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Total integration and active participation in the learning process in textile engineering education

Samuli Kolari† & Carina Savander-Ranne‡

Tampere Polytechnic, Tampere, Finland†
Helsinki Polytechnic, Helsinki, Finland‡

ABSTRACT: The aim of this case study was to study how combining several textile engineering courses into a larger entity and applying student-centred teaching methods helped learning, activation, motivation and commitment. The courses were combined in order to give the students a more holistic view. The subject was a class of textile engineering students in their second year at Tampere Polytechnic, Tampere, Finland, including ten young women in their early 30s. The combination included the seamless integration of lectures and laboratory works. The teaching methods were renewed with hopes of getting better learning results and more meaningful learning. Research tools such as questionnaires, tests, focused interviews and observations were utilised. Also, the students' and teacher's learning diaries and exams were at the researchers' disposal. These teaching arrangements helped the students' learning and understanding. Good motivation and commitment could also be achieved. The close integration of theory and laboratory works turned out to be a successful arrangement. The students also took responsibility of their learning and the lecturer enjoyed his work. However, a decisive attitude and keen interest in pedagogical development is needed in order to succeed.

INTRODUCTION

Changes in engineering education in Finland have been continuous over the last few decades with curricula frequently being developed and rearranged. One aim of curricula development is to offer students greater flexibility to organise their studies and to ensure that they have opportunities to take courses from other disciplines.

To reach this aim, many longer, 5-10 credit-unit-courses have been split to become shorter, consisting of just 1-3 credit units. According to the authors' experiences as lecturers and teacher educators in the field of engineering education, this has led to the disadvantage of students learning small details instead of gaining a global view of the relevant subject matter. The authors also experienced that students' skills in transferring knowledge and seeing connections and relations between various learning subjects are insufficiently developed. This may, in some cases, lead to lower motivation and a lack of commitment, which may be regarded as possible reasons for the increasing number of dropouts in engineering education.

The above-mentioned problems were evident also in the Textile Engineering Department at Tampere Polytechnic, Tampere, Finland [1]. Students expressed dissatisfaction in their annual evaluation of the study year. This increased the motivation of the teaching staff to take practical steps in finding solutions to eliminate problems.

To ensure the students gain a more holistic view of the subject matter, several shorter courses were combined into larger units. For example, some parts of the courses of Weaving Technology, Textile Structures and Textile Manufacturing Laboratory Works were combined into one single course of 5 credit units. This combined course was called Weaving Technology 1.

WEAVING TECHNOLOGY COURSE

Having compiled the new course, departmental staff contacted the authors and suggested cooperation. The authors' role in the project was defined twofold. On the one hand, help was to be given to departmental staff to develop textile technology education in general. The Weaving Technology 1 course was chosen as a pilot project. On the other hand, staff were to be introduced to new pedagogical ideas and methods and be tutored in their application. The aim was improved student learning and understanding of the subject matter.

In addition to combining several courses, the authors suggested some changes in the teaching practices and arrangements. The general recommendation was to adopt a constructivist approach to teaching and learning, which also means introducing more varied instruction practices [2][3]. The authors decided to undertake this research because of their interest in measuring the results of the measures taken.

The pilot course, Weaving Technology 1, consisted of seven hours of weekly classes, all given during one school day and continuing for 16 weeks. Laboratory practices were integrated into the class work. The lecturer, laboratory staff and all necessary facilities were always available during the whole day. The authors wanted to place special emphasis on activating, motivating and committing the students.

In order to achieve these goals and to measure the results, the use of pre-class tasks, peer instruction, cooperative learning, learning diaries, various tests, questionnaires and focused interviews were introduced. Discussions with students, observations of teaching and learning in the class and interviewing the students and teaching staff of the course gave the necessary feedback and assisted the authors in following the situation.

Present classes are often heterogeneous in their background knowledge. This generates extra challenges for teaching and becomes problematic if students do not sufficiently master the fundamental concepts of the subject matter and if the lecturer does not have a realistic picture of what the students are familiar with [4-6]. Not accounting for students' heterogeneous backgrounds may lead to wasting valuable teaching and learning time dealing with matters that students could learn on their own or that could be dealt with briefly in class.

Pre-class tasks in the Weaving Technology 1 project were included to solve any problems generated by students' background heterogeneity. The weekly pre-class tasks were planned so that they would help students prepare themselves for class and focus their thinking on relevant subject matter areas. Doing the pre-class tasks required students to repeat certain topics from earlier courses, as well as become familiar with some central aspects of new topics that were to be introduced during the next class. Students were also encouraged to apply independent acquisition of knowledge. Furthermore, a prime aim of the pre-class tasks was to give the lecturer an overall view of the students' knowledge, their preconceptions and possible misconceptions. This aim was sufficiently achieved because the lecturer could read the students' answers before class and make use of this information when planning the instruction. It was hoped that utilising these measures would guide students' orientation and deepen their understanding of the subject matter to be learned.

The teaching method adopted was cooperative learning completed with some features of peer instruction [7][8]. These choices were made because the authors had experiential and theoretical reasons to expect them to activate students and increase their involvement in learning activities, such as reading, writing, discussing and problem solving, to improve their communication and teamwork skills, and to address their versatile learning styles [9][10].

In practice these methods presume that students work in pairs or in small groups (see Figure 1). Students are given a question, a task or a problem to solve. First they tackle the problem on their own and then discuss it with their colleague or in a small group. Depending on the task this takes a few minutes. This discussion stage results in processing the problem further until sufficient agreement of the matter is reached. In this process students who are initially right, but not very confident of their opinions, become more confident when it appears that their peers have developed the same kind of answers and suggestions. Such reasoning that obviously leads to expected solutions reinforces their confidence levels [7].

The instruction practices used in cooperative learning and peer instruction offer students opportunities to communicate with each other using vocabulary and linguistic means that they share in common. The authors, as teacher educators in the field of engineering education, found that many concepts become easier for students to understand when they can discuss them among themselves. In doing so, they make use of their own conceptual and experiential frames of reference. At times unconsidered use of academic vocabulary and routinely adopted academic traditions of explaining learning material may confuse students. In the above mentioned arrangement, students present the solutions reached in pairs or groups and the individual student need not feel embarrassed for incorrect or not yet perfect answers and conclusions.

