Alternative Assessments in Civil and Environmental Engineering

Angela Lundberg
Water Resources Engineering, Luleå University of Technology, Luleå, Sweden
Angela.Lundberg@sb.luth.se

Abstract: *Examination greatly influences course structure and student study strategies. Three courses for students in the Civil and Environmental Engineering programs at Luleå University of Technology were reconstructed with the aims of making the assessment part of the learning process and to facilitate deep learning. Several different types of assessment were tested. Assessment in the form of a large project and field- and laboratory work was shown to be successful when applied to a course in snow engineering for university students with various backgrounds. A course in hydrology and hydraulics was reconstructed with the aim of assessing increasing levels of understanding. A simple written test was designed to assess lower levels of understanding (definitions, concepts etc.). Laboratory work, fieldwork and extensive assignments (calculation tasks) were intended to assess medium levels of understanding (apply, use and combine algorithms etc). A final oral group exam that was used to assess high levels of understanding (compare/contrast, explain causes, analyse, relate) concluded the course. A course in International Sanitary Engineering was assessed with cross-group presentations and literature seminars. Teaching and assessing features known to encourage deep learning approaches were adopted. Different types of peer assessment were tested with varying degree of success. For all three courses both the students and the teachers reported increased learning with these course structures and assessment strategies than from courses with a final written exams.*

Keywords: *Assessment, learning strategies, peer assessment.*

Introduction

Assessment greatly influences course structure and student study strategies

That the type of assessment greatly influences both course structure and student study strategies have been shown by Bowden and Marton, (1998) and Marton et al. (1999). Surface learning strategies are characterized by: “Students focus their attention on the details and information in a lecture or text. They are trying to memorize these individual details in the form they appear in the lecture or text or to list the features of the situation” while deep learning is characterized by: “Students focus their attention on the overall meaning or message in a lecture, text or situation. They attempt to relate ideas together and construct their own meaning, possibly in relation to their own experience” (Biggs, 1999, Marton et al., 1999). Ramsden (1984) has shown how the learning environment influences student learning approaches. The same student may apply a surface or a deep learning approach depending on the learning environment. Course structures and assessment strategies that promote cooperative work in small groups with frequent and individual teacher response were shown to be important for study success according to Light (2001).

Most written exams at the end of a study period seem to favour student-learning strategies that lead to surface learning. One reason for this is that it is difficult to construct questions for a written exam that: a) students can answer in a few hours b) are easy to correct c) measure more than detail knowledge d) promotes learning during the exam itself. Another reason is that assessment solely by a written exam at the end of the study period encourages students to concentrate their study effort to a short period just prior to the exam.

Students at the Civil and Environmental engineering programs at Luleå University (LTU) claimed that written examination was a too dominating form of assessment at the university (Petterson and Jonsson, 1998). Since each assessment method will place some students at a disadvantage to a certain extent, a range of assessment strategies should be adopted to allow students who are at a disadvantage under one assessment method to excel in others (Brown et al. 1994; Gibbs and Habeshaw, 1998).

In order to increase the diversity in assessment forms and to facilitate deep learning, a three-year project "Environmental education with alternative assessment methods" was undertaken. The intent was to use a diversity of assessment forms to assess the theoretical knowledge of the students as well as their ability to co-operate, to analyse, to synthesize and to be creative. Methods to measure the depth of learning have been presented by Angelo and Cross (1993) but are beyond the scope of this study. Instead we tried to use factors which encourage students to adopt deep learning approaches when we reconstructed the courses (Bowden and Marton, 1998; Biggs, 1999) and tried to avoid those factors which encourage surface approaches.

The work with three of the courses: "International Sanitary Engineering" "Hydrology and Hydraulics" and "Snow Engineering" is summarised here. The project lasted for three years so we had different numbers of students in the courses in the different years.

Reconstructed and new courses

The first two courses described below were originally rather traditional courses with lectures, exercises and a written exam at the end of the course, while the last course was already designed for assessment with a large project work component. All three courses corresponded to 4 weeks full work (6 ECTS credits) distributed over a period of approximately 10 weeks

Hydrology and Hydraulics

A mandatory course in hydrology and hydraulics was reconstructed with the aim of assessing increasing levels of understanding. The work with this course will be described in detail in Lundberg (2003). The goal for the course was to help the students to attain basic understanding of hydrological and hydraulic engineering processes. Between 45 and 90 students attended the course each year. We reduced the original number of lectures and exercises and after the reconstruction the course started with an introduction that explained the practical details and then a few "traditional" lectures and exercises followed. The rest of the course consisted of a short written test, laboratory work and a field task, and two large assignments concluded by a final group exam.

The SOLO taxonomy (Biggs & Collins 1982) stands for Structure of the Observed Learning Outcome and provides a systematic way of describing how a learner's performance grows in complexity when mastering different academic tasks. This taxonomy was used when designing the different parts of the assessment.

