLO levels. Discussions at the relational and even extended abstract levels are common.

Determine experimentally the power required to make coffee in a coffee machine

Figure 3.1 shows in principle how a coffee machine works. Water (A) flows through a tube and is heated with a heating coil (B). After the heater the flow in the tube consists of both liquid water and steam. It is a two-phase flow where the steam lifts the water upwards and into the filter where the coffee is brewed.

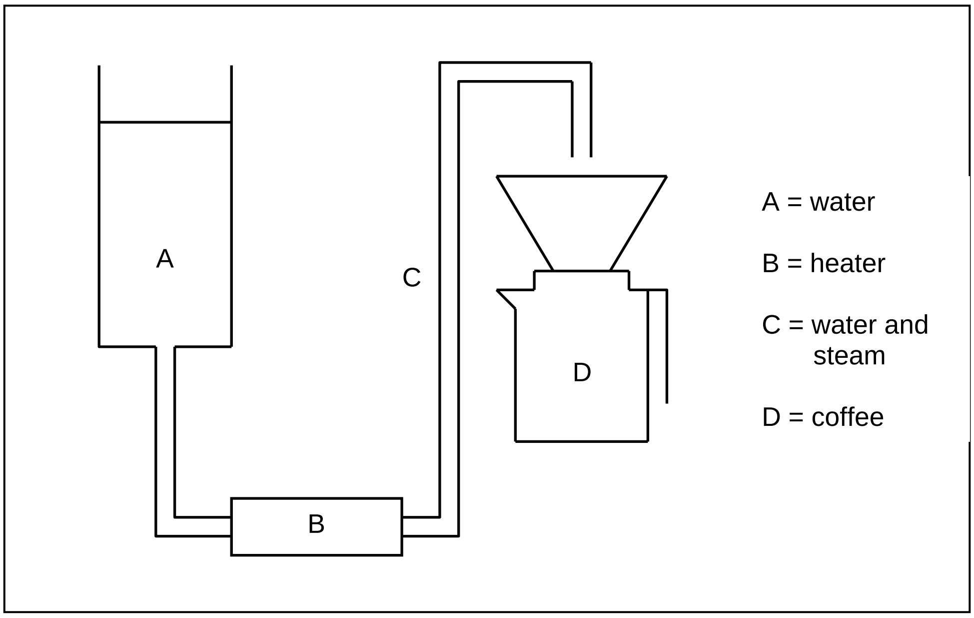


Figure 3.1 A coffee machine

This problem is similar to that of the microwave oven but more difficult because energy is needed both to heat the water to the boiling point and to vaporise some of the water to steam. Not all of the water (A) will end up as coffee (D) and the measurements must take this into account.

The coffee machine problem also initiates discussions about heat of vaporisation, two-phase flow, mammoth pumps etc. Such discussions often reach high SOLO levels.

Construct a plate heat exchanger

This problem is different from the two problems just described since no measurements are performed. A plate heat exchanger consists of different kinds of plates (Fig. 3.2). The plates, usually corrugated, are supported in a frame. Hot fluid passes between alternate pairs of plates exchanging heat with the cold fluid flowing between adjacent pairs of plates. Students receive a number of plates each marked with a number. The task is to build a plate heat exchanger, in working order, according to given specifications and to tell where the hot and cold streams enter and leave the apparatus.

The solution of the problem is easily presented since all that students have to show is a correct series of numbers.

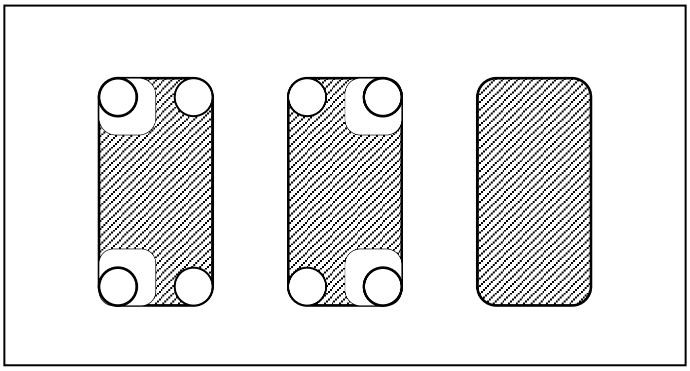


Figure 3.2 Some different plates of a plate heat exchanger

Construct a plate and frame filter press

This problem is similar to the plate heat exchanger problem. A filter press consists of plates, frames and washing plates. The task is to build a filter press, in working order, according to given specifications.

Some other examples of examination tasks are listed below:

Experimental estimation of the viscosity of a fluid

Experimental determination of the characteristic curve of a centrifugal pump

Experimental estimation of the risk of cavitation of a centrifugal pump

Experimental determination of the friction factor of a pipe-line

Experimental determination of the loss coefficient of a globe valve

Experimental determination of the heat conductivity of a solid

Measurements of temperature in an oven

Experimental determination of overall heat transfer coefficient of a heat exchanger

Experimental determination of the plate efficiency of a bubble-cap distillation column

Experimental determination of the apparent overall heat transfer coefficient of an LTV evaporator

Several other problems have been developed and they all show the same general structure as the problems described above.

3.3 Comments and discussion

All problems developed can be solved at different levels of performance. Students can be assessed individually or in groups of students. This flexibility makes the proposed modified OSCE method an appealing assessment method used as a summative performance-based examination in the laboratory.

Discussions of the problems with teachers enable students to demonstrate learning at high SOLO levels. The occasion of the examination becomes an occasion for learning.

4 QUALITATIVE RESEARCH – DESIGN AND FINDINGS

The methodology employs the use of a modified Course Experience Questionnaire (Ramsden, 1991) and different Focus Groups (e. g. Morgan and Krueger, 1997). These tools are used to investigate attitudes, intellectual development (Perry, 1970) and approaches to learning. The total number of students participating in the investigations is between 20 and 30 and the obtained data should *only* be *used qualitatively*. All investigations are focused on laboratory teaching and especially performance-based assessment.

4.1 Modified "Course Experience Questionnaire"

The Course Experience Questionnaire (CEQ) is a quantitative research and evaluation method that consists of about 40 statements covering good teaching, clear goals, appropriate workload, appropriate assessment, student independence and approaches to learning.

In this project new statements about assessment and intellectual development have been constructed. These new statements are all added to the CEQ and mixed with the original statements of the questionnaire. All students answered the complete modified CEQ but only items relevant for this study were used in the evaluation of the results.

When a "course" is referred to in the statements the students were asked to think about "laboratory teaching". Students responded to the statements on a scale from 1 to 5 where:

1 = definitely not
2 = hardly
3 = maybe/maybe not
4 = agree
5 = exactly

4.1.1 Assessment of skills

Figure 4.1 gives four new statements (A-D) about assessment and the corresponding results.

The students do think that varying forms of assessment are positive and increase their abilities to demonstrate knowledge and skills and they do not think that a written examination is the most objective examination. However, perhaps all students do not quite realise the impact of assessment on how they perform their studies (statement A).

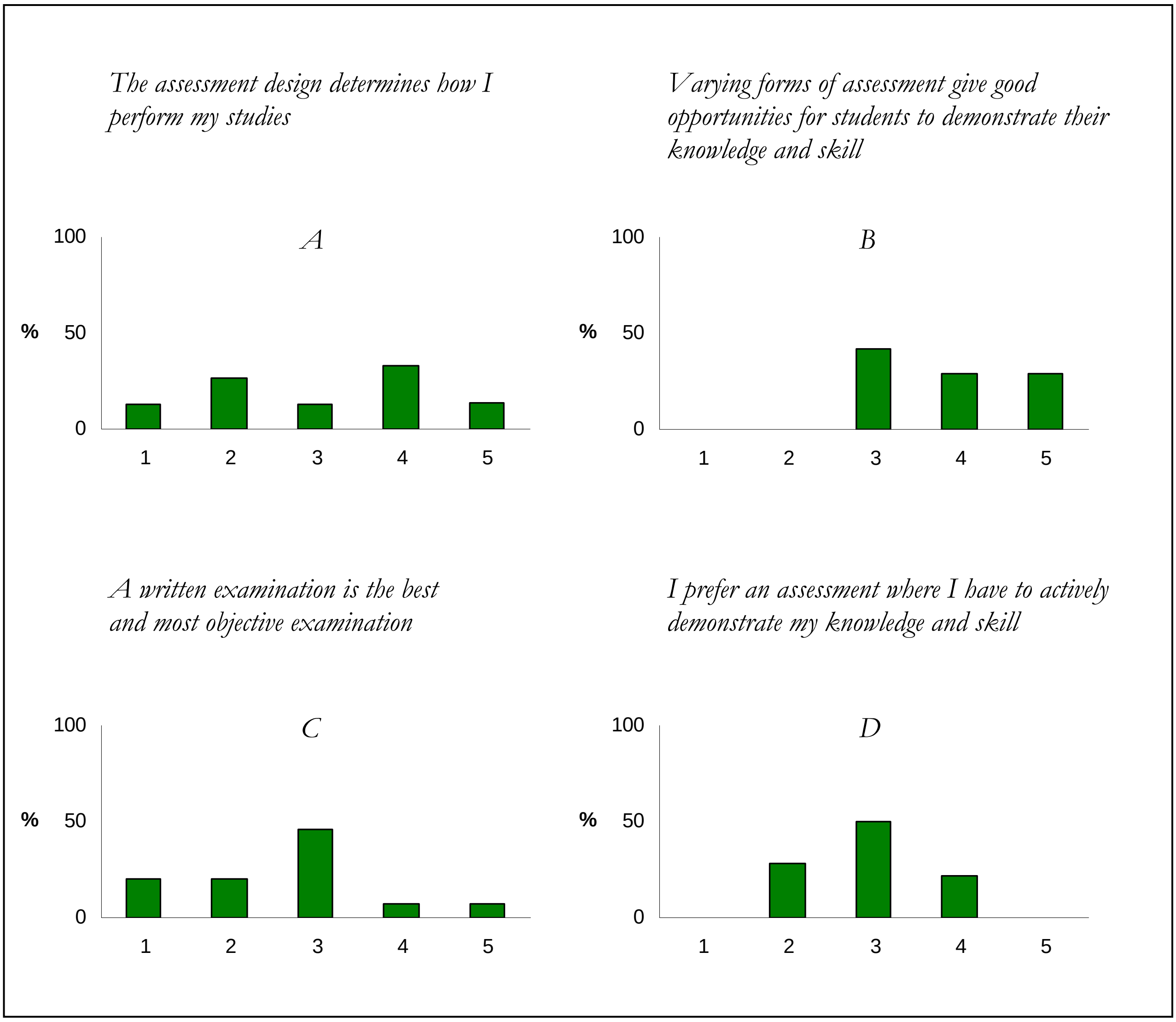


Figure 4.1 Results from questionnaire items about assessment

4.1.2 Intellectual development

Five new statements about intellectual development have been added to the CEQ. These statements are connected to the different stages in Perry´s scheme of ethical and intellectual development (Perry, 1970). Perry argues that all students follow a development from dualism through multiplicity to relativism and commitment.

Figure 4.2 gives the statements and the results. Statements A and B deal with duality, C with multiplicity, D with relativism and finally D deals with commitment.

It is interesting to discuss these kind of questions but the results are difficult to interpret. At a first glance the results of A and B seem quite inconsistent. However, many students probably understand statement A as roughly "a teacher must be a skilful communicator".

If statement A is disregarded the result shows that the students' intellectual development is well on its way towards the higher levels of Perry´s scheme. More discussions about intellectual development and connections to laboratory teaching follow in Chapter 4.2.2.

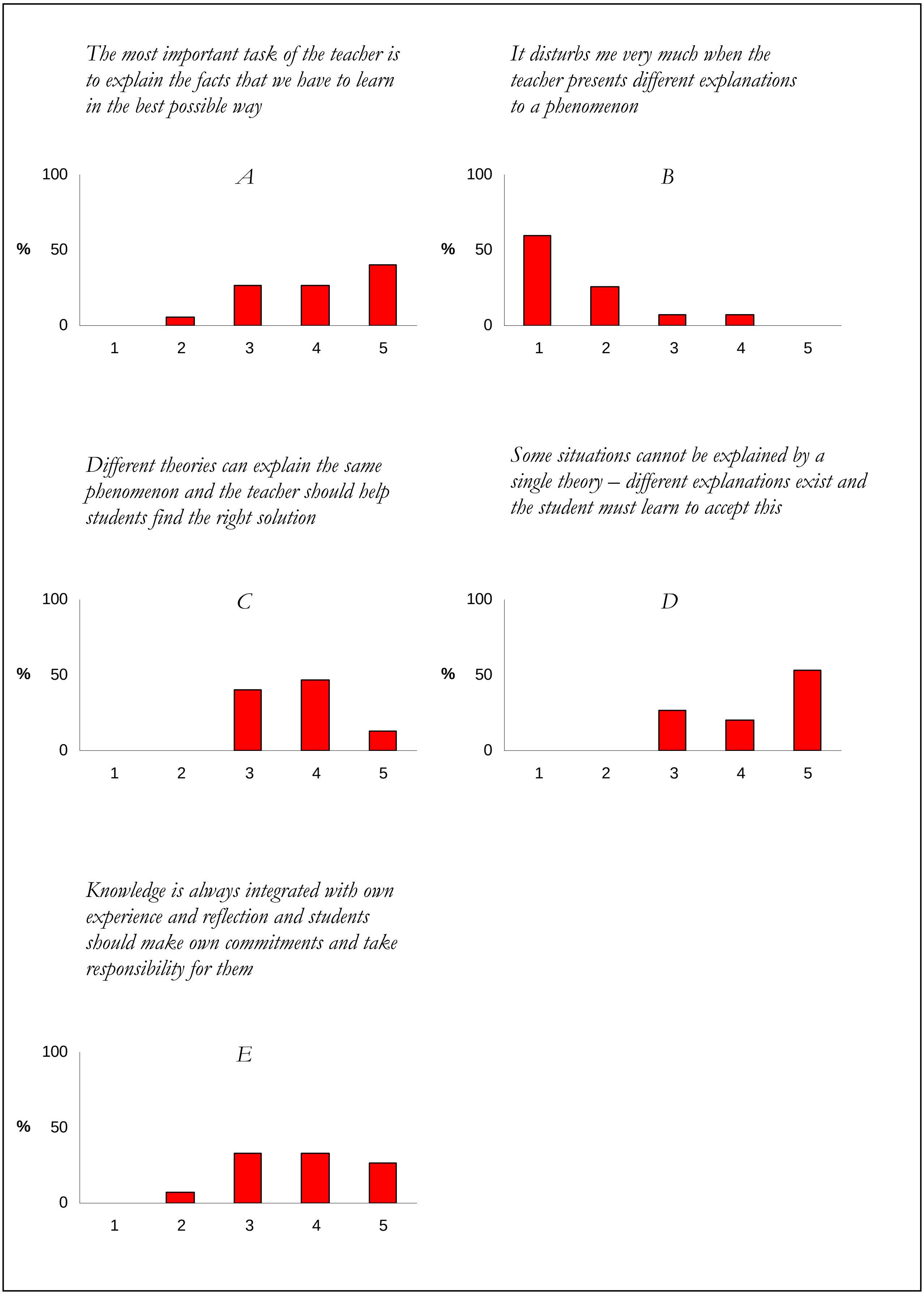


Figure 4.2 Results from questionnaire items about intellectual development

4.1.3 Approaches to learning

Figure 4.3 gives the statements and the result. The statements about approaches to learning are from the original CEQ (A, B and C). A new statement (D) is also added.