Interestingly, Mazur offers a likely reason why students are sometimes able to explain concepts more clearly than their teachers [7]. He states that students who understand a concept usually have only recently mastered it. They are still aware of the difficulties involved in gaining understanding and so they know what to emphasise when explaining the concept for others. However, the lecturer has gained mastery of the concept over the course of the years and experience. This inevitably leads to forgetting the initial difficulties in gaining understanding. Lecturers may no more know how to address such difficulties.

Peer instruction and cooperative learning enable students to practice the use of professional terminology. It is considered very important that they, in the process of instruction, gain the specific professional fluency typical and necessary in each professional field. Discussing and processing questions, tasks and problems also promotes acceptance and utilisation of different viewpoints on matters. In the class, the lecturer is available if help is needed and can react to instant feedback when walking around in class observing the work and asking for groups' opinions and justifications (see Figure 1).

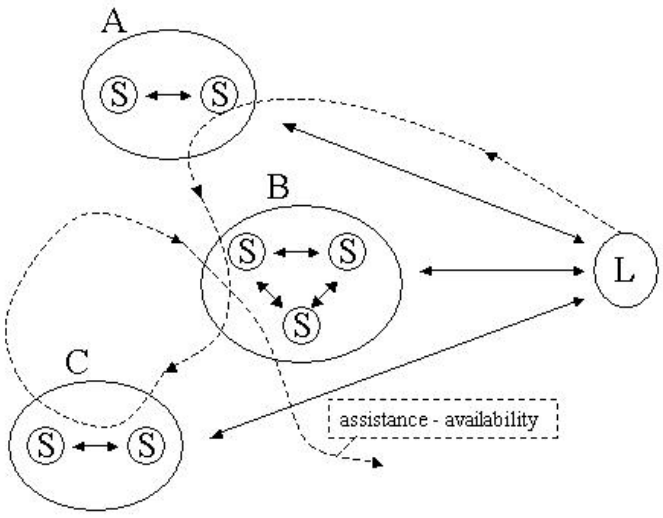

Figure 1: Combining peer instruction and cooperative learning. The lecturer (L) assists the students (S) in their group (A,B,C) works being available when needed.

Tests and Questionnaires

The teaching arrangements and this case study included tests that surveyed teaching staff's and students' learning styles and measured their self-directed learning readiness, plus a concept test on the subject matter for the students. Three questionnaires were also distributed to survey the students' opinions.

Students preferentially focus on different types of information in a learning environment. They tend to operate on perceived information in different ways and achieve understanding at different rates. These individual ways of receiving and processing information are called learning styles [11].

The Index of Learning Styles (ILS) indicates preferences of learners on a four-dimensional scale: active-reflective, sensing-intuitive, visual-verbal and sequential-global. Active learners prefer to learn actively and interactively while reflective learners prefer to function introspectively and individually

and to think quietly about matters. Sensing learners tend to focus on facts, data and algorithms. Intuitive learners feel comfortable with new concepts, theories and mathematical models. Visual learners respond to pictures, diagrams, films and demonstrations, while verbal learners get more from written and spoken information. Sequential learners tend to gain understanding in linear, orderly and small incremental steps, while global learners prefer holistic approaches and systems and learn in large jumps [12][13].

The Self-Directed Learning Readiness Scale (SDLRS) is composed of eight factors: openness to learning opportunities, self-concept as an effective learner, initiative and independence in learning, informed acceptance of responsibility for one's own learning, love of learning, creativity, positive orientation to the future and ability to use basic study skills and problem-solving skills. The SDLR-scale is a continuum where the lowest score is 41 and the highest is 205 [14].

Also students' knowledge of subject matter was measured by means of a diagnostic concept test on the first day. The test was compiled to show the type and amount of knowledge the students had from their previous courses and training and from life experiences.

Students' opinions about the teaching arrangements and their own learning were asked using three separate questionnaires as follows:

- An introductory questionnaire at the beginning of the Weaving Technology 1 course asking for the students' hopes and expectations of the course.
- A mid-term questionnaire after five weeks of work, asking for the students' opinions about the teaching environment and methods (anonymous).
- A final questionnaire at the end of the course asking for feedback on the whole course (anonymous).

Learning Assessment

It is customary in engineering education in Finland to evaluate students mainly on the basis of one written examination at the end of the lecture series [15]. However, a broader and more comprehensive picture of students' learning was sought in the Weaving Technology 1 course that would assist the researchers to reflect upon learning objectives and guide the research process. Evaluation was based on continuous assessment, as it focuses students' interests on continuous learning efforts and helps them keep a steady pace in studying. This makes learning more efficient.

Research Project

The aims of this case study were to:

- Gain experience in using the chosen teaching methods and arrangements and find out how they support learning.
- Find out and record students' opinions and experiences of these teaching methods and arrangements.

Special emphasis in this case study was placed on motivating and activating students and to increase their commitment to study. Qualitative methods were used to collect information regarding experiences and opinions.

METHODS AND MODE OF OPERATION

This research project examined how students and teaching staff experienced the teaching methods and arrangements adopted in the Weaving Technology 1 course. Special interest was given to students' learning and understanding of the subject matter, their active involvement in the learning process, students' motivation and commitment to study.

The Weaving Technology 1 course started in early September and continued for 16 weeks every Tuesday until mid-December. The first lesson focused on motivating and building students' commitment as described below.

Being a new teacher for this class the lecturer introduced himself and the laboratory technician to the students. He briefly explained the reason for the authors' presence. Having told them some details of his own career in industry and education he asked the students to introduce themselves and tell something about their backgrounds and expectations of the course.

The lecturer also introduced the Weaving Technology 1 course, its general goals, brief contents and explained how and why reform was to be carried out. He shortly described this research project and asked if the students were willing to cooperate and participate. The students expressed their willingness. The authors introduced themselves and explained to the students what kind of teaching methods would be applied in this course, what this research would focus on, what the research methods would be, the timetable and special features of the course (see Table 1).