A simple written test was designed to assess lower levels of understanding (definitions, concepts etc.). Laboratory work, fieldwork and extensive assignments (calculation tasks) were intended to assess medium levels of understanding (apply, use and combine algorithms etc). The assignments were designed to imitate real engineering tasks. An example of a hydrology assignment was to estimate the risk for flooding due to the combination of large flow and ice jam. Students were assigned individual data for their assignments but they were encouraged to work together. They were also instructed to make the solutions clear and easy to follow. When they had completed their assignment, they handed over their solution to another student for comments. Not until their assignment had been corrected following the comments of their peer, were they allowed to hand in the solutions to the teacher. The same procedure was applied to the laboratory work report. A final oral group exam was used to assess high levels of understanding (compare/contrast, explain causes, analyse, relate) and this assessment concluded the course.

International Sanitary Engineering

The course "International Sanitary Engineering" was chosen for a test with assessment by literature seminars and by a large construction task with cross-group presentation. The course is offered as an optional course at Luleå University of Technology, Sweden, for students at the 4th or 5th year of the Environmental Engineering program and for exchange students from other universities studying similar programs. Water supply and wastewater treatment was dealt within an international perspective with focus on Asia, Africa and South America. The number of students varied between 10 and 25. After the reconstruction the course consisted of a few lectures, seminars, a term paper and a large construction task with cross presentations. The most interesting results dealt with the construction task, the cross presentations and the seminars and only those items are treated here.

Construction tasks with cross-group presentations

Cross-group assessment is described by among others Bessman et al. (1985). The aim with the assessment is that the students will be well acquainted with the subject when they <u>leave</u> the assessment occasion, not as for a written examination when they <u>arrive</u> to the exam. The students work with a rather complicated task (in this case a construction task) in teams of approximately 4 students per team. Let's assume there are 16 students in the course, the team members are then divided into four teams. Each team then works with the task for several weeks and suggests a solution to the task. One construction task given in this course was to design technical solutions for water supply and sanitation and suggest institutional arrangements for project implementation for a village in Africa. The tasks were based on real cases and the students were required to suggest solutions based on knowledge received during lectures, seminars and from literature found in a special library. They had to agree on the solution and each student needed to be able to explain why the solution was chosen. New groups (cross groups) were then formed with one member from each of the previous teams. In the cross-groups the members were supposed to report on and defend the solution suggested by their original team and then agree on a new final solution in the cross-group.

Seminars

Three seminars (45 minutes), which principally aimed at preparing the students for guest lecturers coming the following lecture, were given. Another purpose with the seminars was to give students a chance to discuss subjects not focused on technique but still relevant for the subject water and sanitation. Subjects discussed at the seminars were: a) Gender Aspects on Water Supply and Sanitation b) Planning, Implementation and Institutions and c) Hygiene, Water and Sanitation. The general arrangement of the seminars were similar even if the details varied. Before a seminar, the students read a collection of research papers and articles from books (20-50 pages) in groups of 2-3 students. They investigated the studied material together and prepared a presentation according to directions given by the teacher. After each of the different seminar presentations, the students were divided into groups of about 4 where they discussed questions delivered by the guest lecturer.

Snow Engineering

One course was assessed by a large team project where each team was assigned a tutor/ examiner. The work with this course is described in detail in Lundberg et al. (2003). The course chosen for this was a course in snow engineering for students with very varying backgrounds. The aim of the course was to give the students basic understanding of snow engineering processes and to improve general academic skills not directly linked to the snow-engineering subject. Examples of such skills are: oral presentation skills, report writing skills and co-operation skills. The course was an optional choice for students from the Master of Science in Engineering and University Diploma in engineering programs. Approximately 30 students ranging from their second to their final year attended the course. Roughly half of the students were exchange students from countries other than Sweden. The variety in student background meant that the student group was very diversified. The teachers represented three different Engineering disciplines so the diversity in teacher background was also larger than in most engineering courses.

The course started with an introduction that explained the practical details of the course and optional project suggestions. Then a few “traditional” lectures with basic knowledge about the snow subject were presented. The rest of the course consisted of three days of fieldwork followed by some laboratory work and a large project task. An ideal project task contains a literature review, a small practical experiment and consumer interest in the result of the work. Examples of projects used in this course were: “Pullout test of reinforcement in snow”, “Compare two different methods for evaluation of snow strength”, “Snow deposits, local or central?” “Snow removal as a resource”, “Use of remote sensing techniques to determine snow water equivalent”.

The students were to present the projects were in three different ways: a) as a short written report (≈5 pages), b) by a short oral presentation and finally in a third c) optional way. We provided the students with electronic links to snow- and cold-climate-databases, to electronic lexicons and to instructions for report writing, as well as instructions for poster and home page presentations.

