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Effect of continuous assessment on learning outcomes on two chemical engineering courses: case study

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In this paper, the effect of continuous assessment on the learning outcomes of two chemical engineering courses is studied over a several-year period. Average grades and passing percentages of courses after the final examination are reported and also student feedback on the courses is collected. The results indicate significantly better learning results after the adoption of continuous assessment in the courses. Also student feedback suggests higher quality in teaching after the adoption of more activating teaching methods which compel students to study effectively throughout the course.

Keywords: assessment of learning outcomes; continuous assessment; active learning; engineering education

1. Introduction

Entwistle and Peterson (2004) have discussed the difference between the concept of knowledge and the concept of learning, and their relationship to study behaviour. What students actually believe about learning guides their attitudes towards studying. Also the evaluation method that is used on a certain course guides how and what students study (Brown 2001). Bloxham and Boyd (2007) claim: ‘Assessment strongly influences students’ learning, including what they study, when they study, how much work they do and the approach they take to their learning.’ In fact, assessment plays a key role in fostering learning and is a central feature of teaching (Boud 2010). Brown (2004) has seen assessment as the most important way to help students learn. The assessment method is impacted by the reasons for assessment: the motivation and activation of students, and feedback (Brown 2004).

The form of assessment can lead to different ways of studying; exams lead to memorisation, whereas assignments encourage application skills (Biggs 1999). If there is a traditional exam after a course, students often only study for it on the previous day, trying to retain the information until the exam is over simply to pass the course. Trotter (2006) found out by interviewing students that most of the work for the subject was done just before the final examination. Usually only few students are truly interested in learning issues instead of only passing the course if nothing else is required. Goubeaud (2010) has noted that assessment is increasingly recognised

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to have the potential to improve teaching and learning. The quality of learning can be greatly improved through the development of assessment, as it guides students in how they study but also forces teachers to think what and how to teach. Torrance (2007) has stated that assessment has to move from 'assessment of learning' to 'assessment for learning' or even 'assessment as learning'. According to Olds, Moskal, and Miller (2005) the whole advancement of engineering education depends in many ways on assessment, which they see to refer to all methods of collecting data which can be used for measuring individual students' competencies, for example, exams or homework assignments. Thus, all assessment procedures will support learning by underpinning student achievement.

In the field of engineering, the role of different transferable skills, such as communication, team work, problem-solving and independent study skills, has increased in the world of work and education has to answer to this challenge (Fenner et al. 2001; Grant and Dickson 2006). The European Federation of Chemical Engineering (EFCE 2013) has published Recommendations for Chemical Engineering Education, which also includes a list of different transferable skills that students should learn beside subject knowledge during their studies at the university.

Traditional teaching methods may not sufficiently support the learning of those skills. Therefore, the education, including evaluation and assessment, must appropriately respond to these requirements. By using new, alternative teaching methods, different transferable skills can be taught by integrating them into the subject education. Lectures and other teaching methods used in the course should support students to acquire problem-solving and other transferable skills by encouraging students to study actively and continuously with different study methods. According to Molzahn (2006), teaching and learning methods should be chosen so that they develop students' skills to work both independently and in groups or teams.

According to El-Naas (2011), active learning is a teaching process that requires direct involvement of the students in the learning process. Parker and Loudon (2013) have reported about good learning results when encouraging students towards active learning by doing evaluated online homework in organic chemistry.

Continuous assessment has been seen as one solution to improve teaching. In his literature review, Cimer (2007) has presented common principles of effective teaching, and according to him continuous assessment with corrective feedback given by the teacher is needed for students to enhance learning.

Various methods of continuous assessment and evaluation have been studied. Reasons for introducing it have been lecture attendance (Cole and Spence 2012), learning results (Trotter 2006; Isaksson 2008; Cole and Spence 2012), motivation and study time management (Trotter 2006; López et al. 2007), and continuous feedback (Trotter 2006).