A short demonstration was given to show an example of the teaching methods to be used. The demonstration helped the students to see what they would be involved in. It also gave them an experience of the activity levels needed in class work. After the demonstration, the students willingly agreed to participate in the project. A more detailed description can be found elsewhere [3][16]. The authors also emphasised that learning requires everyone's personal activity and participation, the idea being that a successful learning process requires students to take responsibility for their share and the teaching staff for theirs [7].

Next, the lecturer introduced the curriculum, some relevant literature and study material for the course. After this, the students applied the method introduced by spending a few minutes pondering, first on their own and then in pairs, what they want to learn during this course. The lecturer collected the results on the blackboard asking every pair for their opinions. He promised to take them into account when completing the goals and contents of the course. Thus, the students had the possibility to influence course content. The students were also asked to suggest rules and norms of the course, such as class attendance, doing pre-class tasks, and finishing reports and laboratory works on time. The lecturer asked *How do you think it should be?* and let the students decide. The students agreed on pretty strict rules and timetables.

The first day's activities covered: introductions, answering the introductory questionnaire, concept test, learning styles and self-directed readiness tests, as well as starting the teaching. Students needed about 1½ hours to complete the questionnaires and tests.

Table 1: Timetable and special features of the teaching arrangements.

	Teaching and Learning	Researchers
1st Teaching Day	Motivation and commitment	Observation
	Introductions: Teacher, lab. technician, students, researchers	Tutoring discussions with the lecturer 10 times during the course
	Curriculum	
	Teaching arrangements and methods	Demonstration of peer instruction and cooperative learning
	Introductory questionnaire	
	Tests: Concept test, Learning styles, Self-directed readiness	
		Analysing of ILS and SDLRS
	Working in pairs and groups	
	Discussion on goals	
	Demonstrations and elucidations	
	Agreeing on rules and customs	
2nd Teaching Day	Motivation and commitment	Observation
	Feedback on concept test and introductory questionnaire	
	Agreeing on goals, rules and responsibilities	
3rd Teaching Day	Ordinary class and laboratory works	
	Teaching arrangements and methods applied as agreed	
4th Teaching Day	Feedback discussion with every student: *Have you learnt? Is class useful?*	Observation
6th Teaching Day	Mid-term questionnaire	Observation
		Personal feedback discussion on ILS and SDLRS tests outside class
7th Teaching Day	Feedback discussion on basis of mid-term questionnaire	
	Motivation and commitment	Observation
	Refining the methods	
	Pre-class task given both on web page and as a paper version one week ahead	
9th Teaching Day	Feedback discussion with every student: *Have you learnt? Is class useful? Do you have any problems?* Preparation for the excursion, pre-class tasks for the excursion to two textile factories	Observation
10th Teaching Day	Excursion to two textile factories	
11th Teaching Day	Discussion on details of the excursion	Observation
	Evaluation of the excursion day	Personal focused interviews of the students during the next two weeks
14th Teaching Day	Final questionnaire	Observation
15th Teaching Day	Exam	
	Special classification of exam questions	
	Self-assessment questions in exam	
16th Teaching Day	Feedback discussion on the exam	Observation
	Feedback discussion with every student on the whole course, *Did you achieve the goals we agreed on?*	
		Personal focused interviews of the lecturer and lab technician

Note: Ordinary class and laboratory works, teaching methods and arrangements applied as agreed on 5th, 8th, 12th and 13th days.

The Introductory Questionnaire

The following questions were modified on the basis of Mazur [7]. These were asked in the introductory questionnaire, which has the following format:

1. What do you want to learn during this course?
2. How do you want to use the new knowledge you have learned?
3. How do you assume the lectures and laboratory work will benefit you?
4. How do you assume the course material will benefit you?
5. What is your own estimation of your rate of attendance in class? _____ %
6. How many hours do you assume you will use for the following:
   Attending lectures: _____ hours/week
   Getting prepared for lectures including pre-class tasks: _____ hours/week
   Doing exercises and lab reports: _____ hours/week
   Studying for the exam: _____ hours totally
7. Space for free comments.

The purpose of the questions was also to build positive expectations of what was going to happen and to show students that their learning was considered important.

The Concept Test

The lecturer responsible for giving the Weaving Technology 1 course has eight years of experience in teaching the contents that comprise the new Weaving Technology 1 course. He knows by experience what concepts students need so that they can follow the course. The authors became familiar with the

course contents and chose concepts that would be needed in order to use the instruction material fluently. The authors' choices were compared with those of the lecturer and, after that, the lecturer compiled the subject matter concept test.

Students were asked to evaluate how confident they were of their answer of every question being correct. The scale was from 1 (= very unsure) to 4 (= absolutely sure). The answers to the concept test gave an idea of what students knew after one year of textile engineering studies at Tampere Polytechnic. One purpose of the subject matter concept test was to give students a picture of what they were supposed to know at the start of the course. The lecturer gave general feedback on the concept test and the introductory questionnaire one week later.

Learning Styles and Self-directed Learning Readiness

There are many learning style models; one of the best known is Kolb's model [17]. However, the authors choose the Felder-Soloman Index of Learning Styles (ILS) [11]. This was because it had been frequently used in research done on students of engineering [18]. The students and the teaching staff answered a Finnish translation of the paper and pencil version of the ILS questionnaire [11].

The ILS was used to help determine students' learning preferences and to assess probable individual strengths, tendencies and habits that may affect learning. The authors also wanted students to become aware of their own preferences as well as the lecturer to be aware the of preference profile of the class. The idea was to encourage the lecturer to really use the various teaching methods that had been planned, the use of which had been agreed on, since there were good reasons to assume that they sufficiently addressed the different learning styles of the students [18-20].

The objective of the use of the SDLRS was to show students that their own responsibility and activity play an essential role in igniting a life-long learning process. Additionally, the authors considered the SDLRS test as a means to enhance students' study motivation. Students and teaching staff received personal feedback on the ILS and SDLRS tests during the sixth week.