The report was required to refer to a minimum of five articles (not textbooks) with correct references to those. We practiced peer assessment with the aim of enhancing the writing skills of the students. (A feedback evaluation sheet to check report structure, grammar/spelling etc was provided). The examiners graded the final report.

At the end of the course, student presentations were scheduled. Each group gave a short oral presentation (≈10 minutes) and presented their work as a poster, a home page, a physical model or in some other form. During the presentations, both the examiners and the peer (opposing) group assessed the presentation (evaluation sheet). Presentation structure, language, illustrations and performance were assessed.

The project was graded (report, oral presentation and optional presentation) by the examiners and peer assessment of individual team members' contribution was applied.

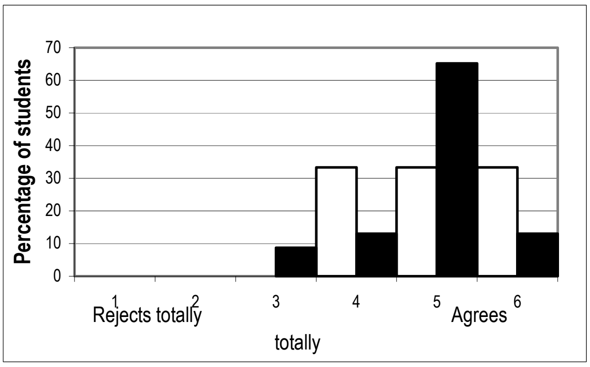
Evaluation of the courses

Slightly different types of evaluations have been made over the years depending on the type of course. The questions at the evaluation during the last study year (2001/2002) for the two courses Snow Engineering (SE) and Hydrology and Hydraulics (HH) were similar and are shortly reported here.

Student evaluation

At the end of the course, the students filled in a questionnaire about the course. They graded how well they agreed with a number of statements regarding the course using a 6-point scale. A score of six meant that the student totally agreed with the statement and a score of one meant that the student totally disagreed. Marks 4-6 on the 6-point scale were interpreted as positive to the statement.

The students seem to have appreciated the entire courses since 91% of the SE-course students agreed to the statement: *"The entire course has worked well"* and so did all the HH-students (Figure 1, below). The students also experienced that they had learned more with these types of assessment than with a traditional written exam at the end of the course since 96% of the SE-course students agreed to the statement: "*I have learned more with this assessment than with a "traditional" course with written exam at the end of the course"* and so did 93% of the HH-students: (Figure 1 below).



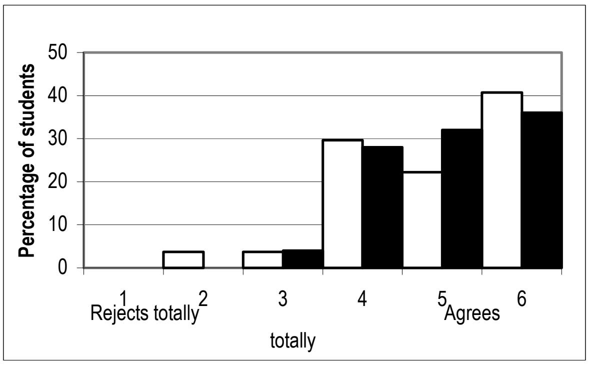


Figure 1: Percentage of students that agree with statements: Left: The entire course has worked well. Right: I have learned more with this assessment than with a "traditional" course with written exam at the end of the course. (SE course black and HH course white piles).

Teacher evaluation

The teacher evaluation consisted of informal discussions with the teachers. The teachers were convinced that the students learned better with this approach, but for the course in hydrology and hydraulics they still all expressed concern for a supposed decrease in width of student knowledge. The teacher workload was estimated to be approximately the same with the traditional written exam and more students passed the course.

Discussion

One of the aims with using these assessment forms was to promote deep learning. The students experienced that they had learned more with this assessment, but we did not really prove this. It is, however, likely that deep learning had taken place since we tried to avoid course characteristics (Gibbs 1997; Biggs 1999) associated with a surface approach and instead used features that can foster a deep approach. As an example factors are listed which can foster a deep approach with comments on how we succeeded in using them for the two courses Snow Engineering (SE) and Hydrology and Hydraulics (HH):

- Motivational context
  - the calculation tasks used in the HH course were constructed so they resembled real life engineering problems and this created a motivational context
  - most of the projects used in the SE course had a consumer interest in the result of the work; this created a motivational context.
- Learner activity
  - the calculation tasks used in the HH course as well as the the project work used in the SE course both required a lot of learner activity.
- Interaction with others
  - the students in the course HH were encouraged to interact with each other both when writing the laboratory reports and doing the calculation tasks. The oral exam was also based on interaction between students and with the teacher.
- A well-structured knowledge base
  - the initial traditional lectures and exercises used in both courses provided the students with a structured knowledge base.