Continuous assessment could motivate students to work harder and evaluate their learning during the course when they are given feedback. Trotter (2006) has analysed undergraduate students' interviews and found out that the external stimulus of continuous summative assessment and hard work were appreciated by the students, and regular feedback from an early stage motivated them to improve their performance. Kniveton (1996) has interviewed undergraduate students of different departments in two universities, and reported that students had considered continuous assessment as a fair process, as a better judge of their skills and as a tool for working time management. According to Scott and Fortune (2013), students are today more focused in the time they use for learning, and both students and teachers are expecting that they have a framework that enables effective learning, teaching and assessment.

Isaksson (2008) has used short essays after each two-hour lecture for summative assessment, the criteria of which were taken from the curriculum, combined with direct feedback. Students were given between 5 and 20 minutes for writing. As a result, a higher level of understanding was obtained. The study points out that direct feedback might be the key factor. Also the increased effort of the students had led to better results (Isaksson 2008).

Assessment should be linked to the objectives of the course. Biggs (2003) has presented the constructive alignment (CA) of teaching and assessment in the curriculum as ‘an assessment system that tells you how well each individual student’s assessed performance matches what is required’ and has given problem-based learning as an example of aligned teaching. This rather subjective way of judging individual performance is questionable: how can the teacher be objective? Finally, it is stated that CA can be integrated into teaching and assessment if the objectives are clearly declared and if students’ performance can be linked with objectives (Biggs 1996, 2003).

This paper describes pedagogical methods involving continuous assessment that have been adopted in two chemical engineering courses of Lappeenranta University of Technology as a response to the needs discussed above and to achieve better learning results.

2. Case courses

The courses selected for this study were *Particle Technology and Treatment of Particulate Solids* (2 ECTS, European Credit Transfer and Accumulation System, cr) and *Introduction Course in Paper Technology* (5 ECTS cr), which are second- and third-year Bachelor-level courses, respectively. In both courses, active learning and continuous assessment methods were adopted several years ago.

2.1. Particle Technology and Treatment of Particulate Solids

The course *Particle Technology and Treatment of Particulate Solids* is a compulsory second-year course for all students in chemical technology consisting of four hours of contact teaching per week in seven weeks, corresponding to one teaching period of the university. On this course, the characterisation, sampling, storing, transportation and comminution (i.e. crushing and grinding) of particulate solids are studied. After the course, students are expected to be able to preliminarily select suitable methods and equipment for processing and analysing particulate solid materials.

In the course, students were assessed based on four to five home assignments. To pass the course, the students had to obtain 25% of the points for each individual assignment and 50% of the overall points for all assignments together. The aim of this was to keep the students active during the entire course. Every year, the students also had a possibility to choose a traditional written exam instead of home assignments, but students were encouraged to choose home assignments. Table 1 presents the number of students who selected home assignments each year.

The aim of adopting continuous assessment in the course was to keep students working throughout the period. As a result, students actually study all of the core areas of the course in small parts, leading to better and deeper understanding of entire studied area, as opposed to

Table 1. Number and proportion of students who chose home assignments each year.

Year	Total number of students on the course	Number of students who chose home assignments	Proportion of students who chose home assignments (%)
Ref.	36	N/A	–
1	20	18	90.0
2	40	37	92.5
3	32	27	84.4
4	21	19	90.5
5	16	15	93.8

studying for a traditional examination after the course. In the case of a final examination, students are quite often very passive during the course and just trust their ability to study the course topics over the last evening or two before the exam, which leads to poor passing percentages and grades. Moreover, it does not lead to understanding of the phenomena, but only the short-term retention of some details. Felder and Brent (1999) have stated that we mainly learn by doing things and by reflecting outcomes, not only what we see or hear, for example, on lectures. Thus, it is important to have students actively participate in the whole learning process.

By using continuous assessment with home assignments, understanding was ensured by the lecturer's feedback after every assignment. When at the same time students were encouraged to actively discuss the problems with other students and the lecturer, different transferable skills of the students were also improved. In this method, students will automatically take responsibility for their learning, but at the same time, the lecturer also receives feedback about the level of learning throughout the course and can modify the teaching in the direction needed. Therefore, this study can also be classified as an action research approach, which is usually a cyclical process including action and critical reflection based on qualitative and/or quantitative data (Gray, Chang, and Radloff 2007; McDowell et al. 2008).