Before the second week's class, both the introductory questionnaire and the subject matter concept test were analysed by the lecturer and authors. A tutoring discussion was also held with the lecturer in order to talk about the feedback given to students. This should serve the aims of this research, motivate the students and commit them to working towards the goals that had been set.

The second week's class began, as all from now on would do, by introducing the general agenda of the day. The lecturer gave feedback on the introductory questionnaire by emphasising the positive impact the students had made on him and the positive expectancy he now had of the course. Mostly, he agreed on the comments and opinions of the students. However, he made a couple of comments explaining why some special wishes could not be fulfilled. He emphasised the importance of active thinking and participation in general, and the importance of the pre-class tasks as a means to improve learning. The final course content was agreed on. After having discussed the results of the subject matter concept test, the lecturer and students decided that repeating some concepts would be necessary both independently outside the class, as well as in the class.

The Mid-term Questionnaire

Feedback was collected after five weeks of studying. The mid-term questionnaire was modified on the basis of Mazur [7]. The following questions were included in the questionnaire:

1. What do you like about this course?
2. What do you hate about this course?
3. If you were teaching this class, what would you do? Why?
4. If you could change one thing in this course, what would it be? Why?
5. Your opinion on the course material: positive and negative points.
6. Space for free comments.

The objectives of the mid-term questionnaire were to find out if there was something that the students seriously disliked, to strengthen the students' motivation and commitment and to demonstrate interest in their opinions and learning.

The Final Questionnaire

The students answered a final questionnaire one week before the exam. The final questionnaire included questions about learning, teaching arrangements, students' feelings, teaching staff, course content, as well as the use of time (Appendix 1).

Observation and Tutoring

The authors were usually present in class and always at special situations, such as feedback discussions. When observing the class, special attention was paid to the implementation of the teaching method and the learning atmosphere. Tutoring the lecturer was based on these observations. Attending the lessons helped the authors keep in touch with the situation. Additionally it showed the authors' interest in the project, which was considered important from the point of view of the motivation of the lecturer and the students.

Ten tutoring discussions were held during the 16-week period, in addition to the discussions before starting the course. The aim of the tutoring discussions was to tell the lecturer what had been noticed, to support and guide him and to exchange ideas. The authors and the lecturer together agreed on possible changes and further actions.

Learning Diaries

The students kept learning diaries, which the lecturer read once during the course and after the course had finished. The diaries were also at the authors' disposal.

The Examination

The examination included questions measuring students' learning and understanding of the subject matter. One question asked them to evaluate the questions they were asked. Two specific questions queried students on how confident they felt of their answers being correct.

The Interviews

All students, the lecturer and the laboratory technician of this course were interviewed. The students' interviews took place in an otherwise empty classroom during the 10^{th} and 11^{th} week.

Each interview took about one hour. The interviews were recorded and transcribed. The teaching staff was interviewed after the course. Some of the questions were related to this course and some questions were made to get a general view of the students' study life. The questions were differentiated depending on whether the interviewee was a student or teacher.

The themes of these focused interviews where:

- Students' study habits and learning strategies.
- The general learning environment.
- Background and motivation for the choice of vocation.
- Ideas on high quality teaching.
- Learning assessment methods: is meaningful learning and understanding measured?

RESULTS

Meaningful learning and holistic understanding was achieved.

Students had been asked both in the introductory and final questionnaires what their goals were that they had set for this course. The answers revealed that their goal setting was both ambitious and realistic: ambitious in the sense that they really wanted to get a holistic picture of weaving technology, realistic in the sense that their goals, to a large extent, corresponded to what was planned to be included in the course and what was possible to be achieved.

Almost every student wanted to learn something of the relevant machines, especially of weaving machines, and of the whole weaving process from the beginning to end. The lecturer was especially pleased with the way one of the students expressed her goal: *I know how to do things I am able to present to others what I have done and I am capable of evaluating it*. It is not self-evident that engineering students would set their goals as clearly as this student does. In fact, the interviews revealed that the students' picture of the duties of a textile engineer were not at all clear when starting their studies the year before.

Students were asked to evaluate in the final questionnaire how they had achieved the goals they had set for themselves in this course. Everybody said they had learnt a lot. One student said she had learnt more than expected and one said she had received a solid basis for future weaving courses. All but one of them felt they had nicely achieved their goals and most of them were certain they had learnt very much of the machines and the weaving process. There was only one student whose opinion is considered to be an exception among the expressions of general satisfaction. Nevertheless, she, too, experienced being on the way to the right direction towards her goals. She answered in her final questionnaire: *Maybe I didn't quite achieve what I wished, but I am moving in the right direction anyway*.

The students were satisfied with their learning results as these two typical extracts from their learning diaries show:

- *As to my learning I have internalised things and understood why things are how they are. Full internalising can take time … it is a wonderful feeling you have when you realise that you understand something. It's great and it brings enthusiasm to studying*.
- *I have learnt lots about a textile mill and the phases needed to make it all work … There is still much to learn in this field, but when one knows the basics, one can figure out new, not so simple things by reflecting*.

The authors could rely on the lecturer's opinion on students' learning because he has solid experience in the field. According to his diary and the opinions he expressed in the interview, the group had made steady progress, clearly better than the groups he had lectured to before. He was also pleased with the amount of subject matter covered during the course. He estimated that he had now covered 25% more subject matter than before. He told us that all students certainly passed the final exam and almost all of them mastered the basics excellently. The lecturer said:

> *The group was of homogeneous character. I expected more excellent grades, but anyway, no one hit the bottom. The group was more homogenous than I have ever had before. There were no poor grades even though I demanded more than average learning*.

The problems and questions presented in the exam had been compiled so that the understanding of the subject matter could be measured. The lecturer stated: *Mere rote learning was not sufficient in passing the exam.* Students shared his opinion; the authors heard some students commenting on the exam: *It's no use just memorising things for this exam because applications are required*.

Students' abilities to evaluate their learning were appraised by the lecturer on the basis of the final questionnaire and feedback discussions. He appreciated the fact that the students had learned to reflect on their learning dispassionately, although, of course, subjectively. He stated further that the students had improved in their abilities of evaluation, self-assessment and estimation of situations during this course. They were able to observe the teachers, teaching activities and their own learning from an outside perspective, which was new to them.