The result shows that the students have an acceptable deep approach to learning. Statement C, indicating a surface approach, is disturbing but probably more a manifestation of an overall heavy workload than a surface approach attitude. Discussions with students indicate this.

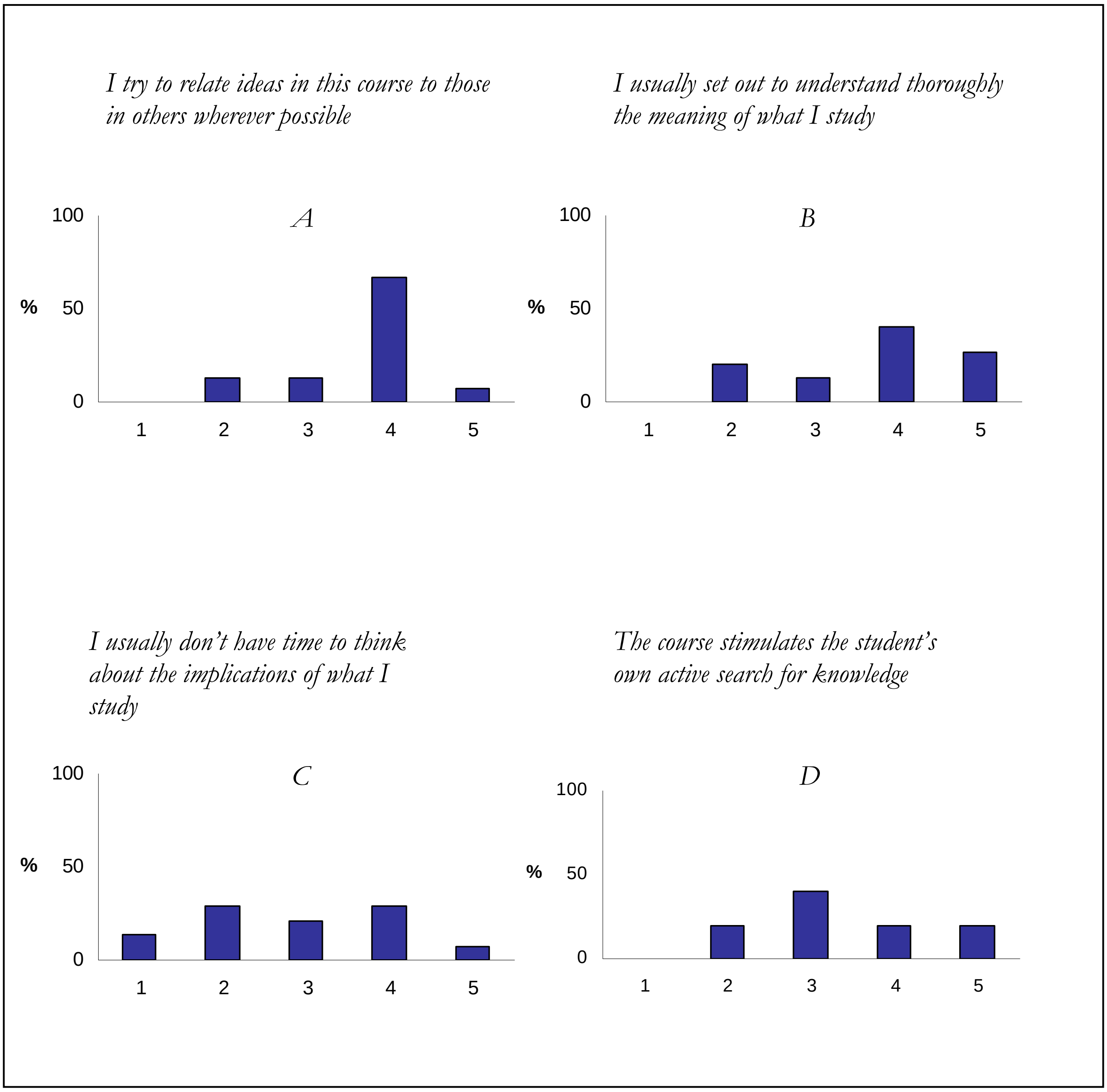


Figure 4.3 Results from questionnaire items about approaches to learning

4.1.4 General questions and overall quality

Figure 4.4 gives statements and results for some general questions about workload, goals and future professional life. All statements are considered in connection with laboratory teaching.

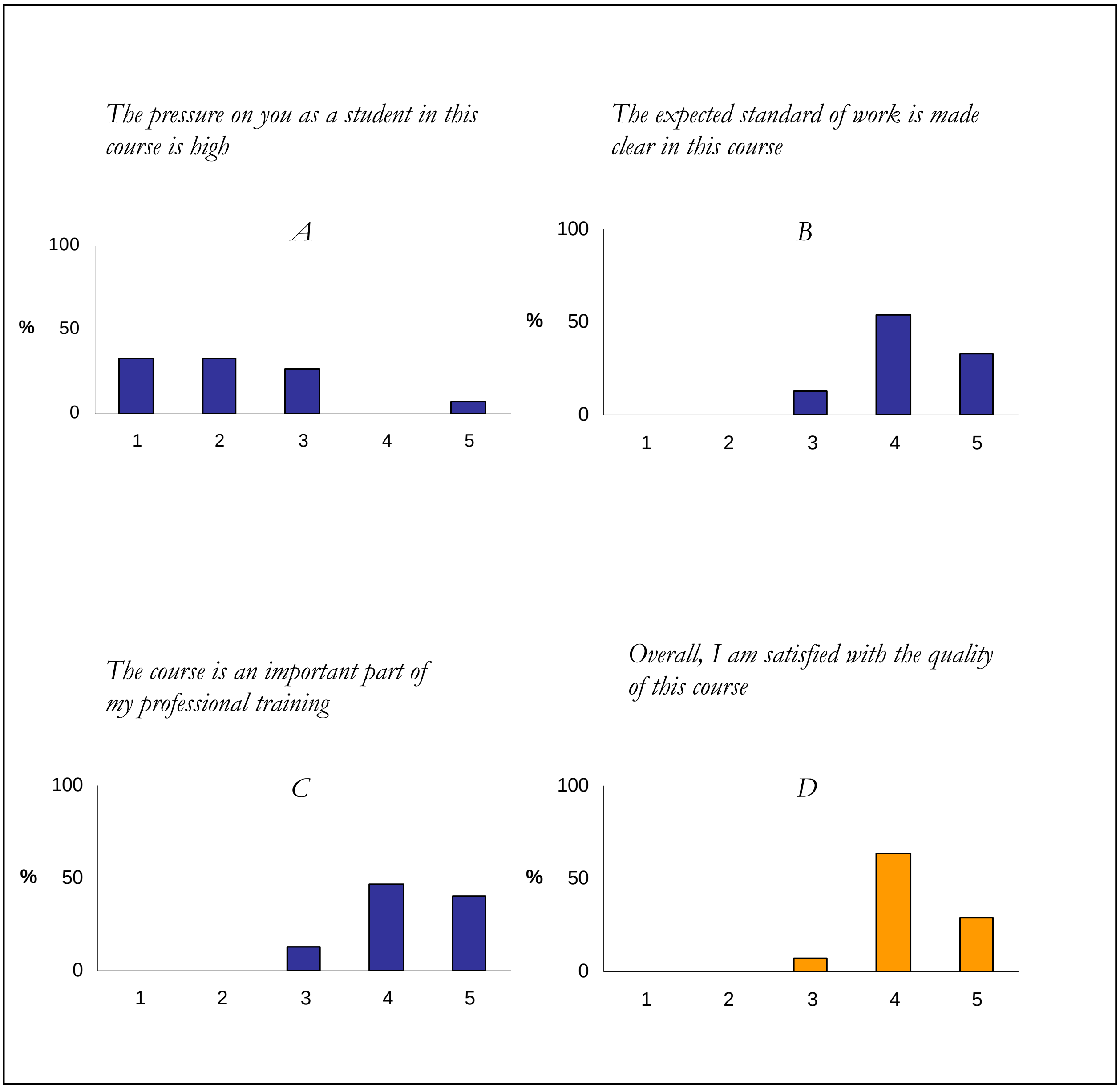


Figure 4.4 Results from questionnaire items about general questions and overall quality

4.2 Focus groups

Focus groups are group interviews where a small group of people discusses a topic decided by a moderator (Morgan and Krueger, 1997). Focus groups are a qualitative research method where the interactions between the participants, guided by the moderator, generate a rich understanding of experiences, views and beliefs of the participants. The data from focus groups are what the participants say during the interviews.

In this study three different focus group interviews, each with 6-8 students, were carried out. The topics discussed were assessment of skills, intellectual development and learning technologies. All topics were focused on laboratory teaching. Each focus group interview lasted for about one hour and the entire interview was audio taped.

4.2.1 Assessment of skills

The discussions about assessment were lively and instructive. A general view is that performance is not properly assessed today and most students would welcome a summative assessment. Some of the most important and representative comments are listed below:

"The report is assessed – not how the work is done"

"Emphasise planning and performance"

"Laboratory work should be a part of the examination"

"The assessment should be individual – even if the laboratory work is done in groups"

"Clear instructions are important but they must not be too detailed"

"…. now we are ready with this report – get on with the next one – and the next …. - an examination at the end of the course prevents this"

4.2.2 Intellectual development

The students are surprisingly aware of their intellectual development. These discussions were mature and showed interesting views of the matter. Students especially demand a much better follow-up of intellectual development with individual interviews, group discussions and more individual responses to students from teachers during their years at the university. Some representative comments:

"Discussions at the laboratory make you realise that there are different ways to reach the same goal"

"It is at the laboratory you realise that theory does not provide you with one single solution to a problem"

"In school you learn that things are right or wrong. Suddenly this is not so. It is frustrating. Discussions with other students and teachers help you overcome this. But it is a process of maturity. It is complex. The more you learn the more you understand about this. Especially the laboratory work helps you realise what it is all about …."

"Emphasise the role of an engineer"

"More responses from teachers to individual students"

4.2.3 Learning technologies

These discussions focused on video and audio recordings. Most students are positive and the main argument is that then all students must demonstrate their abilities. Important comments from the focus group interviews are listed below:

"All students must be active"

"It is good – nobody can wangle"

"Interesting – you can see how students think and it is easier to correct any faults that occur"

"Good method – but it can have a restraining effect on shy students"

"Time-consuming – but instructive"

"If it is really good – broadcast it as a 'docu soap' called 'a jolly good time at the lab ….' "

4.3 Comments and discussion

It is important that varying examination methods are used within an engineering curriculum. Laboratory work should be a part of the assessment and a summative performance-based examination has many benefits.

Students develop intellectually during their education at the university. Teaching and assessing at the laboratory influence this development positively. However, the ethical and intellectual development should be discussed more between students and teachers.

5 FINAL CONCLUSIONS AND REFLECTIONS

A summative performance-based assessment influences the way students accomplish their studies

- students must focus on all educational objectives
- students must demonstrate different abilities
- students qualitative level of learning is increased - higher SOLO levels are reached
- students must focus on a deep approach to learning
- students intellectual development is favoured

Learning technologies

- provide better feed back on student performance
- can facilitate the assessment
- ensure that everyone is seen (important and common student view)

Finally, and most important, the assessment becomes an opportunity for learning – not just testing.

6 REFERENCES

Axelsson, A., 1995. *Solving Practical Problems - an Alternative in the Chemical Engineering Laboratory*, Proceedings at the Conference on Teaching Science for Technology at Tertiary Level, 7th-9th June 1994, Stockholm

Biggs, J. B., 1999. *Teaching for Quality Learning at University*, Society for Research into Higher Education & Open University Press

Biggs, J. B. and Collis, K. F., 1982. *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome)*, Academic Press

Harden, R. M., Stevenson, M., Wilson Downie, W. and Wilson, G. M., 1975. *Assessment of Clinical Competence Using Objective Structured Examination*, British Journal of Medical Education, 1, 447-451

Metaplan GmbH, 2001. *Primer for the Metaplan Technique*. http://www.metaplan.com

Morgan, D. L. and Krueger, R. A., 1997. *The Focus Group Kit. Vol. 1: The Focus Group Guidebook. Vol. 2: Planning Focus Groups. Vol. 3: Developing Questions for Focus Groups. Vol. 4: Moderating Focus Groups. Vol. 5: Involving Community Members in Focus Groups. Vol. 6: Analyzing & Reporting Focus Group Results*, SAGE Publications

Olsson, T., 2000. *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy*, Proceedings of the 7th International Improving Student Learning Symposium, University of York, 1999. Improving Student Learning Through the Disciplines, Rust, C. (Ed.), pp. 304-324, The Oxford Centre for Staff and Learning Development

Perry, W. G., Jr., 1970. *Forms of Ethical and Intellectual Development in the College Years. A Scheme*, Holt, Rinehart and Winston

Prosser, M. and Trigwell, K., 1999. *Understanding Learning and Teaching. The Experience in Higher Education*, Society for Research into Higher Education & Open University Press

Ramsden, P., 1992. *Learning to Teach in Higher Education*, Routledge

Ramsden, P., 1991. *A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire*, Studies in Higher Education, Volume 16, No 2

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More information about this project can be found at:
http://hgur.hsv.se/activities/projects/financed_projects/k-s/olsson_thomas_99.htm

V

A combined formative performance assessment and summative reflective assessment fostering experiential learning and integration in an engineering curriculum

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Paper presented at the Learning Communities and Assessment Cultures Conference organised by the EARLI Special Interest Group on Assessment and Evaluation, University of Northumbria, 28-30 August 2002

ABSTRACT

Generic skills include important non-technical competencies that must be mastered by all professionally successful engineers. This paper presents assessment methods that foster integration of generic skills in an engineering curriculum through experiential learning. The study investigates how a summative reflective assessment influences the experiential learning promoted by formative performance-based assessments and how this affects students' integrative abilities. The assessment procedure is focused more on quality assurance of learning outcomes than quality control.

Introduction

Assessment has a major influence on all aspects of student learning in higher education. Using this knowledge we can influence the way students accomplish their studies (Biggs, 1999; Prosser and Trigwell, 1999).

How can assessment design increase students' abilities to integrate generic skills and competencies in a biotechnology or chemical engineering curriculum? This is the central question in this project. The proposed solution comprises formative performance-based assessments combined with a self-reflective summative assessment. The combination of assessment methods foster integration of non-technical skills through experiential learning (Kolb, 1984).

Overview of the project

The introduction and integration of non-technical competencies such as quality assurance, engineering ethics, communication skills, environmental issues, applied economics and social psychology in the curriculum are discussed. Case studies investigating integrative learning outcomes through open-ended questionnaires are presented.

Self-reflective papers presented by the students are discussed and also analysed using the SOLO-taxonomy (Biggs and Collis, 1982) and Perry´s Scheme of Intellectual and Ethical Development (Perry, 1970). The effects of the combination of different assessment methods are analysed and special attention is paid to the integration of generic skills with other competencies. The paper discusses how a reflective assessment influences Kolb's experiential learning cycle (Kolb, 1984).