Home assignments included theoretical and calculation tasks. They were compiled so that the students received basic information about the subject in the lectures and calculation exercises weekly. After that, they studied the topic independently by using the provided study materials and course literature to solve the assignment which had to be returned the next week. In the following lecture, students were returned their evaluated assignments and the lecturer gave feedback about them to the students. This procedure is described by the following learning cycle presented in Figure 1.

Every assignment involved a key issue that students had to understand before they could solve the problem. This improved the problem-solving skills of the students. Students were also expected to remember what had been studied earlier in the course, and thus new content was always connected to earlier knowledge of the area. In this method, students regularly received detailed information about how well they were doing and how they could work better. Goubeaud

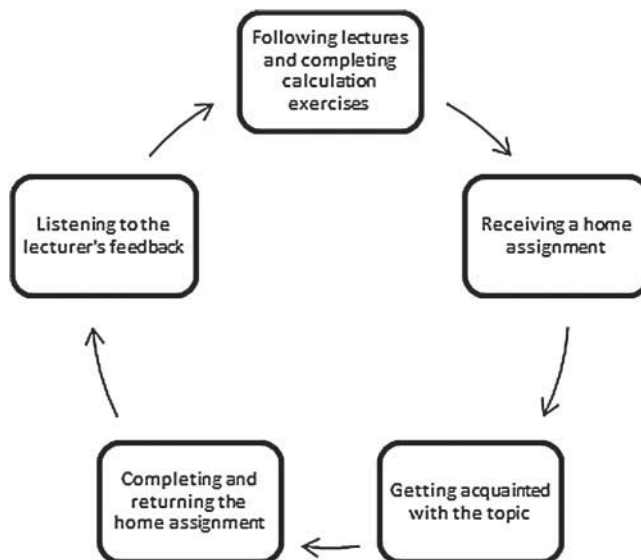


Figure 1. Learning cycle for home assignments.

(2010) has also mentioned that this type of real-time continuous assessing leads students to be active participants in learning.

2.2. Introduction Course in Paper Technology

Introduction Course to Paper Technology was a compulsory course for third-year chemical engineering students whose major or minor subject was Paper Technology. This paper examines a four-year period over which the course was taught. The assessment method was not always the same:

- *The first year* acted as the reference year when continuous assessment was not established. The teaching and evaluation methods were lectures, seminar work and a final exam. It was possible to obtain additional points for the final exam by completing seminar work.
- *In the second year*, an evaluated home assignment was adopted. The seminar work and assignment gave additional points for the final exam.
- *The third and the fourth years* mainly applied continuous evaluation as an assessment method: 30-minute exams, home assignments and self-evaluation all affected the final grade.

The reasons for changing the assessment method were mainly the poor participation and activity of the students during the lectures. Also the feedback on the course indicated that a substantial workload for one exam led to weak learning. Furthermore, the students did not receive any feedback on their learning. The intention of the continuous assessment was primarily to increase the activity of the students and improve the learning results. Parsons (2008) has raised a question about examination stress, which can be one factor in weak grades, and how to eliminate it. Some of the methods suggested by Parsons were adopted in this paper technology course.

The course included a two-hour lecture or self-study twice a week for a period of 16 weeks. The methods of continuous assessment in this course were six 30-minute exams with feedback, various assignments and students' active participation during lectures. Thirty-minute exams were held every two or three weeks, each lasting 30 minutes. Students were given a set of test questions beforehand, and a number of them were included in the 30-minute exam. These test questions dealt with issues that were important for the students to learn. According to Svinicki (2005), criteria set for the students should be clear so that they can focus on the most important issues. Each 30-minute exam included two questions about previous lectures and self-study materials, and there were 12 questions overall, which is twice as much as in a typical final exam. Students could also choose between alternative questions.