Conclusions

General

Both teachers and students experienced that the students had learned more with these course structures and types of assessment than with courses with more lectures and a final written exam.

- It is likely that most students adopted a deep learning approach to the courses since we succeeded rather well in applying course characteristics that can foster a deep learning approach and in avoiding characteristics that can foster a surface approach.
- The workloads for the teachers were approximately the same with these course structures and assessment types as for courses with more lectures and a final written exam.
- It was very helpful to use factors which encourage students to adopt deep learning approaches and to try to avoid features that encourage surface strategies when we reconstructed the courses and the assessment.

Hydrology and Hydraulics

- The teachers experienced a deep learning approach among the students and more students passed the course but still all teachers expressed concern for a supposed decreased in width of the student knowledge.

- The major advantage with this course structure was according to the teachers the large amount of feedback the students got on their different assignments.
- It was difficult to convince the students of the benefits with peer assessment since they found the system too time consuming.
- The SOLO-taxonomy was helpful when designing the assessment types with the aim to assess increasing depths in understanding

International Sanitary Engineering

- The cross-group presentation used in this course to assess the project-work was successful since the students were very active and seemed to learn much during them. One difficulty however was that the teams who had first agreed on a rather poor solution had difficulties abandoning this solution when confronted with better solutions.
- Appreciated forms of literature seminar were seminars that involved all students such as: a) short role play/dialogues b) one team acted as seminar leader for the seminar.
- Discussions and open type problems where no obvious correct answers were given worked best for the seminars.
- When introducing literature seminars with the purpose to prepare students for guest lectures it is important to enhance the level of the following lectures.

Snow Engineering

- The resulting projects were generally of high quality.
- The students appreciated peer evaluation of the relative contributions to the project work.
- Two weaknesses with the course were identified: The teams were too large (4-6 student) and the course was too concentrated in time.

References

Angelo, T. and Cross, P. (1993). Classroom assessment techniques, San Francisco, Jossey-Bass.

Bessman, M., Eklundh, M. and Mårtenson, D. (1985). Examination för kvalitet. Exempel från högskolan. UHÄ FoU Skriftserie 1985:3. Stockholm.

Biggs, J.B. & Collins K.F. (1982). Evaluating the quality of learning: the SOLO taxonomy, New York, Academic press.

Biggs, J.B. (1999). Teaching for Quality Learning at University, What the students does. Published by The Society of Research into Higher Education and Open University Press. Edmundsbury Press, Suffolk.

Bowden, J. and Marton, F. (1998). The university of learning. Beyond quality and competence in higher education. Biddles Ltd, Cogan Page Ltd.

Brown, S., Rust, C. and Gibbs, G., (1994). Strategies of diversifying assessment in higher education. The Oxford centre for staff and learning development, Oxford Brookes University, Oxford, UK.

Gibbs, G. and Habeshaw, T. (1998). Preparing to teach. An introduction to effective teaching in higher education. Technical & Educational Services Ltd. Bristol.

Gibbs, G. (1997) Workshop: Assessment, course design, labs and practicals for improving student learning, Luleå University of Technology, 17-19 Sept., 1997.

Light, R. J., (2001). Making the most of college: students speak their minds. Cambridge, Mass., London, Harvard University Press.

Lundberg, A. (2003). Assessing Different Levels of Understanding. Submitted March 2003 to Assessment & Evaluation in Higher Education.

Lundberg, A. Vikström, L. and Viklander, M. (2003). Assessment by project work in snow engineering. European Journal of Engineering Education 28(1), 7-16.

Marton, F. Dahlgren, L. O. Svensson, L. och Säljö, R. (1999). Inlärning och omvärldsuppfattning: en bok om den studerande människan. Prisma, Stockholm, Sweden.

Petterson, O. och Jonsson, B. (Eds.) (1998). Utvärdering av civil- och diplomingenjörsutbildningarna i samhällsbyggnadsteknik och väg och vattenbyggnad i Sverige och Finland, Luleå tekniska universitet, Tryckeriet, Luleå tekniska universitet.

Ramsden, (1984). The context of learning, In: The experience of learning, Edinburgh, Scottish Academic Press, (Marton, F. et al. eds.) pp. 144-164.

Acknowledgements

This work was financed by the Swedish Council for the Renewal of Higher Education as the project: "Environmental education with alternative assessment methods" with project no 052/98. The teachers (Associate Professor Maria Viklander, PhD Signhild Gehlin, Professor Anders Sellgren and Senior Lecturer Lars Vikström) and PhD students (Annelie Hedström and Kjell Skogsberg) who taught parts of courses are acknowledged for their willingness to adopt these new assessment methods and for constructive suggestions to improve both course structures and assessment forms. The students Tina Roos and Sofia Hansson are acknowledged for their constructive criticism of new-constructed assignments.