Generic skills and competencies in an engineering curriculum

A curriculum is a framework implying values and priorities and it deals with philosophical as well as practical issues. It should emphasize knowledge and skills but also foster intellectual development, social interaction and student diversity. Different measures are taken to integrate generic skills and attitudes into the curriculum.

Generic skills are sometimes called transferable skills and they are essential for all undergraduate students. Some examples of important generic skills include:

- intellectual development and critical thinking
- transferring and application of conceptual understanding in novel situations
- effective written and oral communication of ideas and information
- effective teamwork including interaction with others, leadership capacity and appreciation of diversity
- understanding of the social context and the impact of the work of professional engineers
- international awareness and openness to different cultures
- information retrieval from a variety of media together with critical evaluation of information sources
- identification of ethical dimensions of problems
- environmental issues
- ability to reflect on and evaluate learning

These skills should be regarded as a complement to scientific and technical competencies and they provide a basis to support life-long professional development and learning. Potential employers regard generic -or non-technical- skills as very important. Professionally successful engineers must possess more than technical excellence.

Generic skills are most often taught *implicitly* within an educational program. The method described in this paper clearly identifies different generic skills and they are taught *explicitly*. Scientific and technical knowledge and skills of course form the core of the curriculum but it must be expanded to include important non-technical and professional skills and attitudes of the engineering profession.

The proposed approach to integrate generic skills in different courses throughout the curriculum gives students the opportunity to develop these skills while studying the core disciplines of the educational program. Integration is based on a holistic view of learning and helps students link different competencies across disciplines together. They see how single concepts appear in diverse situations and connect their academic studies with the engineering profession.

Alumni judgement of professional demands and present education

An investigation performed by the Evaluation Office at Lund University among alumni (186) and employers (10) from the fire safety engineering area shows that the professional demands of many of the generic competencies discussed in this paper are very high (Fasth and Nilsson Lindström, 2002).

The professional demands were very high but the satisfaction with the present education was low for the following skills

- Ability to argue and convince
- Ability to explain facts to non-specialists
- Ability to work with persons with other educational backgrounds
- Ability to handle different social circumstances
- Understand motives for different actions of individuals or groups of people

The professional demands were fairly high but the satisfaction with the present education was low for the following competencies

- Detect and analyse ethical problems
- Understand different cultures
- International matters

The professional demands were high and the satisfaction with the present education was also high or fairly high for the following competencies

- Problem solving
- Critical thinking
- Oral presentations
- Written presentations

It is interesting to notice that traditional academic competencies such as problem solving or critical thinking are considered as well treated in the educational program whereas professional skills such as explaining facts to non-specialists or analysing ethical problems are not.

Introduction and integration of generic skills in the curriculum

The design of the curriculum includes an accurately prepared schedule of integrated courses supporting a deep orientation of teaching and learning and an integration of non-technical skills and competencies such as communication skills, engineering ethics, quality assurance, applied economics, environmental issues and social psychology. These important items are introduced in an introduction course, *The Engineering Profession – Quality Assurance, Ethics and Communication*, during the first year and are then integrated throughout the curriculum. Figure 1 shows an outline of the curriculum design.

Students (20) in their second year of the chemical engineering education (Bachelor of Science level) at Lund University were asked to express their opinions about to what extent other topics than scientific and technical should be included in the curriculum. Some relevant comments were:

"to a very great extent – in the professional life you cannot manage with only technical knowledge, you must have a much broader base"
"get an insight into the thinking of social science and the humanities"

"the social part – to work in groups"
"co-operate with others"
"social aspects – ethical and environmental aspects"
"what is ethically acceptable and why"

"how to handle different technical situations - to be more environmentally conscious"
"communication and leadership are important"
"economics – integrated in most subjects"

One or two students answered *"don't know"* but all other comments were positive and emphasised the importance of generic skills in an engineering education.

Students integrative abilities

A very interesting problem to investigate is whether students integrate different aspects of complex problems (technology, ethics, quality, economics, communication etc.) spontaneously or if this ability is passive and specific tasks must be formulated to help students integrate knowledge from different areas. This study presents case studies investigating integrative learning outcomes through open-ended questionnaires (Arvidson, 2002). The students (20) participating in this investigation were in their second year of the chemical engineering education.

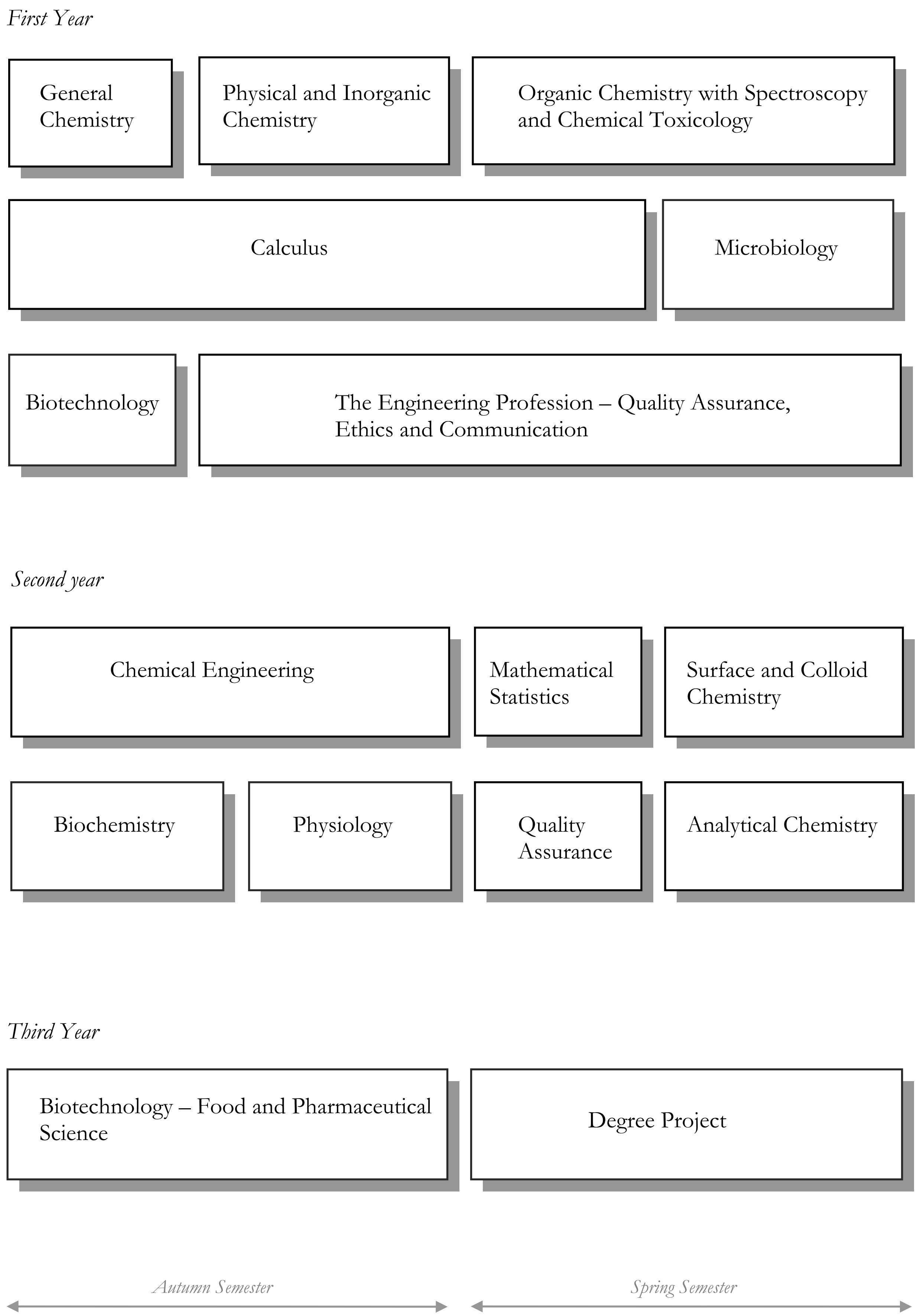

Figure 1 Curriculum design

The students were given the following instructions:

Your task is to discuss different aspects of

- planning
- design
- operation
- management
- maintenance
- production

from raw material to consumption for the following processes:

- Pasteurised milk products – processing of pasteurised market milk
- Pasteurised milk products – yoghurt
- Rape oils – especially hot pressing and solvent extraction
- Sugar – manufacturing from sugar beets
- Acetylsalicylic acid
- Hydrogen peroxide
- Manufactured textile fibres – nylon 66
- Production of electricity – nuclear power station

Some background information, process diagrams etc. are provided. In the different processes raw materials are converted (chemically and/or physically) into products.

Write down *everything* that you think is important. It is not necessary to describe in detail how different activities should be carried out but you must state *that* it is important and *outline* what must be performed etc.

Each student worked with 2 or 3 of the different processes for about two hours. They handed in their solutions and then received the following complementary instructions:

Pay attention to the integration of different aspects of

- quality assurance
- environmental aspects
- ethics
- economics
- communication
- organisation

in your solutions.

They now worked with new processes and solved the same problem as before but with the complementary instructions in their minds. All solutions were analysed both with respect to technical solutions and how different non-technical aspects were integrated in these solutions. In addition the qualitative and intellectual level of the papers were also judged using the SOLO-taxonomy (Biggs and Collis, 1982) and Perry´s Scheme of Intellectual and Ethical Development (Perry, 1970).

All students presented at least ten different scientific or technical aspects relevant to the problem. The standard of these proposals was very high. Students presented extensive analyses of process design. They discussed raw materials, logistics, packing, transportation and distribution. Different aspects of planning and project work, production and maintenance, selection of equipment, location and consumer questions were also discussed.

The extent to which generic non-technical aspects such as quality assurance, ethics, communication, environmental problems and organisation were integrated in the solutions is presented in Table 1. The result shows that the incorporation of these aspects raised considerably when students were given specific instructions to do so. It is interesting to notice that all students integrate quality assurance in all solutions whereas no students integrate ethics or communication without instructions (50% with instructions). About half of the students spontaneously integrate environmental and economical issues and almost all students integrate these aspects after having received special instructions. The conclusion of these results is that many students possess latent integrative abilities.

Some relevant areas discussed by the students in the integration process include

- relations between transportation, environmental effects and economics
- relations between recycling, environmental effects and economics
- relations between packaging and environmental effects
- quality assurance, microbiology and hygiene
- co-operation and communication with customers
- internal communication within the company and external communication with the public and authorities
- ethical aspects contra economics
- ethical aspects contra aesthetics

Once students start integrating generic aspects in complex engineering problems they do it with maturity and capability. The results are very promising for these students' future professional careers.

The qualitative levels of the presented works were evaluated using the SOLO taxonomy. About 70% reach the multistructural level and 30% the relational level. No significant differences were observed before and after instructions were given to integrate generic aspects. Higher levels would be reached if students had been given the opportunity to present their results orally. Discussions with students clearly indicate this (Biggs and Collis, 1982; Olsson, 2000).

The intellectual levels of these papers are difficult to interpret. Most students seem to be at the levels of multiplicity and relativism according to Perry´s scheme (Perry, 1970). No students demonstrate dualistic views whereas a few are really trying to make commitments.

Aspects of …	Integration *without* specific instructions (%)	Integration *with* specific instructions (%)
Quality assurance	100	100
Ethics	0	40
Communication	0	50
Environment	50	100
Economics	50	90
Organisation	40	70

Table 1 Students' integrative abilities

Assessment

Students (42) at the end of their first year of the biotechnology or chemical engineering curricula participate in formative performance assessments and a summative reflective assessment of generic skills as part of the introduction course *"The Engineering Profession – Quality Assurance, Ethics and Communication"*.

The Course Experience Questionnaire, CEQ, (Ramsden, 1991) was used to investigate student views and conceptions of generic skills and their general impressions of the curriculum. The CEQ was also complemented with new statements about assessment and intellectual development (Olsson, 2002). Students responded to the different statements of the CEQ on a scale from 1 (definitely not) to 5 (exactly). A total of 62 students from the first and second years of the curricula participated.

Parts of the results are relevant to assessment. These results show that:

- Students prefer varying forms of assessment.

  Statements like "*Varying forms of assessment give good opportunities for students to demonstrate their knowledge and skill"* and *"To do well in this module all you really need is a good memory"* received an average of 4 with a slightly higher result for second year students.

  Results from statements like "*A written examination is the best and most objective examination", "I prefer an assessment where I have to actively demonstrate my knowledge and skill"* and *"The assessment design determines how I perform my studies"* all indicate a development in students' views throughout the curriculum.

- Students shift between a surface and a deep approach to learning but a deep approach dominates.

  It is gratifying to note that statements like *"I try to relate ideas in this subject to those in others, wherever possible", "I usually set out to understand thoroughly the meaning of what I am asked to read", "I generally put a lot of effort into trying to understand things that initially seem difficult"* and *"In trying to understand new ideas I often try to relate them to real life situations to which they might apply"* all received an average of 4 indicating a clear deep approach. All statements investigating a surface approach received around 3. There is no significant difference between students in the first or second year of their studies.

- Students' intellectual and ethical development is well on its way towards the higher levels of Perry´s scheme (1970).

  Statements (9 different) like *"The most important task of the teacher is to explain the facts that we have to learn in the best possible way", "It disturbs me very much when the teacher presents different explanations to a phenomenon"* and *"Some situations cannot be explained by a single theory – different explanations exist and the student must learn to accept this"* (Olsson, 2002) together with an analyses of the reflective papers (see below) indicate a positive intellectual development.

Formative performance assessment

Formative performance assessments of generic skills include written reports, oral presentations and formal opposition from teachers and other students.

The formative assessment of *communication skills* include

- Rhetorical speeches

  Students demonstrate their abilities to argue and convince using classical and modern rhetoric. They argue in favour of or against a given subject. The speeches are presented both written and orally with formal opposition from teachers and other students.

- Case studies

  Groups of students work with different scenarios. Students adopt different roles in a company and the scenario could e.g. be a discharge of an effluent affecting the environment or a microbiological contamination of a food product. The task is to present all relevant actions that have to be taken to solve the situation, especially communications within the company and with authorities and the public. All propositions are discussed in a written report and presented orally at a seminar with formal opposition.

- Scientific papers and poster presentations

  All students attend lectures of researchers in the field of environmental studies. The task is to write a summary of the presented research in the form of a scientific review article. Students use the resources of the library to find relevant papers or reports. Finally students make a popular scientific presentation of the same material and present it at a poster session where students oppose each other's work.

The assessment of *quality assurance* consist of writing a standard operating procedures (SOP) for a given procedure, product or apparatus. *Ethics* is assessed when students make an ethical investigation on a relevant aspect of chemistry or biotechnology. In both quality assurance and ethics students write reports that are presented orally at formal group discussion seminars.

Social psychology is assessed through field observations. Students observe people or groups of people's behaviour in different situations. They write reports and use the theory of social psychology to describe their findings. The results are presented orally at group discussions.

Summative reflective assessment

The purpose of reflection is to learn from experiences. Students write reflective papers that are personal, self-reflective and focus on knowledge, skills and attitudes acquired during the introduction course. They reflect on how they will use these competencies in engineering courses and in their future professional careers. They also reflect on learning and how to improve as learners.