After the 30-minute exam, the suitable answers with general feedback were given by the teacher to the students. In addition, the students were given the previous graded exam and assignments. From this teacher's feedback, students could see the cumulative progression and evaluate their own performance. The feedback on the examination was intended to help students to evaluate the amount of work they need to carry out for the exams and become better at taking examinations, as Knight (2001) suggests.

The 30-minute exams accounted for 70% of the overall grade of the course and other assignments and activity 30%.

3. Results

In order to examine the success of continuous assessing, the quantitative data on the final grades and passing percentages of the target courses were collected after the final examinations during the research period. At the same time, student feedback was collected systematically on both

courses with questionnaires in which the students could report their satisfaction with teaching and their learning experience. Students must respond to the following statements or questions in all feedback questionnaires at the university:

- *The forms of work used were well suited for the course and supported learning during the course*, assessment on a scale of 1–5 (1 = I completely disagree, 5 = I completely agree).
- *Overall grade of the course* on a scale of 1–5 (1 = unsatisfactory, 5 = very good).
- *General comments* and proposals for improving the course.

Even though the relevance of students' ratings of teaching can be questioned like 'High ratings go to the easy graders', Felder and Brent (2004) have noted that the students are the only ones who can say how the teacher has affected their attitude towards the course topic and their study motivation for learning.

3.1. Particle Technology and Treatment of Particulate Solids

The research period for the course *Particle Technology and Treatment of Particulate Solids* was six years. In the first year, only a traditional written exam was used for evaluation. In the following five years, however, home assignments were offered as an alternative method for evaluation. The number of students who chose home assignments each year is presented in Table 1.

Average course grades and passing percentages for the first examination (includes home assignments and the first written exam) of the course for each year are given in Figures 2 and 3.

After the adoption of continuous assessment with home assignments, most students (approximately 90% annually) chose them instead of a traditional written exam. The results presented in Figures 2 and 3 show that both the average final grades and passing percentages increased clearly after the adoption of home assignments as an evaluation method in the course. Savander-Ranne, Lundén, and Kolari (2003, 2008) and Wanous, Procter, and Murshid (2009) have reported similar positive effects on learning results when using activating teaching methods and continuous assessment or evaluation.

Figures 4 and 5 give the results regarding two university-wide questions in the student feedback questionnaire: satisfaction in the working methods of the course and the overall grade.

Changing assessing methods in the course also made the teaching more interactive compared to traditional lectures due to the weekly reflective discussions with the students about home assignments and at the same time about overall topic of the course. The role of the students was also naturally more active in this kind of teaching and they found the studies more motivating.

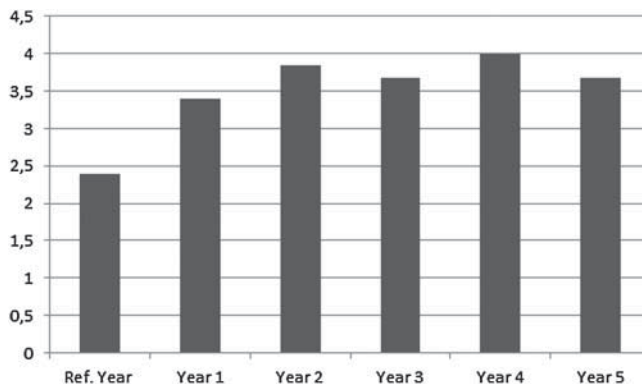


Figure 2. Average final grades (highest grade 5) in final examinations of each academic year studied.

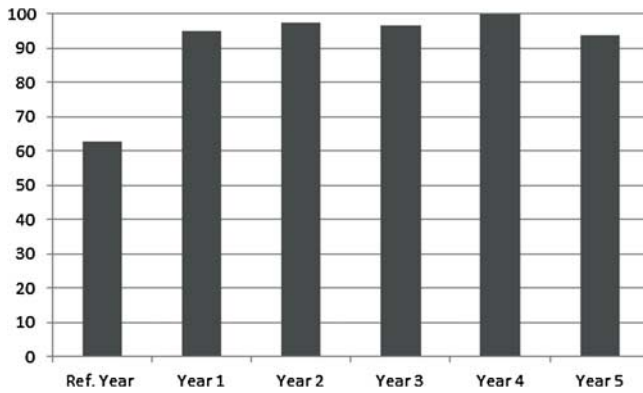


Figure 3. Passing percentages of the course after the final examination in each academic year studied.