A self-assessment task was included in the final exam. Students evaluated how confident they felt about their answers in two of the questions. When comparing the students' own evaluation with that done by the lecturer, it was concluded that the students had a reasonably accurate idea of their own subject matter knowledge. There were only a couple of students who slightly underestimated their knowledge. Two students out of ten had expected to get more points from one of the questions than they actually did. The students' confidence had grown when compared with the subject matter concept test completed at the start of the course. The authors, in evaluating the concept test results, were greatly astonished on how often the students did not appreciate their own correct answers. Figures 2 and 3 show that, even though the students gave a correct answer, they felt uncertain or very uncertain in the concept test, whereas in their final exam, they were certain or very certain about their correct answers.

The teaching arrangements and methods were received with almost unconditional acceptance. The students expressed very positive opinions in the mid-term and final questionnaires. They appreciated the efforts that had been made with the teaching arrangements. Another aspect they expressed appreciation over was that so much emphasis had been placed on their learning. According to the students, the integration of theory and practical work had resulted in a successful reform.

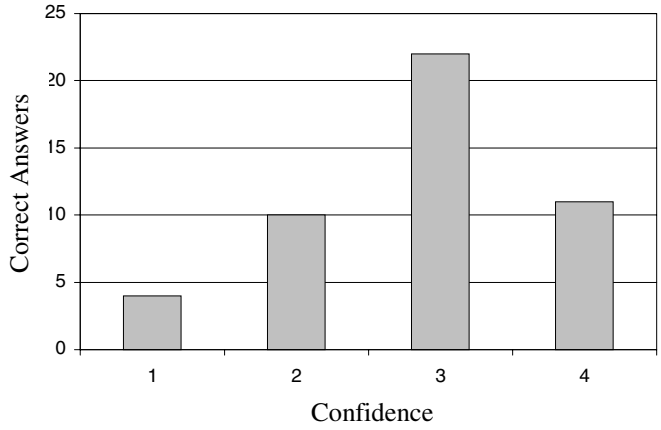

Figure 2: The confidence of 47 correct answers in the subject matter concept test at the beginning of the course. The test included 100 answers, of which 47 were correct.

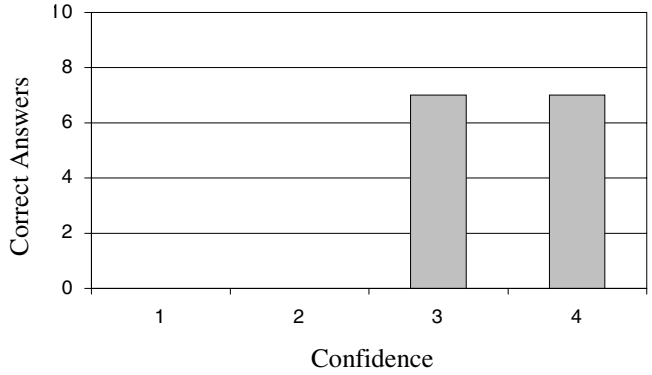

Figure 3: The confidence of 14 correct answers in two questions in the final exam. The total number of answers was 20, of which 14 were correct.

A couple of examples of typical students' comments on the question: *What did you find most rewarding in this project?* include:

- *The integration of the courses and lab work, combining theory and practice. The lecturer's genuine interest in the students' learning.*
- *Time and energy have been used … the lecturer has planned the daily agenda well and the topics are clear … It's nice that you are interested in our learning.*

The information obtained from the mid-term questionnaire was very encouraging. In the first place, it was interpreted as an encouragement to continue the project according to the original plans. The students valued the lecturer's attitude and enthusiasm and said that he had succeeded in creating an encouraging atmosphere where everybody was equally cared for and that the daily work was well planned. All except one student thought it was a good idea to reserve the whole day for the same subject, ie the Weaving Technology 1 course. Students stated that they enjoyed the day and that time passed quickly. They also appreciated having the opportunity to get actively involved in the learning process and doing things on their own, in pairs and in small groups.

All in all, the mid-term questionnaire raised three opinions on the basis of which some changes were made: some students hoped for a tighter schedule; all of them had difficulties in getting the pre-class tasks from the Web pages and wanted to have a paper version; and several wanted more practice for using the machines. All of these changes were implemented.

The student interviews included several questions where students could comment on the teaching arrangements and the integration of theory and practical work. Mainly positive expressions were used. Students indicated that it was good that one whole day was reserved for this course; statements given by three students reinforced this.

One of these students, when asked what she considered difficult in her studies, answered: *Such things are difficult where there is just lots of theory … when there are practical things in the way we now have, it is always easier to understand.*

She continued and described what she considered useful:

> *I think it is useful to do some practical work too, and not just have transparencies swung at you one after another. I don't learn that way. I myself like it when we go through some theory and then go to the weaving laboratory and also do those things in practice. Well, of course, the teacher is enthusiastic and really wants us to learn.*

She is not quite certain when she describes her feelings about the seven-hour package:

> *I have not experienced it very negatively; however it's bad when we cover so much in one day, it might be easier to have class twice a week, you could repeat things in between. But it has gone well this way actually: no problems.*

Another student commented on the teaching arrangements as follows:

> *I learn there much better than if I were to go separately to a theory class and a lab class. The lab class might even be later on, maybe even several months later … Even though it's a long day … I enjoy it and the teacher is good.*

When asked about the balance between theory and practice, the student made the comparison that:

> *We had a course last year, which we called … It was so that we had theory and maybe weeks later we went downstairs to have a quick look at some experiment. We flailed around like this; just imagine what came out of it. Nobody learnt anything.*

A third student's comments also gave evidence of the popularity of these teaching arrangements:

> *It has felt nice. Class has varied, not only theory and practice, but things have been done from beginning to end. It has been good and time has flown. You have got something done and things stick in your mind when you have done something and pondered over it.*

All of the other students pretty much held the same opinion as those cited above. However, the most critical opinion put forward was:

> *At first, I thought it was a really good solution; actually I still think it is good; there is the possibility to have the theory in the classroom and then we can go to the machine and have a look. Otherwise, it would be too separate and I remember from a course last year dealing with machine elements. We wondered what on earth are those parts, of course we could draw them in the exam, but we had no idea where they were used and where they could be found. So this is good, we can go there at once and see, but now, gradually I feel that we should have five hours there on Tuesdays and then two hours theory some other day, because it is very tiring in the end. … But it's good that it at some stage is a bit longer, but two hours could perhaps be somewhere else.*

Students' answers to the final questionnaire did not present many new aspects. Indeed, students held their opinions till the end. No new problems arose and some earlier problems had been dealt with in a satisfactory way. Questions 1, 8, 9, 14 and 15 (see Appendix 1) dealt with teaching arrangements and the grades given settled mostly between 4 and 5; the scale being from 1 (very poor/very little) to 5 (very good/very much).