Examples of relevant opinions from the reflective papers:

Quality assurance:

"I have already changed the way I deal with laboratory journals. I have become more accurate when I work and when I handle different kinds of reports. The importance of keeping correct notes is very high"

"Quality assurance is not something you think about every day. But it will be a very important part of our professional life"

"That quality assurance is so incredibly important in the pharmaceutical industry was new to me"

"I know now how important documentation is - it is impossible to remember everything you do"

"I have realised how important quality is when you think and work"

Ethics:

"It is a subject that differs totally from what we normally study, nothing is right or wrong, all depends on your own opinion. Important knowledge to have in the professional life when you have to work together with many different kinds of people"

"To consider the probable ethical costs against profits and to think in terms of assets and liabilities felt strange at the beginning"

"If you do not realise that you can greatly influence peoples lives it can even become dangerous when you start your professional life"

"It is important to understand why people come to the decisions they do in different situations"

"Ethics is a very interesting subject that sometimes makes you really upset"

"How we reflect ethically influence our actions and will also influence our professional life"

“I think ethics is an area that engineers should pay more attention to”

“Ethical questions and different views created new ways of thinking”

“Something that is OK in Sweden may be unacceptable in another country and as an engineer you must be aware of this since a decision in Sweden may have consequences elsewhere”

Communication:

“It is important to be able to talk to people and make them listen to what you say. We learnt many tricks. In a realistic case we practised communicating with the public outside a factory. Very instructive”

“We have learnt how incredibly important the delivery is when you want your message to reach and convince other people”

“Communication was a bit frightening at the beginning but I think that it helped you become tougher and that is needed”

“I need to be able to communicate, to dare to stand in front of a group of people and have the situation under control and talk”

“I noticed that it became easier and easier each time you talked in front of the other students - you need to practice”

“Solve problems, talk in front of other people, argue, express yourself correctly in writing - important!”

“You can never practice oral presentations enough”

“You did not only practice oral and written presentations but you also learnt about rhetoric, cases, articles and posters”

Social psychology:

“I have learnt to be more tolerant towards people’s different behaviours - I have gained a better insight into why certain human behaviours are considered normal and other abnormal”

“I am a human and I live among humans. Therefore I should also have some knowledge about human social behaviour. To be able to function in a group of people - no matter where, when or how - you need knowledge about their behaviour”

“Social psychology is of vital importance for a successful professional life. Work in groups and contacts with colleagues, the public, authorities or customers demand that we possess some knowledge in social psychology”

“At contacts with companies, partners or media it is important to know how to behave and why other people behave as they do”

“It is important at a place of work that you can interpret people and understand their behaviour”

Learning:

“The student takes on the responsibility for his or her studies”

“Learning is for me a process that continues throughout life”

“You must learn to sort out what is important from what is not so important, to study critically”

"This course has helped me feel that I am quite close to my goals. It has totally focused on competencies that are useful in the professional life"

"It is not only chemistry that you need to be a competent and complete engineer"

"In your professional life it is not enough to know a lot of chemistry and biology, you have to master so much more"

"As an engineer you sort out important information, analyse and solve problems"

When students write the reflective papers they are given the instruction that it is not a course evaluation although evaluative aspects may be included if considered appropriate. Students do write several evaluative comments. When the reflective papers are compared with the CEQ and a complementary open questionnaire it is obvious that the reflective papers give a much more balanced and informative view of the introduction course. On a scale from 1 to 5 the CEQ gives an average of 3. Especially the statements about "appropriate workload" and "student independence" lower the overall figure. If the reflective papers are evaluated with respect to students' appreciation of the course and their judgement of the usefulness of the generic skills obtained an average of close to 4 is more appropriate. These are interesting findings that require a thorough follow-up and should initiate further investigations and research.

A SOLO analyses (Biggs and Collis, 1982) of the reflective papers show that these students (all in their first year of the education) present papers with varying qualitative standard. About 20% do not pass the unistructural level, 60% reach the multistructural level and 20% the relational level.

Assessment and experiential learning

The combination of formative and summative assessment methods favours experiential learning as described by Kolb's learning cycle (Kolb, 1984). Formative performance assessments give several concrete experiences that are reflected upon and conceptualised in the summative reflective assessment. An active experimentation occurs when new competencies are integrated and applied in engineering courses that in turn results in new concrete experiences.

Figure 2 shows how the different assessment procedures affect Kolb's learning cycle and Figure 3 shows how integration and evaluation affect the learning cycle.

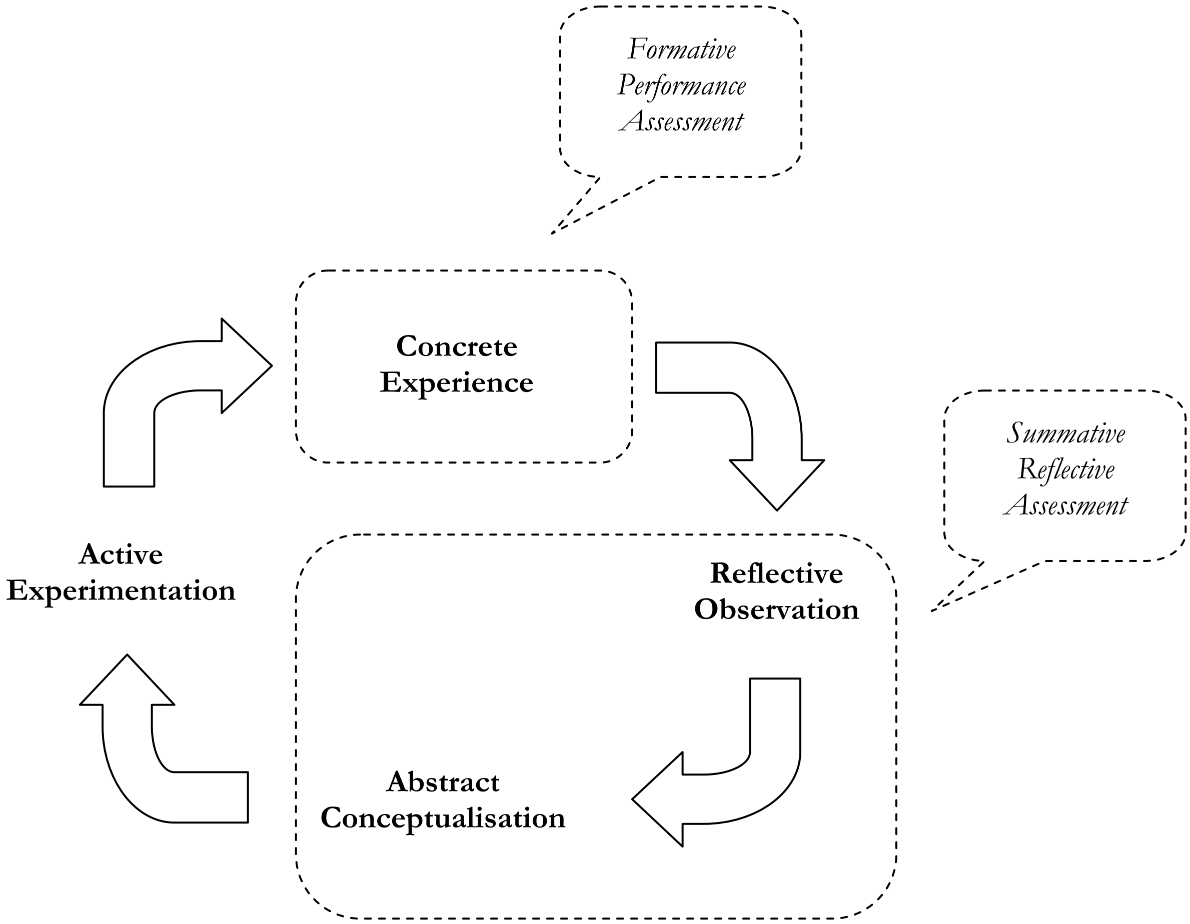

Figure 2 Assessment and Kolb's experiential learning cycle

The formative and summative assessments (Fig. 2) are parts of the introduction course during the first year of the curriculum. Generic skills are integrated in different courses of the curriculum and students' new concrete experiences from this integration result in improved competencies used in further integration processes. The result is a cyclic experiential learning process that leads to an improved learning of generic skills (Fig. 3).

Students give evaluative comments in their reflective papers. These comments are used by teachers to improve the formative parts of the assessment process within the introduction course. This cyclic evaluation process is incorporated in the learning cycle (Fig. 3).

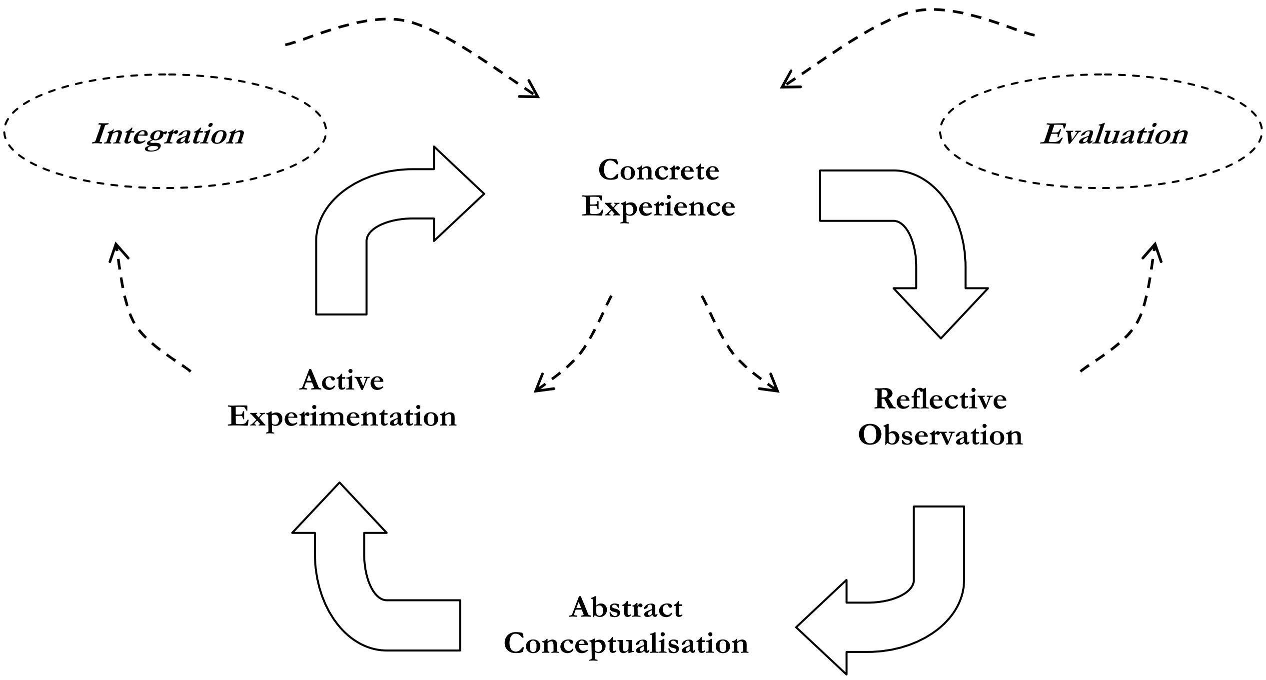

Figure 3 Integration, evaluation and Kolb's experiential learning cycle

Comments and conclusions

The main results of this study are:

- a formative performance assessment of non-technical skills and attitudes allows students to demonstrate different abilities and facilitates feedback on student performance
- the combination of a formative performance and summative reflective assessment increases the quality of the learning process
- many students possess latent integrative abilities and integration of generic skills in different engineering courses is favoured by a reflective assessment
- metacognition is favoured by the use of a reflective assessment and metacognitive skills influence the student learning process throughout the curriculum
- the proposed assessment procedure is more oriented towards quality assurance of learning outcomes than just testing of knowledge and skills (quality control)
- a modified experiential learning cycle combining assessment, evaluation and integration with Kolb´s learning cycle is presented

The most important result of all proposed activities presented in this paper is that the assessment is an integrated part of the learning process and that the assessment becomes an important opportunity for learning.

References

Arvidson, P. (2002), Personal communication, Learning and Teaching Development Centre, Lund University

Biggs, J. B. (1999), *Teaching for Quality Learning at University*, Society for Research into Higher Education & Open University Press

Biggs, J. B. and Collis, K. F. (1982). *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome)*, Academic Press

Fasth, E. and Nilsson Lindström, M. (2002). *Report 2002:213* (in Swedish), Evaluation Office, Lund University

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, New Jersey: Prentice-Hall

Olsson, T. (2000). *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy*, In Rust, C. (Ed.), pp. 304-324, Improving Student Learning Through the Disciplines, The Oxford Centre for Staff and Learning Development

Olsson, T. (2002). *Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-Based Examination in Chemical Engineering*, In Rust, C. (Ed.), pp. 310-323, Improving Student Learning Using Learning Technologies, The Oxford Centre for Staff and Learning Development

Perry, W. G., Jr. (1970). *Forms of Intellectual and Ethical Development in the College Years. A Scheme*, Holt, Rinehart and Winston

Prosser, M. and Trigwell, K. (1999). *Understanding Learning and Teaching. The Experience in Higher Education*, Society for Research into Higher Education & Open University Press

Ramsden, P. (1991). *A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire*, Studies in Higher Education, Volume 16, No 2

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More information about this project can be found at:
http://hgur.hsv.se/activities/projects/financed_projects/k-s/olsson_thomas_99.htm

VI

Reflective Assessment - Qualitative Aspects of Evaluation and Learning

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Critical reflection plays an important role in the learning process at universities. Successful reflection can help students develop new insights, new mental models and professional improvement. Thus reflection involves a mental processing and students who reflect in a structured and creative way on their own learning activities and achievements are more likely to reach the higher levels of the SOLO taxonomy (Biggs and Collis, 1982) and to adopt a deep approach to learning. This paper presents an investigation on how reflective writing used as an assessment method also can serve as a complement to course evaluation techniques such as the Course Experience Questionnaire, CEQ (Ramsden, 1991).

Generic skills are introduced in an introduction course during the first year of a biotechnology curriculum at Bachelor of Science level. These skills comprise quality assurance, engineering ethics, communication skills, environmental issues, applied economics and social psychology. The main assessment procedure is formative with written reports and oral presentations with formal oppositions and includes standard operating procedures, ethical investigations, rhetorical speeches, case studies, scientific papers, poster presentations and field observations. A reflective summative assessment was introduced two years ago. Students produce papers that are personal and self-reflective. The papers focus on knowledge and skills acquired during the course and how to use this competence in future professional careers.

The main research question is illustrated in Figure 1.