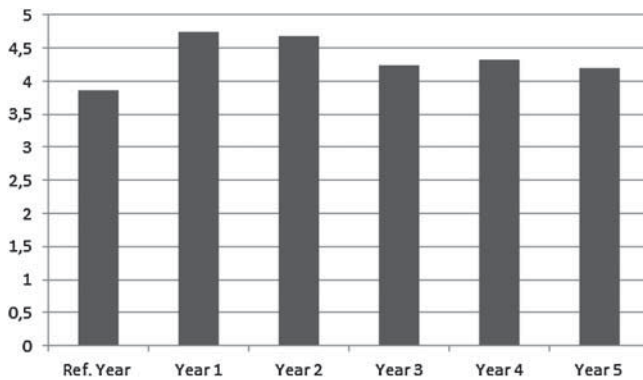


Figure 4. Average grade for the statement: *The forms of work used were well suited for the course and supported learning during the course* on a scale of 1–5 (1 = I completely disagree, 5 = I completely agree).

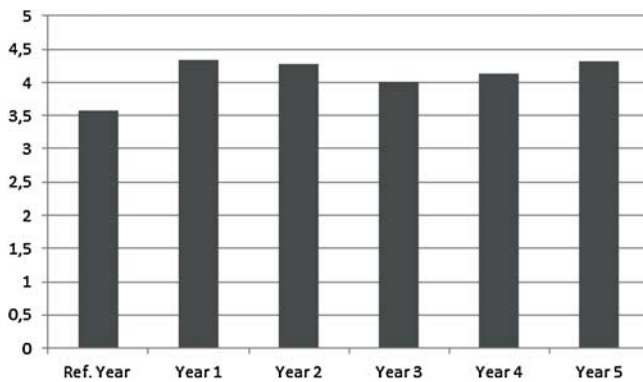


Figure 5. Overall grade of the course on a scale of 1–5 (1 = unsatisfactory, 5 = very good).

Continuous assessment also provides variety for learning styles, which Fitzpatrick, Cronin, and Byrne (2011) have estimated to have a major influence on what students gain from the lectures.

Course feedback results presented in Figures 4 and 5 indicate that students were very satisfied with changes to the course implemented together with continuous assessment. Especially in the

first year following the adoption of continuous assessment, course feedback improved significantly, after which it stabilised at a good level. A slight decrease in the feedback score in the past two years is probably due to the fact that similar teaching methods have also been adopted in other courses in the degree programme, slightly decreasing their novelty value.

The course feedback system also provides a possibility to write free-form comments about the course. In this course, students reported, for example, the effect of continuous assessing on time they used for studying:

- The assessment system with home assignments was good because now I had to study throughout the course.
- The workload of the course was a bit greater than in many courses with equivalent credits, but because it was spread equally over the entire course, you did not feel stress at all.
- Home assignments were a good way to learn because you had to take time to study and search for information when you did them.

They also reported how continuous assessing affected study motivation:

- The course was good and for a while I felt that it is important to really learn about the topic area instead of simply passing the course.
- It was good that the assessment criteria were clearly given beforehand and you always knew which grade you still had a chance of obtaining → made you try harder.
- The teaching methods applied improved my motivation and interest to really study this topic because they showed clear links between practice and theory.

Also the students gave some comments about need of deep understanding of the topic instead of superficial studying:

- I liked the fact that there was always some key issue in every assignment that you had to understand before you could solve the problem.
- I think that by using this kind of continuous assessment, the studied issues will be committed to your long-term memory better than if you just read for one final exam the previous evening.

These comments by students support all of the statistical results on learning for the course presented in this paper.