Students were also asked in Question 19 what was most rewarding and in Question 20 what was most troublesome in the course. Question 21 was reserved for free comments. There are several matters that the students expressed great satisfaction over: the teaching arrangements, the integration of theory and practice, the motivation of the teacher, the possibility of getting involved in something that they considered important and relevant, as well as the possibility of really *doing* something. They liked handling the whole weaving process from beginning to end.

Although the lecturer did not always give straightforward answers or tell the students what to do and how to do it, this did not generate criticism. On the contrary, students' comments on his strategy were positive: *You had to think on your own because the teacher did not tell straightaway how things are. You learned to reflect*.

Pre-class Tasks

Students had agreed to pre-class tasks, which proved to radically increase the time and effort they used to get prepared for each class. They all regarded the pre-class tasks as a good solution because getting prepared now became a necessary duty. Students said that pre-class tasks helped to focus their attention on essential matters. They also helped the class to pay greater attention to those matters they had not yet understood.

The interviews revealed that seven out of ten students normally never prepared for class by reading or getting acquainted with the forthcoming items. Three students said they might sometimes do some preparations, eg repeat something from previous lectures. Some typical comments to the question *How do you prepare for class?* included: *Too little, formerly I had this skill, but nowadays I am just too lazy. I know that I should prepare myself.*

After a hearty laugh, one student said: *So, well, I don't particularly prepare myself, I should probably, but it does not come out to much.*

Students described the benefits of the pre-class tasks as follows:

- *I think they are good, you learn better when you first read on your own and hear it again in class … I myself have experienced these pre-class tasks as good, you get acquainted with the items beforehand.*
- *It's good, not everything is new. You have some kind of basis anyway…*
- *Yes they have been useful. When there are new things you have familiarised yourself with it, even though you understand nowhere near everything.*

One of the students gave some ideas on how to develop the pre-class tasks. She wished they could cover a broader scope, but not be included in every lesson.

The lecturer felt very satisfied with the conscientiousness that the students showed in doing pre-class tasks. The first few weeks were somewhat troublesome because the Web page worked poorly. Once this problem was solved, it was a rare exception if somebody had missed doing the pre-class tasks. All answers and solutions were not always entirely correct, but students had shown a serious effort and the pre-class tasks had served their purpose. The lecturer's estimation was that over 90% of the pre-class tasks had been done satisfactorily during the course. The students were more modest in evaluating their diligence in doing pre-class tasks; the mode of students' estimations in the final questionnaire was 4 (Appendix 1, Q.6).

The lecturer expressed his contentment with the pre-class tasks in many instances during the course and in his interview:

> *… the researchers introduced the idea of these pre-class tasks. This is such a simple thing that it should have been thought of 300 years ago, and be in general use in the school system … Time has been wasted in vain when pre-class tasks have not been in use … But for me, these pre-class tasks are a big thing … I wasn't able to think in this way, that's why it felt foolish, because it had not crossed my mind, I had not been able to apply them … This has made an impact on me and, as I said earlier, it seems just stupid that a pre-class task system like this has not been in use earlier.*

He described the students' positive attitudes as follows:

> *I think the students grasped the idea of pre-class tasks almost with too great an enthusiasm, in view of the material they had, what I had ready for use in weaving technology and what they had available. The students grasped this idea at once and I even imagine that they would be very satisfied if someone else also were to use pre-class tasks.*

Cooperative Learning

The student interviews revealed that most students studied alone and also preferred studying alone, even though some could see the benefit of working in pairs or groups. The authors' experiences as lecturers and teacher educators in the field of engineering education has shown that teamwork and cooperative learning are not in frequent use. However, there fortunately seems to be some interest developing now. The teaching arrangements in the Weaving Technology 1 project

included many elements of cooperative learning, peer instruction, working in pairs and small groups.

Observations made in this project demonstrated that these students adapted to the use of new methods and felt satisfied with them. It could be seen that the students started working as soon as they understood the assignment. They also completed their assignments; no one stood aside or took *free rides*. Students were of the opinion that the teaching arrangements were beneficial in view of learning. In the final questionnaire they valued the lectures giving scores of 4 (good) and 5 (very good). Similar scores were given for the laboratory works (Appendix 1, Q.15a & b). One exception among the positive evaluations was a student who did not value the laboratory works and scored two in the final questionnaire (Appendix 1, Q.15b). An explanation for this exception is that, in some instances, the group size was four and she did not feel that the division of duties was suitable.

Another interesting case was a student who, on many occasions, stated that she liked neither group work nor working with machines. She said that group work seldom fits her study pace and habits. This same student answered the question*: How does a good student act?* stating that a good student is active, creative and considerate towards other students. A good student shares his/her knowledge with peers. Yet it was never noticed that she would have been somehow unhappy when working in groups. Maybe she just wanted to act like a good student; in her words, she *practised as she preached*.