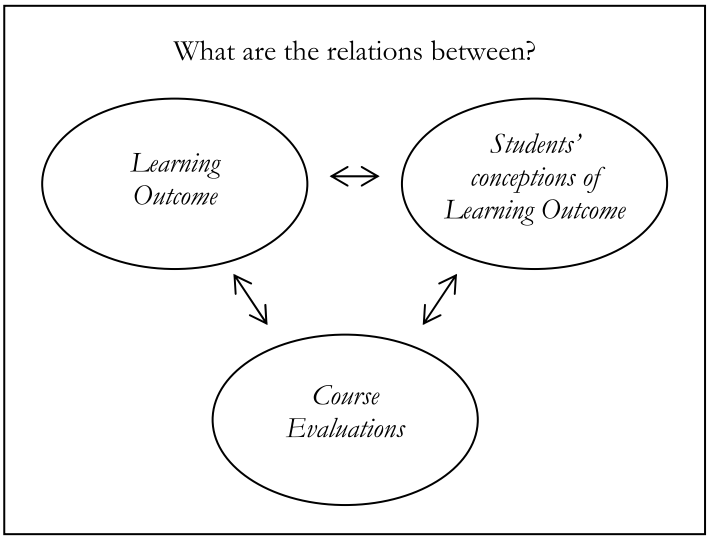

Figure 1. Research question

Three types of reflection that can be associated with experiential learning (Kolb, 1984) are reflection-in-action, reflection-on-action, (Schön, 1983) and reflection-for-action (Cowan, 1998). In the summative papers students mainly reflect "on" and "for" action and they are critically reflective and connect the assessment to their own learning. The papers comprise both a cognitive (students' reflection on knowledge and skills) and a meta-cognitive (students' reflection on learning) dimension. In most cases there are also clear and distinct course evaluative aspects found in the papers. The different dimensions of the reflective papers and the relation between the papers and external course evaluations are the main purposes of this study (Fig. 2).

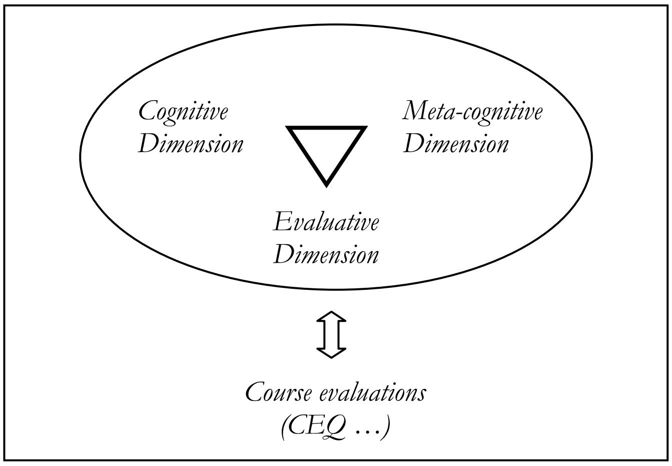

Figure 2. Reflective papers and course evaluations

The research methodology employs several qualitative approaches. Comparative studies of reflective papers, CEQ results and more traditional course evaluation forms were performed and evaluated together with focus group interviews and individual in-dept interviews. The SOLO-taxonomy (Biggs and Collis, 1982) and Perry´s Scheme of Intellectual and Ethical Development (Perry, 1970) were also used in the evaluation process.

The reflective papers

- are balanced and informative especially about learning outcomes.
- include discussions of future usefulness of acquired knowledge and skills.
- are significantly more positive than corresponding course evaluations.

A representative example of quantitative results includes *"general satisfaction"* and *"future usefulness of knowledge and skills"*. The results are presented in Figure 3 where the marks from the Course Experience Questionnaire (CEQ) are mean values on a scale from 1 to 5. The marks from the reflective papers are estimations where ++ means significantly more positive (probably above 4.0) and + means more positive than the CEQ.

General satisfaction		
CEQ	2.9 (2002)	3.2 (2003)
Reflective papers	++ (2002)	++ (2003)
Future usefulness of knowledge and skills		
CEQ	3.2 (2002)	3.5 (2003)
Reflective papers	+ (2002)	++ (2003)

Figure 3. Examples of quantitative results

An example of qualitative results include citations of students' cognitive, meta-cognitive and evaluative statements:

- "Awareness of quality assurance is an important part of the engineering profession."
- "I feel that after my studies it is very important that I know my attitudes to such problems {ethical} and learn to argue in favour of them."
- "…you face a problem where all solutions involve several ethical considerations. Therefore it is very useful to have been given the opportunity to think in such ways."
- "When you work in project groups it can be very useful to be aware of how people act in different situations."
- "Especially how people change roles depending on the situation and on what is expected of them."

- "All problems are complex and must be analysed very carefully from all angles to reach the best solution."
- "Now I have learned to investigate a problem and a solution in many different ways and to criticise different solutions to the same problem."
- "I wish that you already in upper secondary school reached this level of search for knowledge, but …"
- "Learning is a process that should continue throughout your life."
- "To take a personal responsibility for your learning is a must - if you fail to do that you must take the consequences yourself."

- "Two important parts of social competence are the abilities to communicate and co-operate. I feel that I have developed these two parts considerably during this course."
- "In spite of the fact that I did not like the video camera I must admit that it was instructive to study oneself while performing."
- "What I before had been so anxious about now turned into something pleasant and stimulating. For this I am very grateful today since most of my fear has disappeared and I have learned how to act when I give a speech in front of a larger group of people."
- "The usefulness of ethics is probably greater than what I feel at the moment…"
- "…as usual my preconceived ideas had to give way to reality after a while."
- "My interest in the different parts {of the course} has been low at times but I have learned a lot."
- "In general I think that the course was good and I actually think that when you start working it will be more useful than you realise now."

The main results of this study imply that a reflective summative assessment provides an evaluation of the learning outcome that is more detailed and informative than the results of the CEQ. Even more interesting is the finding that the CEQ and the papers give diverging results about learning outcomes. Students demonstrate excellent learning outcomes and write positively about them in their papers but at the same time give quite modest marks in the CEQ. Results from focus groups and interviews indicate that students do not regard traditional course evaluations as measures of the learning outcomes. This is an important finding since the goal of all educational activities at a university is learning at qualitatively high levels.

Learning at qualitatively high levels is not equivalent to positive course evaluations. Course evaluations measure some aspects of the experience of a course but probably only to some extent the actual quality of student learning. This knowledge is of practical importance for faculty management, departments and individual teachers.

Further development and research activities involve

- development of critical reflection as a complementary assessment method in traditional engineering courses and as an overall assessment method covering several courses of the curriculum.
- introduction of reflective exercises as an integral part of regular classroom activities in courses throughout the curriculum.
- more investigations of the main research question perhaps complemented with a phenomenographic study of variations of students' conceptions of the quality of learning outcome and course evaluations.

References:

Biggs, J. B. and Collis, K. F. (1982). *Evaluating the Quality of Learning. The SOLO Taxonomy (Structure of the Observed Learning Outcome)*, Academic Press

Cowan, J. (1998). *On Becoming an Innovative University Teacher. Reflection in Action*, Society for Research into Higher Education & Open University Press

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*, Englewood Cliffs, New Jersey: Prentice-Hall

Perry, W. G., Jr. (1970). *Forms of Intellectual and Ethical Development in the College Years. A Scheme*, Holt, Rinehart and Winston

Ramsden, P. (1991). *A Performance Indicator of Teaching Quality in Higher Education: the Course Experience Questionnaire*, Studies in Higher Education, Volume 16, No 2

Schön, D. A. (1983). *The Reflective Practitioner*, Basic Books

VII

The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching

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1 INTRODUCTION

Students that enter universities today have a much more diversified educational, social and ethnical background than just ten or fifteen years ago. Universities are faced with new challenges and must develop new strategies to solve different problems but also take advantage of new possibilities. Pedagogical research has increased our knowledge about teaching and student learning in higher education and numerous activities and projects initiated from the government as well as from the universities themselves have started in recent years (Bowden and Marton, 1999).

The pedagogical academy is a novel approach to stimulate and reward scholarly teaching. It has been developed in accordance with widespread views of what a teacher's role is at a university (Boyer, 1990; Kreber, 2000; Trigwell et al., 2000; Biggs, 1999). In this paper we will present and discuss the main ideas behind the pedagogical academy and some important findings and experiences from the implementation of the project.

University lecturers at Lund Institute of Technology (the Faculty of Engineering at Lund University), LTH, may apply for admission to the pedagogical academy. Their teaching skills are assessed and, if they are accepted into the Academy, they receive a certificate declaring that they have attained the grade, *"Excellent Teaching Practice (ETP)"*, and an immediate rise in salary. Moreover, the department to which they belong will receive an increase in their grant.

Lecturers who will be admitted to the Academy are those who can show that they have, over a period of time, and preferably, consciously and systematically, endeavoured to develop themselves as teachers as well as their teaching activities, regardless of the level at which they teach.

1.1 Pedagogical Development

How can university lecturers be motivated and stimulated to develop their teaching skills? How do we increase lecturers' interest in the scholarship of teaching? An important experience from Lund University is that it is crucial how projects aimed to develop and change teaching activities are initiated and how the objectives are communicated to lecturers at the faculty. Another very important factor is the involvement in such projects by active lecturers from different departments at the faculty.

The Pedagogical Academy has been developed within a larger project at LTH entitled *The Breakthrough*. The aim of this project is to make LTH a faculty that consciously and systematically strives to develop its teaching and learning culture. It is about changing the paradigm of education from teaching to learning and to create a scholarly teaching environment. An increased dialogue and co-operation about educational issues is very important to stimulate a positive development.

Different pedagogical courses about teaching and learning have been available at LTH for about ten years. Many teachers have attended these courses. This has secured a well-established view within the faculty that pedagogy can help teachers improve their teaching and many lecturers now shear the same experiences of pedagogical research, methods and terminology. This is the main reason why it is now possible to develop the teaching and learning strategies more systematically at the faculty. Another important reason is that the board and management strongly support and encourage this development.

The Pedagogical Academy has been developed by a group of five lecturers representing different departments at LTH together with a pedagogical expert (the authors of this paper). This project group is responsible for the development of criteria, instructions and procedures for the assessment of pedagogical competence according to the basic ideas of the Pedagogical Academy.

1.2 Aims of the Pedagogical Academy

The main aim of the Academy is to afford status to pedagogical development at LTH. Lecturers and students, present and prospective, should be given a clear signal that LTH is an institute of higher education that systematically strives to improve the quality of its teaching. This will be achieved in the following ways:

- Good, ambitious, quality-conscious lecturers will be rewarded by a certificate of competence and an increase in salary. These lecturers and other ambitious teachers will be a sign that LTH is investing in good teaching and that there are goals to aim at.

- The departments from which lecturers have been admitted to the Academy will be deemed to have better capacity to provide good teaching. Moreover, if the department in question actively supports its lecturers in applying for and obtaining this certification, it is believed that, in the long run, they will find it easier to recruit and retain good teachers, and thus good students. For this reason, such departments will receive an additional financial contribution for every employee who achieves this certification. This system is based on what today is called *docentur*, i.e. achieving the grade of senior lecturer or reader.

- The aim of the system is to initiate positive development, where it is clear that it pays to invest in good, carefully prepared teaching. This in turn will lead to the professionalisation of teaching, i.e. that good teaching is documented and scrutinized, and thus acts as a springboard for further development.

- The certified lecturers are assumed to be able to contribute to pedagogical development at LTH. This may be realised through active participation in LTH's pedagogical debate and development, and by acting as mentors for younger teachers.

This takes place in line with national and international development regarding the perception of a university lecturer (Boyer, 1990; Healey, 2000; Kreber, 2000; Trigwell, Martin et al., 2000; Abrahamsson, 2001; Fransson and Wahlén, 2001).

2 PROCESS OF APPLICATION AND ACCEPTANCE

University lecturers (but not postgraduate students) may apply to the Pedagogical Academy. There are no special demands on how many years the applicant should have lectured or that he or she should use a special pedagogical method. However, the applicant should have a broad experience in higher education and should be able to show that he or she has worked, in a reflecting and open way, to improve the goal of teaching, namely the student's learning.

Lecturers wishing to apply to the Pedagogical Academy should:

- attend the workshop "How to write a teaching portfolio",
- submit a teaching portfolio together with a recommendation of their head of department, and
- take part in an interview.

2.1 The Workshop

The workshop "How to write a teaching portfolio" is organised regularly. Lecturers will be admitted to the workshop following a selection process by submitting a short outline of their teaching portfolio. Participation in the workshop is compulsory but it does not guarantee that the lecturer's merits will be approved. The aim of the workshop is to ensure that the portfolio is presented in the required format and to present opportunities for the participants to communicate and share their experiences of teaching and learning.

The workshop consists of four seminars including group discussions mixed with information about the process of application. Two individual consultations with a pedagogical expert are also included.

2.2 The Teaching Portfolio

The method of using portfolios to assess the quality of a lecturer's teaching skills has a long tradition and has been found, through studies, to be very reliable. For further details, see Seldin (1997), Apelgren and Giertz (2001), Karolinska Institute (2001) and Magin (1998).

The portfolio, which is the most important component of the application, consists of three main parts. The first is a *CV* with a special section dedicated to pedagogical activities. The second is a document of 1-3 pages in length describing the lecturer's personal reflections regarding teaching and learning. This is to be a personal document, focusing on the different aspects of the teaching role, and in this way form what can be referred to as the lecturer's *personal teaching philosophy*. The third part constitutes *a description of what the lecturer has achieved*. The examples (4-5 in number) should be related to the second part of the portfolio in such a way that the portfolio constitutes an overview, from which it is evident that the lecturer has reflected on teaching over a period of time and has made the effort to implement his or her ideas in practical teaching. The portfolio is to be related to the six criteria described in Chapter 2.7. References, certificates and other documents supporting the claims presented should be enclosed.

2.3 The Recommendation of the Head of Department

The intention of this document is to show that the head of department is convinced that the lecturer in question has no shortcomings in his or her relation to the students. Another intention is to provide the head of department with the opportunity to express an opinion on the pedagogical abilities of the applicant.

2.4 The Interview

The interview is a complement to the recommendation of the head of department and the portfolio submitted by the applicant. The main aim of the interview is to gain an idea of the lecturer's ability to communicate verbally the claims made in the portfolio. It is especially important that the interview is consistent with the portfolio, so that the application is perceived as an integrated whole. The interview also provides an opportunity to clarify confusions arisen during the assessors reading of the portfolio.

2.5 Assessment and Scrutiny

The qualifications of the applicant are assessed by a group of lecturers (*the assessors*) working at LTH, and who have themselves been awarded the grade of ETP. These are appointed by the rector of LTH. This group of assessors also includes a representative appointed by the Students' Union at LTH and a pedagogical expert. The assessors read the portfolios and lead the interviews.

The opinion of *a scrutinizer* will also be appended to the statement of the assessors. This person must also have the grade of ETP. The scrutinizer will have access to the applicant's portfolio and other material submitted, and his or her task is to check the claims made therein. The scrutinizer writes a report which must be available to the assessors before the applicant is interviewed.

The assessors have the right to accept or reject the application. They can also refer it back to the applicant for supplementation. The result of the assessment together with feedback on the application is presented to the applicant at an individual meeting with the pedagogical expert.

2.6 Acceptance

Those applicants whose qualifications have been approved will receive a certificate of "*Excellent Teaching Practice*", signed by the rector of LTH. The lecturer will also receive an increase in salary, equivalent to that received by those obtaining a senior lectureship or readership (*docentur*), at present 140 Euro per month. The department at which the lecturer is employed will also receive additional funds.