3.2. *Introduction Course in Paper Technology*

The examination period of this course was four years. The first year was the reference year, in which continuous assessment was not applied. Teaching and assessment in the reference year was carried out in a traditional way: lectures, seminar work and a final exam. Years 2–4 were executed using 30-minute exams, seminar work and other assignments. The final exam was still left as an optional evaluation method and some students chose it. The numbers of students who chose continuous assessment or final examination can be seen in Table 2.

The number of students participating in the course varied during these years. The proportion of students choosing 30-minute exams and other assignments of continuous assessment has increased. Also the proportion of failed students has decreased. The reason for some students not passing the course is that it is also quite popular with students other than chemical engineering students and they have a greater tendency to abandon the course or are only interested in the lectures to learn about pulp and paper processes.

The average course grades are shown in Figure 6. As can be seen, continuous assessment has had an effect on the course grades.

Table 2. Number and proportion of students who chose 30-minute exams.

Year	Total number of students on the course	Number of students who chose other assignments and/or 30-minute exams	Proportion of students who chose other assignments and/or 30-minute exams (%)	Number of students who chose a final exam	Proportion of students who did not pass the course (%)
Ref.	20	N/A	–	13	35
1	13	6	46	2	38
2	19	14	74	1	21
3	27	19	70	2	25

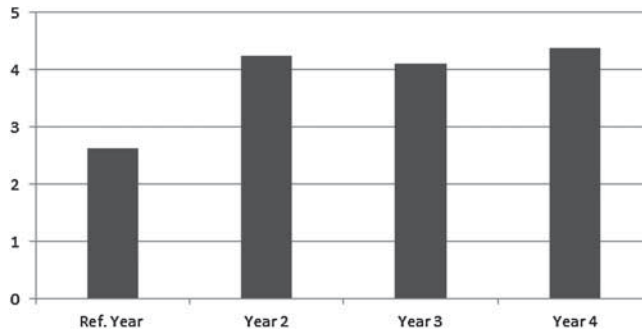


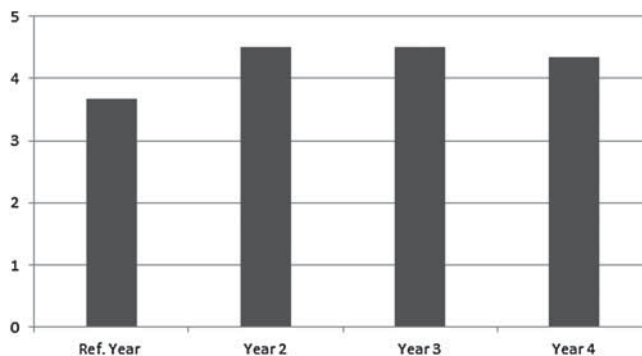
Figure 6. Average final grades (highest grade 5) in final examinations of each academic year studied.

The adoption of other evaluation methods than a final exam has affected the final course grades. Results presented in Figure 6 show that final grades improved by more than one grade. Continuous assessment seems to have enhanced learning results.

Figures 7 and 8 display the results of the student questionnaire. Students found the working methods better suited to them during the years of continuous assessment compared to the reference year; also the overall feedback score for the course is higher.

In the questionnaire students have commented on their own experience in learning, when continuous assessment (30-minute exams and assignments) was used:

- Thirty-minute exams and essays are a good way to carry out the course. Learning is more efficient when things are digested in smaller parts.
- You had to think about the things during the course due to the 30-minute exams. It would have been impossible to learn all these things just for the final exam.
- Thirty-minute exams motivated a student to study harder.

Figure 7. Average grade for the statement: *The forms of work used were well suited for the course and supported learning during the course* on a scale of 1–5 (1 = I completely disagree, 5 = I completely agree).