Also the mid-term questionnaire showed that the teaching arrangements had supported learning in a satisfactory way. Nobody complained about the peer instruction or group work; indeed, students seemed to like it. Answers to questions like *What do you like in this course?* explicitly refer to the positive experiences gained in group work:

- *Pondering in groups is both nice and a useful way to learn.*
- *We go through things, then we handle applications with the help of exercises and group work.* She continued using the Finnish version of *Repetitio mater studiorum est.*

During the interview, the lecturer expressed his opinions about the group dynamics that had developed during the course. He felt great happiness about students' collaborative and caring working attitudes. As an experienced teacher, he based his opinions on the many earlier groups he had taught. An openness to learning, to one another and to questions were results that the lecturer placed particular emphasis on. Students preferring group work instead of individual work gave him special satisfaction:

> *I think the students are more open towards learning, more open towards each other, more open towards questions and particularly more willing to start to solve their exercises together than other groups have been.*

The lecturer told us that he had initially been worried about some students being left aside from the teams, but that never happened. Rather, students took care of each other; they checked that everyone understood what was being done and automatically started tutoring one another.

> *But they learned … they learned something very important, to look after each other … I think this is one of the most important things you can learn … But this group learned also to check that everybody in the group had understood … if somebody had missed something or was nowhere near the solution, they started, without any mocking, to tutor this student back to the picture.*

The learning diaries revealed to the lecturer that students had adopted an open and helpful attitude; this was not customary in their Department: *The students had learned to share distinctly in another way than what has been customary in our Department.*

The lecturer drew the conclusion that students' abilities of social cooperation had grown by leaps and bounds and he felt very proud of this: *That's something to be proud of. This is the point. This is our point indeed*.

There was no usual passiveness to be detected in the class. The authors' experiences have shown student absenteeism from class to be increasing alarmingly over the last few years in engineering education and, even when present, the students often assume a passive role. However, student absenteeism from class in this course was a rarity. The final questionnaire (Appendix 1), where the students evaluated their motivation, commitment and activity, gives a mode of 3 for class preparation (Q.5), a mode of 4 for doing pre-class tasks (Q.6), and a mode of 4 for activity in both class (Q.7a) and lab works (Q.7b). Interaction was also appreciated giving a mode of 5 (Q.9).

Already the mid-term questionnaire revealed that the students were committed and motivated to get actively involved in their learning process. The students' opinions were positive and one answer to the question *What would you do if you where a teacher in this course?* describes their attitudes well:

> *I would probably do things the same way. The teacher has with his own attitude managed to create a different kind of atmosphere than that which was, for example, last year in … The atmosphere is enthusiastic and this brings a motivation to study and a desire to learn.*

Test Results

The results of the ILS test are shown in Figures 4-7, whereas the results of the SDLRS test are illustrated in Figure 8. The results show that versatile preferences are represented in this group. However, students and teaching staff all seem to be visual. The scale for the SDLRS test ranges from 41 to 205. The left end of the axis refers to learners who want to be taught and consequently do not enjoy independent study; the right end refers to learners who are self-directive and enjoy taking responsibility for their own learning.

DISCUSSION

Learning and understanding are not altogether easy concepts to define. The utmost goal for this teaching experiment and case study was to enhance students' learning and understanding. The authors have discussed these concepts elsewhere [21][22]. These formed a basis for the tutoring discussions with the lecturer. This research, as with others the authors have conducted (to be published), it has been noticed that students often do not concentrate on a specific subject until the

examination approaches. This tends to lead to adopting study habits by means of which students pass examinations, but never come to the level of meaningful learning and understanding of the subject matter. They do not learn the habit to take enough time to process things, reflect, compare and contrast topics, identify relationships, study cause-and-effect relationships and integrate information into larger entities.

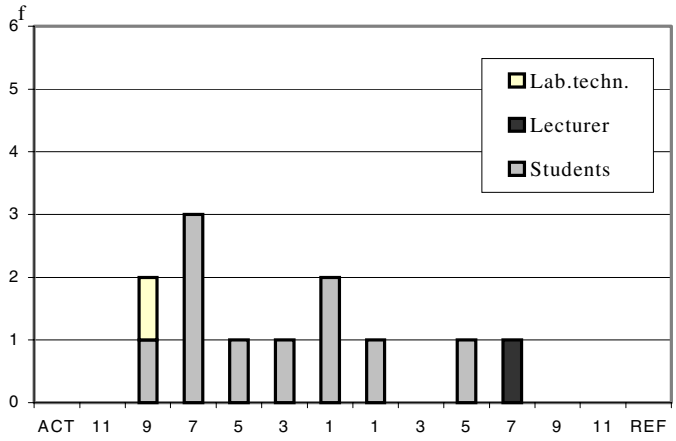

Figure 4: The learning styles dimensions active-reflective. The number of students tested = f.

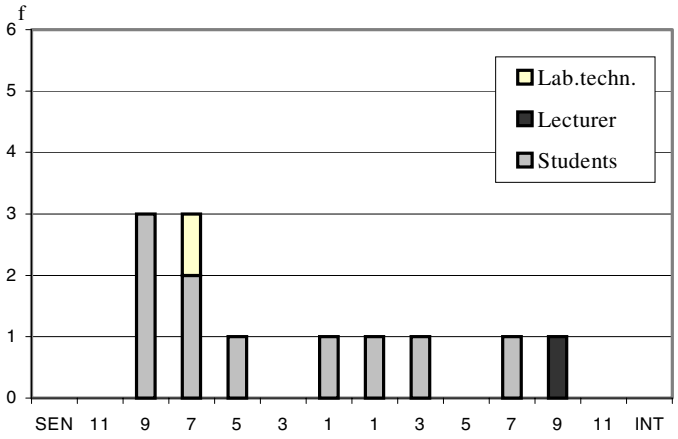

Figure 5: The learning styles dimensions sensitive-intuitive. The number of students tested = f.

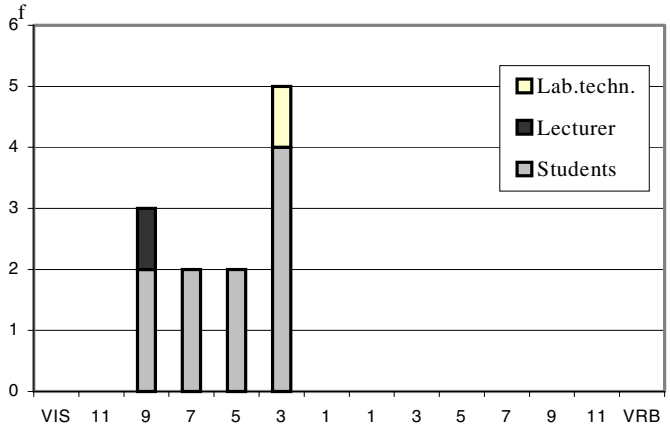

Figure 6: The learning styles dimensions visual-verbal. The number of students tested = f.