Once awarded the grade of ETP, a lecturer cannot lose it, but is expected to continue to strive towards improved teaching practices. This places demands on those who have achieved this grade: apart from continuing to work on their own development, they should act as advisers for other lecturers contemplating application to the Academy, and as pedagogical partners in dialogues with others within their department. They should contribute in other ways to vitalising the pedagogical debate, and have the responsibility of spreading information on LTH's Pedagogical Academy. Furthermore, a lecturer who has been awarded the grade of ETP may be called upon in the future to be an assessor or a scrutinizer.

2.7 Criteria for Assessment

Communication with students is still the heart of all teaching, but to this are added a number of skills and qualities required for a university lecturer to obtain the grade of ETP. They are, the ability to cooperate with other lecturers, to have open discussions on one's own and other's experiences of teaching, the documentation of experience, regarding teaching as a means of providing students with the requisites for learning instead of a final product, and above all, to have the driving power to scrutinize one's own teaching and its effects with the aim of continuous improvement and thus the students' opportunity to learn.

To assess these skills, six criteria have been formulated. They are supported by the rapidly growing amount of literature on learning and teaching in the university environment (Ramsden, 1992; Bowden and Marton, 1999; Biggs and Collis, 1982; Biggs, 1999; Barr and Tagg, 1995; Ellström, 1996; McKeachie, 1999; Prosser and Trigwell, 1999; Trigwell, 2001).

The following criteria are to be made clear in the material submitted for assessment:

1. that the applicant bases his/her work on a learning perspective,

2. that the personal philosophy of the applicant constitutes an integrated whole, in which different aspects of teaching are described in such a way that the driving force of the applicant is apparent,

3. that a clear development over time is apparent. The applicant should, preferably, consciously and systematically have striven to develop personally and in pedagogical activities,

4. that the applicant has shared his or her experience with others, with the intention of vitalising the pedagogical debate,

5. that the applicant has cooperated with other lecturers in an effort to develop his or her teaching skills, and

6. that the applicant is looking to the future by discussing his or her future development, and the development of pedagogical activities.

The term *learning perspective* in the first criterion is essential to the Pedagogical Academy and the workshop is focused on this subject. Today, there is a great deal of literature available which describes the learning perspective and empirical research that confirms its advantages regarding the generation of students' learning (Barr and Tagg, 1995; Bowden and Marton, 1999; Ramsden, 1992). This means, briefly, that a lecturer, in the planning, execution and assessment of his or her teaching, focuses more on the *students' work* in the subject than on his or her own work, i.e. a focus on the students' encounter with that which is to be learnt. The opposite is usually described as the teaching perspective, where the focus is instead on the teaching, i.e. the lecturer's work, *what he or she does* in order for the students to learn something.

The second criterion focuses on the lecturer's own pedagogical philosophy. Applicants should take up aspects of their teaching activities and associated problems. Examples are examinations, motivation, communication, student responsibility, etc. As there are many possible aspects, the lecturer must choose a certain number. The aspects chosen should be connected with each other to reflect an integrated whole. This is equivalent to the fourth level of the SOLO taxonomy, "relational" (Biggs and Collis, 1982), and can thus constitute a description of the lecturer's understanding of what is happening in the teaching situation. This means that the chosen aspects should be organised relative to each other such that it is clear which is of greatest importance, and which is of less importance.

The third criterion perhaps corresponds most clearly to what Boyer (1990) and his followers mean by ”Scholarship of Teaching”, in the meaning that the lecturer demonstrates that he or she, over time, has worked on developing his or her technique as a teacher. This can be done in a number of ways, but the goal must always be that teaching supports learning. The development of teaching thus means that students learn better. Documentation describing the effects on students' learning should be enclosed.

The research community has demonstrated its ability to make results available for colleagues to scrutinize and build on for a long time. This assumes documentation of activities, the production of data on students' learning performance and a common way of expressing these things. Results from research into ”Scholarship of Teaching” show quite clearly that there is a demand from teachers for this kind of quality assurance in teaching (see e.g. Kreber, 2000), but it also shows that this practice is today the exception rather than the rule (Bain, 1999). Consequently, the fourth criterion is focused on how the applicant can refer to reports, journals, seminars or conferences in which, or at which, he or she has made public his or her experiences, and become engaged in a scrutinizing dialogue.

University teaching has been criticised by many for its lack of a connecting thought and context, from the point of view of the students (The Evaluation Office, Lund University, 2000). Furthermore, lecturers maintain that they lack support in their work (The Evaluation Office, Lund University, 1998). We can see nothing but positive effects arising from the cooperation of lecturers at LTH. This also includes experience of managing pedagogic activities. What is especially required in the fifth criterion is examples of cooperation between lecturers in different subjects or giving different courses. However, other activities in which work related to teaching is performed in collaboration with others may also be of importance.

CVs often relate to what a person has done. However, experience is of greatest value as guidance in future achievements and it should be natural for a good teacher to be contemplating ideas about what can be achieved in the future. The portfolio should thus, as described in the sixth criterion, include clear thoughts and ideas on future development, both for the applicant's own work and for the context in which the applicant is working. Another reason is the important role of the Pedagogical Academy to stimulate pedagogical development at LTH.

Finally, and most important, what is being rewarded is not the use of any particular pedagogical method, a special form of teaching or a simple quantitative enumeration of effort. Rather, reward is given to teachers who, in a reflective and open way, have worked to improve students' learning.

3 FINDINGS AND REFLECTIONS

The Pedagogical Academy was implemented during the autumn term of 2001. Each head of department nominated one lecturer from the department to be assessed in the first trial round. In this way, we gained an idea of what a good teacher at LTH is in relation to the given criteria. Furthermore, it provided an opportunity to test the criteria and the procedures. It also provided LTH with a group of ETP lecturers. These lecturers (20 persons) now form the core of the groups that will assess new applicants in the future. In this trial round, the group of lecturers that developed the Pedagogical Academy assessed the pilot group of candidates.

3.1 Experience of Implementation

Two factors have been found to be critical in the process of implementation of the pedagogical academy. Firstly, a sense of ownership by the academic system itself must be created. This has been secured through the involvement of all the heads of departments and a widespread understanding that the assessment is done by colleagues. It is also very important that lecturers representing different departments at the faculty developed the Academy. Secondly, there must exist a well-established view that pedagogy can help teachers improve their teaching. This is secured through a long tradition of extensive, much appreciated and well attended pedagogical courses.

The findings so far, based on the experiences from the pilot group are:

- The tradition of *how* a subject is taught seems to affect lecturers a great deal. Teaching at universities is traditionally an individual performance and traditions also affect cooperation and discussion where teaching is concerned.

- Many lecturers do not use educational terminology when they describe their teaching. Their own descriptions indicate that they move between different social contexts. Thinking and doing are connected to their research fields and educational terminology is not linked to this. However, the differences between individuals are significant.

- Documentation surrounding scholarly teaching is not systematic. Lecturers are not used to document teaching activities mainly because of lack of motivation in the past.

The teaching conditions differ considerably between basic scientific subjects and courses in comparison with applied engineering courses. The size of a course, the number of students attending a course and the position within the curriculum are other factors of major importance.

3.2 Evaluation of the Pedagogical Academy

The clearest indication of the success of this project is a high degree of interest among LTH's lecturers in applying to the Academy. The first application to the workshop after the trial round resulted in more than twice the number of applicants than could be admitted.

Attracting interest from outside LTH would be another criterion for success. Other faculties at Lund University, other universities in Sweden and abroad and engineering journals have already shown interest in the Pedagogical Academy. Present and presumptive students and lecturers should be aware that a professional attitude to teaching is encouraged and rewarded at LTH.

An extensive evaluation of the effects of the Academy within the faculty will be performed later.

4 CONCLUDING REMARKS

The pedagogical academy was developed to stimulate and reward scholarly teaching and to afford status to the pedagogical development at LTH.

Lecturers wishing to apply to the Pedagogical Academy should attend the workshop "How to write a teaching portfolio", submit a teaching portfolio together with a recommendation of their head of department and take part in an interview. Presently 40 lecturers have participated in the assessment procedure. The project has so far been very successful and some implications and reasons for this are discussed below.

Writing a teaching portfolio has increased many teachers' interest in reaching a better understanding of what actually happens in the process of teaching. It has also increased their interest in developing as teachers.

The focus on pedagogical issues at the faculty has increased. The number of lecturers attending pedagogical courses has risen considerably. The criteria for assessment are used as a starting point for discussions at departments, between lecturers, at conferences and meetings etc. This is especially satisfying in the process of convincing more lecturers to adopt a learning perspective in their teaching activities. The Pedagogical Academy has already stimulated new networks of lecturers sharing a mutual interest and competence in pedagogical issues.

5 REFERENCES

Abrahamsson, B. (2001). *Careers Through Promotion and Recruiting*, (in Swedish), The National Agency for Higher Education, Stockholm

Apelgren, K. and Giertz B. (2001). *Teaching Portfolios*, (in Swedish), Uppsala University, Uppsala

Bain, J. D. (1999). *Introduction to HERD's Special Issue Concerning Evaluation for Learning.* Higher Education Research & Development, 18(2)

Barr, R., B. and Tagg J. (1995). *From Teaching to Learning – A New Paradigm for Undergraduate Education.* Change (Nov/Dec) 13-25

Biggs, J. (1999). *Teaching for Quality Learning at University,* Society for Research into Higher Education & Open University Press

Biggs, J. B. and Collis K. F. (1982). *Evaluating the Quality of Learning: The SOLO Taxonomy,* Academic Press, New York

Bowden, J. and Marton F. (1999). *The University of Learning,* Kogan Page

Boyer, E., L (1990). *Scholarship Reconsidered. Priorities of the Professoriate*, The Carnegie Foundation, New Jersey

Ellström, P.-E. (1996). *Routine and reflection. Prerequisites and Prevention of Learning in Daily Work, Life-long Learning*, (in Swedish), P.-E. Ellström, B. Gustavsson and S. Larsson, pp 142 -179, Studentlitteratur, Lund

Fransson, A. and Wahlén S. (2001). *New Conditions for Learning in Higher Education*, SOU 2001:1. Stockholm

Healey, M. (2000). *Developing the Scholarship of Teaching in Higher Education: a Discipline-based Approach.* Higher Education Research & Development, 19(2)

Karolinska Institute (2001). *Teaching Portfolios for Lecturers at the Karolinska Institute*, Stockholm, 2001

Kreber, C. (2000). *How University Teaching Award Winners Conceptualise Academic Work: some Further Thought on the Meaning of Scholarship.* Teaching in Higher Education, 5(1)

Magin, D. J. (1998). *Rewarding Good Teaching: a Matter of Demonstrated Proficiency or Documented Achievement.* International Journal for Academic Development, 3(4)

McKeachie, W., J. (1999). *Teaching Tips. Strategies, Research, and Theory for College and University Teachers.* Boston, Houghton Mifflin

Prosser, M. and Trigwell K. (1999). *Understanding Learning and Teaching. The Experience in Higher Education*, The Society for Research into Higher Education & Open University Press

Ramsden, P. (1992). *Learning to Teach in Higher Education,* Routledge

Seldin, P. (1997). *The Teaching Portfolio. A Practical Guide to Improved Performance and Promotion/Tenure Decisions.* Bolton, MA, Anker Publishing Company, Inc.

The Evaluation Office, Lund University (1998). *The Teacher Barometer*, (in Swedish) 1998, Lund

The Evaluation Office, Lund University (2000). *The Student Barometer*, (in Swedish) 2000, Lund

Trigwell, K., Martin E. et al. (2000). *Scholarship of Teaching: a Model.* Higher Education Research and Development, 19(2)

Trigwell, K. (2001) *Judging University Teaching.* International Journal for Academic Development, 6(1)

This paper is published in Rust C. (Ed.), Improving Student Learning: Theory and Practice – 10 years on, pp 307-314, The Oxford Centre for Staff and Learning Development, 2003

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VIII

The Pedagogical Academy – Going Public as a Formative Assessment of Scholarship

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4th International Conference on the Scholarship of Teaching and Learning, May 13 and 14, 2004, City University, London

Conference Theme: 'Going Public' – traditional and non-traditional approaches to the Scholarship of Teaching and Learning

Biographical Statement

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Abstract

Scholarship should permeate all major parts of faculty work (Boyer, 1990) – be it teaching, research or service – and it is essential for the concept of the University of Learning (Bowden and Marton, 1998). Sharing our knowledge by making it public is an important and indispensable aspect of the scholarship of teaching and learning. If faculty do not embrace and practice scholarship within the area of teaching and learning important and innovative work will continue to be private and undocumented, not available for scholarly peer review, scrutiny and feedback, not made public in a form others can build on, and consequently lost to the academic community.

The Pedagogical Academy is a model for rewarding excellent teaching that has been developed at the Faculty of Engineering at Lund University. In the process of application candidates submit pedagogical portfolios that are peer reviewed and assessed against six formulated criteria (Hammar Andersson, Olsson *et al.*, 2003).

We studied the process of rewarding excellent teaching by triangulating the analyses of qualitative data including *documents* (pedagogical portfolios, letters of recommendation by department heads, reviewers' reports and judgement protocols), *video-recorded observations* (of interviews that a group of assessors had with each applicant and their internal discussions before and after each interview) and *in-depth interviews* (with strategically chosen applicants and assessors). Kreber (2002) proposed a taxonomy describing excellence, expertise and scholarship in teaching. We used this model to characterize the aims and criteria that constitute the pedagogical academy as well as to characterize individual applications and their assessment process.

Preliminary results indicate variation in the ways and levels applicants go public. This applies to purpose and venue; methods of peer review, scrutiny and feedback, as well as format for others to build on. The nature of the material that applicants go public with does not always contribute to the scholarship of teaching and learning. The assessment procedure mainly focuses on teaching expertise and scholarship while teaching excellence is presumed and taken for granted. This might constitute a legitimacy problem among colleagues.

Important questions that we will discuss include: At what level should teachers have to go public in order for us to reward it as scholarship of teaching and learning? How do we assess teaching expertise and scholarship of teaching and learning without taking teaching excellence for granted? Is it correct to assume that teaching expertise and scholarship of teaching and learning include teaching excellence?

The Pedagogical Academy has stimulated a public discourse on the development of teaching as a scholarly activity. This will orient more teachers towards the scholarship of teaching and learning and increase the public knowledge base of teaching and learning and eventually improve student *and* faculty learning.