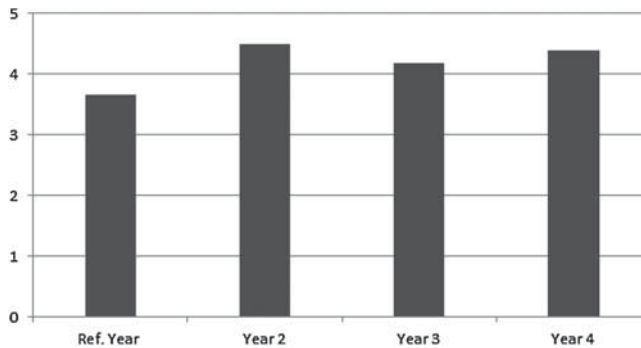


Figure 8. Overall feedback score for the course on a scale of 1–5 (1 = unsatisfactory, 5 = very good).

- Motivation remained high because you could influence your grade during the course.
- Without the test questions given before the 30-minute exams, passing might have been hard.
- Assignments helped me to learn.

Even if the comments concerning continuous assessment were positive, also one critical comment was given:

- The 30-minute exams were pointless. You should not divide the entity into small parts.

Based on the students' views on learning and the overall grades (Figure 8), we can assume that 30-minute exams and assignments really improve learning results and motivate students, as Trotter (2006) has suggested.

4. Discussion and conclusions

In this paper, we studied the effect of continuous assessment on learning outcomes in two chemical engineering courses. The average grades and passing percentages of the courses on the students' first attempt were analysed over a several-year period and compared to the reference year, when only traditional final exams were used in the assessment of learning outcomes. Students' final grades improved significantly after the adoption of continuous assessment in both courses. Similar effects were seen on the passing percentages of the courses, as well. Besides the continuous assessing itself, this can be due to the fact that students participated more actively during the lectures than before the adoption of continuous assessing. These results are in line with those reported by Cole and Spence (2012), who also stated that continuous assessment has a positive effect on exam results and passing percentages. They also reported an increase in lecture attendance as long as students achieved the minimum number of passes from the set of assignments. When applying continuous assessment, it seems to be very important that students work throughout the course to collect points for assignments or smaller tasks to maintain involvement in studying and learning until the end.

Kopelevich et al. (2012) have written about the importance of good planning of methods used for assessing learning so that they really will cover the whole range of course content. The weakness of the traditional written exam is that it usually consists of individual questions that do not have any connections with each other. So, it is possible for the student to pass the course by just studying a few examples from previous exams and try his/her luck that at least some of them will appear in his/her exam. In Finland, it is possible for the student to take the exam several times to try to pass the course until he/she succeeds. The disadvantage of home assignments or

quick exams used in the case courses can also be that they do not form a coherent whole of the course content to the student, if the content is broken down into too small pieces, even though it may result in better marks. So, it requires the teacher to plan all assignments so that knowledge from previous points is needed at later points to ensure constructive learning of the topic. This may also lead to increased workload of the teacher, especially in the first years of applying the new assessing methods.

According to course feedback, overall student satisfaction with the courses and forms of work during the courses increased after adopting continuous assessment. A similar trend in feedback scores was seen in both courses: in the first year after the adoption of continuous assessment, the scores rose significantly, after which they stabilised at a good, significantly higher level than in the reference years. New, activating teaching and learning methods have been applied more frequently at the university, which may explain the slight decrease in the feedback scores in the past few years.

Some individual students commented in their feedback that they believe they learned and understood much more about the subject when studying throughout the course instead of just reading for the final exam. Students also seemed to improve their studying during the course when they realised that they could obtain a better grade if they tried harder. Torrance (2007) has also highlighted the importance of guidance by supervisors and assessors in assignments – the clearer it is to students how they can obtain a good grade and the more detailed the guidance is, the more likely the students are to make the effort and succeed.

In general, students were more active and motivated to study the topics. They participated in face-to-face teaching more often than in previous years. Students seemed to take more responsibility for their own learning with better results when continuous assessment was applied. They seemed to understand the importance of their own work in studying and learning throughout the course. Continuous assessment increased the level of independent self-reflective learning of the students, which should prepare them better for life-long learning. Similar activating teaching and learning procedures are recommended for other engineering courses as well.

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