References

Boyer, E., L. (1990). *Scholarship Reconsidered. Priorities of the Professoriate*, The Carnegie Foundation, New Jersey

Bowden, J. and Marton, F. (1998). *The University of Learning*, Kogan Page

Hammar Andersson, P., Olsson, T., Almqvist, M., Zetterqvist, L., Axelsson, A., Olsson, G. and Roxå, T. (2003). *The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching*, In Rust, C. (Editor), Improving Student Learning: Theory and Practice – 10 years on, pp. 307-314, The Oxford Centre for Staff and Learning Development

Kreber, C. (2002). *Teaching Excellence, Teaching Expertise, and the Scholarship of Teaching*, Innovative Higher Education, Vol. 27, No. 1

IX

Excellent Teaching Practice – ett forsknings-projekt kring LTHs Pedagogiska Akademi

Lotta Antman, Shirley Booth, Pernille Hammar Andersson och Thomas Olsson

***Sammanfattning*—Ett viktigt syfte med den Pedagogiska Akademin är att bidra till att lärare inom LTH utvecklar ett forskande förhållningssätt till sin undervisning. Vidare skall Akademin verka för att ett paradigmskifte kommer till stånd inom den pedagogiska verksamheten vid LTH, från ett undervisnings- till ett lärandeperspektiv. Den Pedagogiska Akademin har redan bidragit till ökad medvetenhet om pedagogiska frågor och placerat undervisningen i fokus på ett sätt som rönt mycket stort intresse, såväl nationellt som internationellt. Den forskning som bedrivs inom detta projekt, speciellt kring antagnings- och bedömningsprocessen, syftar till att ge underlag för ett utvecklingsarbete som skall leda till en ännu bättre Pedagogisk Akademi och därmed förstärka profilen av LTH som en pedagogisk teknisk högskola.**

***Nyckelord*—Bedömning av pedagogiska meriter, pedagogisk kompetensutveckling, pedagogisk portfölj, premiering av pedagogisk kompetens**

I. Inledning

LTHs Pedagogiska Akademi utvecklades av en grupp lärare tillsammans med en pedagogisk konsult under 2000-2001 [1]. Det övergripande syftet är att utveckla en teknisk högskola som systematiskt satsar på pedagogisk kvalitet genom att ge ökad status åt den pedagogiska verksamheten. Detta sker genom att premiera lärare och institutioner som medvetet och systematiskt utvecklat sin pedagogiska kompetens. Ett mer långsiktigt mål är att stimulera till ett paradigmskifte där LTHs pedagogiska fokus förändras från ett undervisningscentrerat till ett lärandecentrerat perspektiv [2, 3, 4, 5]. Hittills har ca 50 lärare antagits till den Pedagogiska Akademin och erhållit kompetensgraden *Excellent Teaching Practice*. Det finns ett stort behov av, och intresse för, att beforska denna djärva satsning. Genombrottet och Lärande Lund samarbetar i detta forskningsprojekt som syftar till att synliggöra de olika perspektiv på lärande som framträder i antagningsprocessen, speciellt i kriterierna, i de sökandes pedagogiska portföljer och i själva bedömningsproceduren omfattande granskning, intervju och slutligt omdöme [6, 7, 8].

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II. Den pedagogiska akademin

A. Antagnings- och bedömningsprocess

Lärare som ansöker till den Pedagogiska Akademin lämnar in en pedagogisk portfölj för bedömning mot vissa antagningskriterier (se II B). Den pedagogiska portföljen består dels av en beskrivning av lärarens pedagogiska filosofi och dels exempel från den pedagogiska verksamheten som stödjer och underbygger den pedagogiska filosofin.

Den pedagogiska portföljen, tillsammans med en rekommendation av den sökandes prefekt, en CV med särskild avdelning för pedagogisk verksamhet och ett utlåtande från en granskare utgör de handlingar som bedöms av en bedömargrupp. Bedömargruppen intervjuar också varje sökande och är den som i sista hand godkänner eller avslår ansökan (eller återsänder den för komplettering).

B. Antagningskriterier

De kriterier som hela antagnings- och bedömningsprocessen till den Pedagogiska Akademin bygger på är [1]:

1. att den sökande i sin verksamhet utgår från ett lärandeperspektiv,
2. att den personliga filosofin är en integrerad helhet där olika aspekter av pedagogisk verksamhet är beskrivna på ett sådant sätt att också den sökandes personliga drivkraft blir synlig,
3. att en klar utveckling över tid syns. Den sökande skall, helst medvetet och systematiskt, ha strävat efter att utveckla både sig själv som lärare och sin pedagogiska verksamhet,
4. att den sökande delat sina erfarenheter med andra i syfte att vitalisera den pedagogiska diskussionen,
5. att den sökande samverkat med andra lärare i strävan att utveckla sin pedagogik samt
6. att den sökande orienterar sig mot framtiden genom att beröra framtida utveckling för egen del och för den egna pedagogiska verksamheten.

III. Problemformulering och vetenskaplig metodik

Vi använde en fenomenografisk ansats [9] för att studera det komplexa fenomen som processen att premiera pedagogisk kompetens utgör. Genom triangulering av empiriska kvalitativa data omfattande *dokument*, *videofilmade observationer* och *djupintervjuer* kunde vi närma oss fenomenet ur flera olika vinklar. Viktiga aspekter att studera var målen för den Pedagogiska Akademin, antagningskriterierna och antagningsprocessen samt bedömningsproceduren.

Dokumenten omfattade de sökandes pedagogiska portföljer, prefekters rekommendationsbrev, utlåtanden från granskare och de slutliga bedömningsprotokollen. Videoinspelningarna omfattade bedömargruppens intervjuer med de sökande samt bedömargruppens interna diskussioner före och efter respektive intervju. Djupintervjuer gjordes med strategiskt utvalda sökande och bedömare, personer som vi nu visste hade uppfattat antagningsprocessen på olika sätt och som representerade olika perspektiv på lärande.

IV. Scholarship of Teaching and Learning

A. *Forskning och undervisning – aspekter av samma sak*

Akademiskt arbete vid ett universitet innebär ett ständigt problematiserande av olika metoder och infallsvinklar inom forskning och undervisning. Man söker efter bättre lösningar eller förklaringar på olika frågeställningar. Ett forskande förhållningssätt utgör själva kärnan inom allt akademiskt arbete – självklart så även inom undervisningen. I den högskolepedagogiska forskningen uppmärksammas detta allt mer som en förutsättning även för pedagogisk utveckling.

Lärande är den gemensamma nämnaren för såväl forskning som undervisning. Bowden och Marton [10] talar om lärande på kollektiv respektive individuell nivå. Kunskapen är ny för den som ska lära sig något och den avgörande skillnaden mellan forskning och undervisning i detta avseende är att inom forskningen är lärandet nytt inte bara för individen utan även för hela vetenskapssamhället.

Boyer [11] ansåg att forskning och undervisning utgör olika aspekter av ”scholarship”. Han breddade begreppet till att omfatta all akademisk kärnverksamhet som bedrivs vid ett universitet och införde begreppen ”scholarship of discovery” som närmast motsvarar traditionell forskning, ”scholarship of integration” som omfattar tvärdisciplinär verksamhet, ”scholarship of application” som orienterar sig utanför universitetet och även innefattar delar av den tredje uppgiften samt ”scholarship of teaching” som är den pedagogiska verksamheten. Huvudtanken i denna teoribildning är att ha ett vetenskapligt förhållningssätt inom all akademisk verksamhet.

B. *Taxonomi för karakterisering av pedagogisk verksamhet*

En annan modell med bärighet för den Pedagogiska Akademin är en taxonomi som presenteras av Kreber [12]. I den beskrivs ”Teaching Excellence”, ”Teaching Expertise” och ”Scholarship of Teaching and Learning” inom lärares pedagogiska verksamhet. Vi har använt modellen för att karakterisera mål och antagningskriterier för den Pedagogiska Akademin och även individuella ansökningar och hur dessa bedömts.

”Teaching Excellence” innebär att lärarens undervisning stödjer studenternas lärande på ett utmärkt sätt men att det sker oreflekterat och utan teoretisk referensram. ”Teaching Expertise” omfattar den föregående nivån vad gäller undervisningens kvalitet men här har läraren även omfattande reflekterade kunskaper hämtade från det högskolepedagogiska kunskapsfältet. ”Scholarship of Teaching and Learning” bygger på de två föregående nivåerna och innebär att läraren dessutom och därutöver delar med sig av sina erfarenheter och kunskaper i form av artiklar, konferensbidrag, seminarier etc. På denna nivå har läraren ett vetenskapligt förhållningssätt till undervisning innefattande peer review, granskning och feedback och bidrar själv aktivt till kunskapsuppbyggnaden inom det högskolepedagogiska fältet och sitt eget ämnesdidaktiska fält.

V. Resultat och slutsatser

Studien visar att det bland de sökande finns kvalitativt skilda sätt att beskriva sin pedagogiska verksamhet i den pedagogiska portföljen.

De sex kriterier som formulerats för antagning till den Pedagogiska Akademin har stor genomslagskraft på såväl sökande som bedömare. Det finns viss risk att själva formuleringarna, vilka subtilt uppmuntrar till att sätta sig själv i fokus, styr de sökande mot att skriva lärarcentrerade portföljer trots att det första kriteriet uttryckligen uppmanar till ett lärandeperspektiv. Kriteriernas utformning påverkar naturligtvis även bedömarna som i vissa fall svarat an genom att fokusera detaljerna i portföljen, dvs. vad läraren gjort och hur lärandekontexten sett ut, utan att nödvändigtvis relatera detta till studenternas lärande.

Bedömningsprocessen är utformad enligt peer review modellen där lärare som tidigare erhållit kompetensgraden *Excellent Teaching Practice* nu bedömer sina kollegors pedagogiska portföljer. Den bärande idén bakom intervjun med bedömargruppen är att den skall ge en bild av den sökandes förmåga att muntligt kommunicera de saker som tagits upp i den pedagogiska portföljen. Intervjuns roll i en akademisk peer review process kan dock ifrågasättas då fokus i alltför stor utsträckning kan komma att inriktas mot den sökandes person i stället för mot innehållet i portföljen.

Det finns en tendens att sökande, som i sin pedagogiska portfölj fokuserat ämnesdidaktiska frågeställningar, haft svårt att vinna gehör för detta i bedömningsprocessen. Det kan bero på att kriterierna fokuserar kring pedagogisk verksamhet utan att direkt nämna relationen till ämnet eller till studenternas lärande i ämnet. Detta kan ses som en svaghet eftersom såväl pedagogisk verksamhet som vetenskapligt arbete alltid sker i relation till ett innehåll.

Det verkar finnas ett gap mellan bedömningsprocessen som praktiserad handling och den högskoleteoretiska teoribildning man lutat sig mot vid dess tillkomst. Precis som i all situerad verksamhet kunde vi även här se tendenser till hur makt, social status och tradition inom universitetet påverkade processen.

Hela antagningsprocessen är till sin natur kvalitativ. Trots detta bedöms de sökande enligt en kvantitativ betygsskala från 1 till 10 där minst 5 krävs på varje kriterium för att bli godkänd. Detta upplevs inte som ett större problem av dem som är involverade i processen, varken som sökande eller bedömare, men leder ändå till ett kvantifierande förhållningssätt vid bedömning där utgångspunkten är betygen och inte den kvalitet som framträder i portföljen.

Forskningsprojektet bör leda till att kriterierna omformuleras för att bättre överensstämma med det uttryckta lärandeperspektivet. Det förefaller vidare mycket viktigt att bedömningsproceduren revideras utifrån de bättre grunder för antagning som framkommit genom kategoriseringen av de sökandes perspektiv på lärande. I dagsläget framstår det som oklart vilken kompetensnivå (enligt Kreber [12]) som efterfrågas av en sökande till den Pedagogiska Akademin. Ifall vi eftersträvar nivån ”Scholarship of Teaching and Learning” måste detta tydliggöras och bedömningen utformas i enlighet med detta.

REFERENSER

[1] Hammar Andersson, P., Olsson, T., Almqvist, M., Zetterqvist, L., Axelsson, A., Olsson, G., Roxå, T. (2003). *The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching*, In Rust, C. (Editor), Improving Student Learning: Theory and Practice – 10 years on, The Oxford Centre for Staff and Learning Development.

[2] Barr, R., B. & Tagg J. (1995). *From Teaching to Learning – A New Paradigm for Undergraduate Education*. Change (Nov/Dec) 13-25.

[3] Trigwell, K., Martin E., Benjamin, J., Prosser, M. (2000). *Scholarship of Teaching: a Model.* Higher Education Research and Development, 19(2).

[4] Trigwell, K. (2001). *Judging University Teaching*. International Journal for Academic Development, 6(1)

[5] Prosser, M. & Trigwell K. (1999). *Understanding Learning and Teaching. The Experience in Higher Education*, The Society for Research into Higher Education & Open University Press.

[6] Antman, L., Booth, S., Hammar Andersson, P., Olsson, T. (2004). *The Pedagogical Academy – Qualitative Research on the Process of Rewarding Scholarly Teaching*. SEFI 2004 Annual Congress. The Golden Opportunity for Engineering Education?, Valencia, September 2004 (accepterad).

[7] Antman, L., Olsson, T., Hammar Andersson, P., Booth, S. (2004). *Rewarding Excellent Teaching – in Theory and Practice. Characterising the Gap*. 12th International Improving Student Learning Symposium: Diversity and Inclusivity, The Oxford Centre for Staff and Learning Development, Birmingham, September 2004 (accepterad).

[8] Olsson, T., Antman, L., Roxå, T., Hammar Andersson, P., Booth, S. (2004). *The Pedagogical Academy – Going Public as a Formative Assessment of Scholarship*. 4th International Conference on the Scholarship of Teaching and Learning, City University, London, Maj 2004.

[9] Marton, F. & Booth, S. (1997). *Learning and Awareness*, Mahwah NJ: Lawrence Erlbaum Associates.

[10] Bowden, J. & Marton F. (1999). *The University of Learning*, Kogan Page.

[11] Boyer, E., L. (1990). *Scholarship Reconsidered. Priorities of the Professoriate*, The Carnegie Foundation, New Jersey.

[12] Kreber, C. (2002). *Teaching Excellence, Teaching Expertise, and the Scholarship of Teaching*, Innovative Higher Education, Vol. 27, No. 1.

X

Opening Dimensions of Variation: A two-dimensional matrix model for analysing scholarly approaches to teaching and learning

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Abstract

The Pedagogical Academy is a model for rewarding teaching competence, developed at Lund Institute of Technology (LTH). Teachers wishing to enter submit a pedagogical portfolio for assessment and successful applicants are awarded the title *Excellent Teaching Practitioner*. The Pedagogical Academy was developed to afford status to pedagogical development and to bring about a paradigm shift at LTH, to change the focal point from teaching to learning (Barr & Tagg 1995). An important objective is to stimulate and encourage teachers to develop a scholarly approach to teaching and student learning (Boyer 1990). This is also in line with official staff development strategies and visions for LTH as a faculty with pedagogical development in focus.

The assessment criteria focus on three important areas:

- a clear focus on student learning,
- a clear development over time, and
- a scholarly approach to teaching and learning.

In a developmentally oriented research project on the Pedagogical Academy we developed a two-dimensional matrix model as an important qualitative tool to be used in the process of assessing teaching competence. The research was based on documents, observations and interviews which were interpreted in light of didactic theory and research in higher education. In order to open up dimensions of variation (Booth & Hultén 2003) in teaching competence the model is based on the following two dimensions: the *degree of holistic analysis*, varying from atomistic to holistic, and the *degree of scholarly approach* varying from un-reflected to reflected.

The didactic triangle is a model for analysing teaching that comprises the teacher, the student and the subject as the nodes of a triangle. We used the triangle to visualise teachers' perspectives on teaching and learning in the application process to the Pedagogical Academy. The difference in focus – on nodes, relations, or wholes – allowed us to distinguish between a teaching perspective and a learning perspective. Didactic theory was thus adopted to examine the degree of holistic thinking, the first dimension of the model, and to distinguish between levels of complexity in pedagogical reasoning. In the second dimension of the model, mainly based on Kreber (2002), the degree of reflectivity could be examined and levels of scholarship in pedagogical action could

be discriminated. This enabled us to effectively distinguish between intuitive practice, reflective practice and scholarly practice.

The model, as a whole, enables us to argue for the Scholarship of Teaching and Learning as an integral part of a true learning perspective. This makes it useful also in other contexts of higher education, such as teacher appointments committees and qualitative undergraduate assessment.

References

Barr, R., B. & Tagg, J. (1995). From Teaching to Learning – A New Paradigm for Undergraduate Education. *Change* (Nov/Dec) 13-25

Booth, S. & Hultén, M. (2003). Opening dimensions of variation: An empirical study of learning in a Web-based discussion. *Instructional science*, Vol. 31, pp 65-86

Boyer, E., L. (1990). *Scholarship Reconsidered. Priorities of the Professoriate*, The Carnegie Foundation, New Jersey

Kreber, C. (2002). Teaching Excellence, Teaching Expertise, and the Scholarship of Teaching, *Innovative Higher Education*, Vol. 27, No. 1

XI

Utforskning av undervisning och lärande med vetenskapliga metoder

Thomas Olsson

I. Inledning

Universitetets huvuduppgift i samhället är lärande. Såväl forskning som undervisning innebär sökande efter kunskap där lärande utgör den centrala aktiviteten. Forskning och undervisning är alltså olika aspekter av samma sak och är till sin natur utforskande verksamheter.

Undervisningen vid ett universitet skall skapa goda förutsättningar för lärande genom att på bästa sätt organisera studentens möte med det som skall läras. Detta omfattar olika metoder för att bl. a. motivera, inspirera, vägleda, handleda och examinera studenten. Allt med målet att generera lärande på hög kvalitativ nivå.

Forskningsanknytning av undervisningen utgör ett signum för god kvalitet inom den högre utbildningen. Men är det samma sak som vetenskapligt baserad undervisning? Och vad menas med de inom universitetspedagogiken ofta använda begreppen ”scholarly teaching” respektive ”scholarship of teaching”?

II. Scholarship of teaching

Ernest L. Boyer [1] framförde 1990 i en numera klassisk rapport, *Scholarship Reconsidered*, åsikten att vi måste komma bort från den gamla debatten om forskning gentemot undervisning. Boyer anser att begreppet vetenskap (scholarship) måste breddas och omfatta all kärnverksamhet som bedrivs vid ett universitet. Han införde begreppen ”scholarship of discovery”, ”scholarship of integration”, ”scholarship of application” samt ”scholarship of teaching”.

”Scholarly teaching” kan sägas vara undervisning som påverkas positivt av lärarens forskningsområde och som drar nytta av forskning och utveckling om lärande och undervisning. ”Scholarship of teaching” omfattar därutöver sådana aktiviteter som egna studier av hur studenter lär och hur och under vilka förutsättningar vi undervisar, egen reflektion kring undervisning och lärande med koppling till den universitetspedagogiska litteraturen, delgivande av egna erfarenheter till vetenskapssamhället (genom seminarier, konferenser, publicering i tidskrifter etc.) vilket möjliggör för andra att bygga vidare på dessa erfarenheter, samarbete med kollegor inom undervisningen samt offentlig kollegial granskning (peer review) av den pedagogiska verksamheten. Centralt och kopplat till alla aktiviteter är naturligtvis tillämpningen av erhållna resultat i praktisk undervisning för främjande av studenternas lärande.

Under utvecklingen av LTH:s pedagogiska akademi har begreppet ”scholarship of teaching” varit vägledande och det täcks väl in av de sex olika kriterierna som måste uppfyllas för att erhålla kompetensgraden *Excellent Teaching Practice* (ETP) [2].

En av de aktiviteter som beskrivits ovan är egna vetenskapligt baserade studier av hur studenter lär och hur och under vilka förutsättningar vi undervisar. Ofta måste man då använda metoder som inte är så vanliga inom teknisk och naturvetenskaplig forskning och undervisning.

III. Vetenskapsteoretiska ansatser

Studier inom naturvetenskap och teknik syftar oftast till att finna förklaringar. Forskningen är objektorienterad och bygger till största delen på ett positivistiskt vetenskapsteoretiskt angreppssätt.

Om vi önskar studera olika aspekter av undervisning och lärande är målet med studierna en ökad förståelse. Forskningen är subjektorienterad och bygger oftast på olika humanvetenskapliga angreppssätt. Man söker kunskap om åsikter, uppfattningar, upplevelser, känslor, innebörder, kommunikation etc. Några exempel på vetenskapsteoretiska angreppssätt är hermeneutik (förståelse genom tolkning), fenomenologi (vi erfar omgivningen genom att erfara fenomen), fenomenografi (kvalitativt skilda sätt att uppfatta ett fenomen), innehållsanalys (analys av innehållet i texter av olika slag), etnografi (sociala och kulturella strukturer och processer) och aktionsforskning (förändra – studera – förändra – osv.).

Vilka grundläggande vetenskapliga antaganden (paradigm) man som forskare utgår från styr metodvalet och kan variera beroende på vad man vill undersöka. Man kan urskilja många olika dimensioner i ett vetenskapligt arbete: atomistiskt (reduktionistiskt) eller holistiskt synsätt, kvantitativa eller kvalitativa metoder, empirism eller rationalism, induktion eller deduktion. Mycket förenklat kan man säga att naturvetenskaplig forskning oftast är kvantitativ och bygger på ett reduktionistiskt synsätt medan forskning om undervisning och lärande oftare är kvalitativ och omfattar en holistisk helhetssyn.

Insamling av de data som behövs för att bedriva en viss forskningsstudie kan ske på olika sätt och beror i hög grad på vilken ansats man utgår från. Kvantitativa tekniker omfattar direkta mätningar (vanligast inom naturvetenskaplig forskning), indirekta mätningar (exempelvis mätningar av kunska-

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per eller uppfattningar med strukturerade enkäter eller strukturerade intervjuer) och strukturerade observationer av skeenden eller beteenden. Kvalitativa tekniker omfattar ostrukturerade (öppna) intervjuer eller enkäter, ostrukturerade (öppna) observationer och dokumentstudier. Oberoende av hur datainsamlingen utförs måste vi ställa höga krav på validitet (vad vi mäter) och reliabilitet (hur tillförlitlig mätningen är).

Den vetenskapsteoretiska litteraturen är mycket omfattande. Det finns emellertid flera lättillgängliga introducerande böcker på svenska [3], [4].

IV. EXEMPEL PÅ STUDIER AV UNDERVISNING OCH LÄRANDE

A. Tillämpningar av SOLO taxonomin [5]

Projektet omfattar undersökningar av kvalitativa aspekter på undervisning och examination inom högskoleingenjörsutbildningen i kemiteknik.

Några frågeställningar som behandlas är: Hur är uppgifterna vid skriftliga tentamina inom programmet utformade? Är de formulerade så att det är möjligt att nå de högre nivåerna i SOLO taxonomin? Vad är viktigt vid utformningen av tentamensuppgifter?

Hur formulerar man kriterier för olika SOLO nivåer för öppna teoretiska och utredande uppgifter? Skiljer sig resultaten vid skriftliga och muntliga tentamina åt?

Hur kan man analysera en undervisningsmetod med avseende på kvalitativ inlärning? Hur klassificerar man olika problemlösningsstrategier med hjälp av SOLO taxonomin?

B. Examination av färdigheter och kreativitet [6]

De flesta kurser i en kemiteknisk utbildning innehåller laborativa inslag. Dessa examineras normalt formativt på laboratoriet. Studenterna lämnar in rapporter och får en direkt återkoppling från läraren. Detta är mycket viktigt och värdefullt. Summativ examination av praktiska färdigheter förekommer sällan inom olika ingenjörsutbildningar. En summativ examination av färdigheter kan vara av stor betydelse för att få studenterna att fokusera på utbildningens färdighetsmål. Projektet behandlar utvecklingen av en modifierad OSCE metod (används inom medicinska utbildningar) för examination av färdigheter i kemisk apparatteknik. Kvalitativa metoder används för att studera olika resultat av förändringen.

C. Reflekterande examination och erfarenhetslärande [7]

Kan utformningen av examinationen öka studenternas förmåga att integrera icke-tekniska färdigheter med övriga kurser i utbildningen? Resultatet från detta projekt är en kombination av formativa färdighetsexaminationer och en summativ reflekterande examination. En sådan examination påverkar erfarenhetslärandet (enligt Kolb) och ökar studenternas förmåga att integrera olika kompetenser. Just kombinationen av examinationsmetoder påverkar Kolbs inlärningscykel. Formativa färdighetsexaminationer ger flera konkreta erfarenheter som studenterna funderar över och befäster genom reflektion och abstrakt tänkande i den summativa examinationen. Ett aktivt handlande och planerande sker när nya färdigheter integreras och tillämpas i olika kurser inom programmet vilket i sin tur leder till nya konkreta erfarenheter och så vidare.

D. Reflektion och utvärdering [8]

Studenter som reflekterar över sitt eget lärande på ett strukturerat och kreativt sätt kommer troligen att nå högre kvalitativa nivåer och ett mer djupinriktat lärande.

Detta projekt visar hur en reflekterande sammanfattning som en del av examinationen i en kurs också kan utgöra ett komplement till traditionella kursvärderingar. De reflekterande sammanfattningarna innehåller både en kognitiv (studenter reflekterar över kunskaper och färdigheter) och en metakognitiv (studenter reflekterar över lärande) dimension. I de flesta fall finner man också kursvärderande aspekter i texterna.

Resultaten indikerar att studenter kan vara mycket positiva till det lärande som en kurs genererat samtidigt som de är kritiska i den traditionella kursvärderingen. Detta är viktigt att undersöka vidare eftersom målet med alla undervisningsaktiviteter är lärande på hög kvalitativ nivå.

V. AVSLUTANDE REFLEKTION

De beskrivna studierna utgör några exempel på en av de olika aspekter som omfattas av begreppet ”scholarship of teaching”. Ökad kunskap om hur lärande genereras och påverkas av undervisningen bidrar till kvalitativt bättre lärande och därmed en bättre utbildning eftersom vår kunskap om hur vi skall organisera studentens möte med ämnet ökar.

REFERENSER

[1] Boyer, E. L., *Scholarship Reconsidered. Priorities of the Professoriate*, The Carnegie Foundation for the Advancement of Teaching, Princeton University Press, 1990.

[2] Hammar Andersson, P., Olsson, T., Almqvist, M., Zetterqvist, L., Axelsson, A., Olsson, G. och Roxå, T., *The Pedagogical Academy – a Way to Encourage and Reward Scholarly Teaching*, 10th International Improving Student Learning Symposium, Bryssel, 2002, Rust, C. (Editor), Improving Student Learning: Theory and Practice -10 years on, The Oxford Centre for Staff and Learning Development, 2003 (september).

[3] Wallén, G., *Vetenskapsteori och forskningsmetodik*, Studentlitteratur, 1996

[4] Patel, R. och Davidsson, B., *Forskningsmetodikens grunder. Att planera, genomföra och rapportera en undersökning*, Studentlitteratur, 1994

[5] Olsson, T., *Qualitative Aspects of Teaching and Assessing in the Chemical Engineering Curriculum – Applications of the SOLO Taxonomy*, 7th International Improving Student Learning Symposium, University of York, 1999, Rust, C. (Editor), Improving Student Learning Through the Disciplines, sid. 304-324, The Oxford Centre for Staff and Learning Development, 2000

[6] Olsson, T., *Assessment of Experimental Skills and Creativity Using a Modified OSCE-method – a Summative Performance-Based Examination in Chemical Engineering*, 9th International Improving Student Learning Symposium, Heriot-Watt University, Edinburgh, 2001, Rust, C. (Editor), Improving Student Learning Using Learning Technologies, sid. 310-323, The Oxford Centre for Staff and Learning Development, 2002

[7] Olsson, T., *A Combined Formative Performance Assessment and Summative Reflective Assessment Fostering Experiential Learning and Integration in an Engineering Curriculum*, International Research Conference - Learning Communities and Assessment Cultures: Connecting Research with Practice, University of Northumbria/Earli Special Interest Group on Assessment and Evaluation, Newcastle, 2002, Publicerad på: Educat*ion-line*, Brotherton Library, University of Leeds, http://www.leeds.ac.uk/educol/, 2002

[8] Olsson, T., *Evaluative Aspects of a Reflective Summative Assessment*, Earli (European Association for Research on Learning and Instruction) 10th Biennial Conference: Improving Learning, Fostering the Will to Learn, Padova, 2003 (accepterad)

XII

Sustainability and survival – analysing examination processes as conditions for students' and teachers' work in higher education

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Abstract

Examination in higher education is a complicated and manifold business involving university culture, formal rules, teachers' professional knowledge and students' learning efforts and fears of failing. In Sweden, as in many other European countries, the Bologna process will change the preconditions for assessment thoroughly. In a previous project the changes in assessment practices in five different university courses were described (Lindberg-Sand, 2005). These practices are normally slowly changing processes deeply embedded in a discipline-oriented teaching culture.

In a recently started project the aim is to research the structure of the examination system in different university programs and to describe the interplay between the formal classification of assessments and the development of students' and teachers' work in the different courses. A further future aim is also to follow the changes induced by the Bologna process in the programs.

The conceptual frame-work for the project lies in combining different strands of social practice theory. The formal aspects of assessments will be viewed as classification systems (Bowker & Star, 1999). These are also working as boundary objects in relation to different expert systems (Giddens, 1991) including both scientific and educational communities of practice (Wenger, 1999). The concept of teaching-learning regimes (Trowler & Cooper, 2002) is utilised to explore the context of assessment design and practices. The description of examination practices will focus on "momentums of torque" (Bowker & Star, 1999) in student learning and in teachers' work in relation to the formal examination system, thus treating the examination process as a whole.

The project consists of three different parts which are mutually dependent on each other and creates an action research design close to practice:

- An initial project consisting of mapping and analysing examination systems in university programs at Lund Institute of Technology, Lund University,
- Teachers' action learning while exploring their own assessment practices in relation to the examination systems described (framed by a teacher training course),
- Research building on the encounter between on the one hand the formal examination system and on the other hand student learning and teachers' experiences of their work in the process of examination.

The presentation is building on the initial results from the ongoing project related to the theoretical frame-work described above. Based on the results we will discuss the character of the critical interactions between student learning and the formal examination system as utilised by different communities of practice and/or teaching and learning regimes.

References

Bowker, G. C. & Star, S. L. (1999). *Sorting Things Out. Classifications and its Consequences*, Cambridge Massachusetts: MIT Press

Giddens, A. (1991). *The Consequences of Modernity*. Cambridge: Polity Press

Lindberg-Sand, Å. (2005). *Examination as an enacted view of knowledge: Internal development versus external demands in Swedish higher education.* Submitted to Higher Education.

Trowler, P. & Cooper, A. (2002). Teaching and Learning Regimes: Implicit theories and recurrent practices in the enhancement of teaching and learning through educational development programmes, *Higher Education Research & Development*, Vol. 21, No. 3.

Wenger, E. (1999). *Communities of Practice: Learning, Meaning and Identity*, Cambridge University Press