A constructivist approach to teaching and learning was adopted in this experiment. As such, instruction methods were chosen that contain elements that support constructivist ideas, including:

- Prior knowledge as an essential factor for effective learning.
- Emphasising understanding to promote a meaningful construction of knowledge.
- Learner's own activity and social interaction as a basis for good learning.
- Flexible curricula to account for individual learner skills.
- Relativity and variability of knowledge.

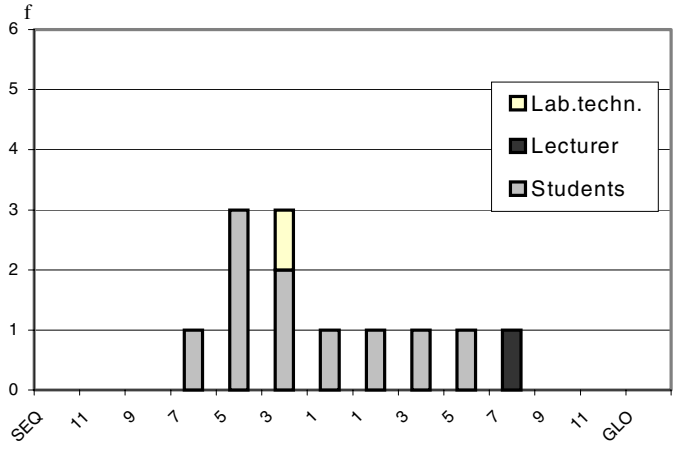

Figure 7: The learning styles dimensions sequential-global. The number of students tested = f.

The students had opportunities to actively take part and process questions and problems on their own, in pairs and in groups. Class activities gave the students many and varying possibilities for cooperation and communication. They took part in negotiations, shared opinions and experiences, debated, disputed and looked for agreement in various kinds of situations. The authors consider that all this helped them become actively involved in the learning process so that meaningful learning could be achieved.

The interviews revealed that the students had come to study textile technology more or less coincidentally. They did have some interest in knitting and weaving as a hobby, but were not sincerely aware of what they had gotten into. One conclusion to be drawn from this is that special emphasis has to be on motivation and commitment in such a case.

The number of student places in engineering education in Finland is great in comparison with the size of the age group. This has resulted in a situation in which quite a few of the incoming students may lack the necessary orientation towards a technical way of thinking. This has to be taken into consideration when the teaching is planned. The Weaving Technology 1 project offered students many opportunities to become acquainted with the technical details of the weaving process and the machines needed in it.

It could be concluded from the authors' observations that the students had taken responsibility not only for their own learning, but also for the learning of their peers. This is considered to be due to a good learning atmosphere in the class. It is thought that creating a positive atmosphere in the class encouraged motivation and strengthened students' commitment to their studies, which, in turn, supported learning and improved their self-esteem as learners and future engineers of textile technology.

All students' comments on the working atmosphere were positive. One student compared how things differed from the previous year:

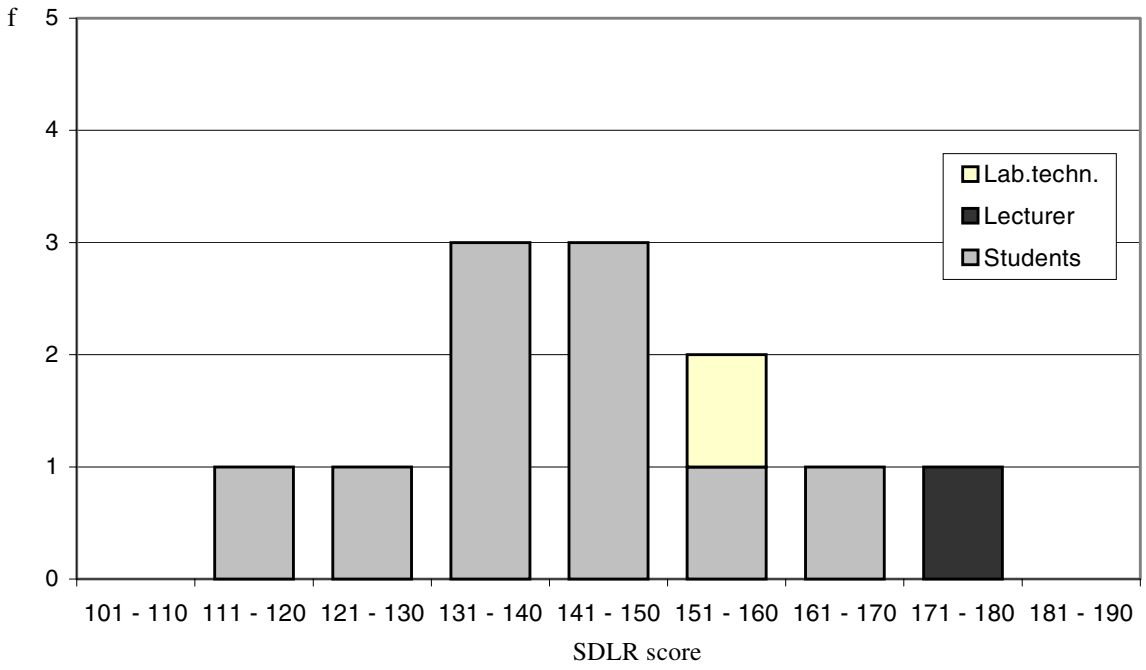

Figure 8: The results of the SDLRS test. The number of students tested = f.

> *You could see this even last year, now there is not much non-attendance, now it doesn't matter who is your pair, it can be whoever, we are all alike. Last year, there were those who didn't do their jobs; you didn't necessarily enjoy working with them.*

The teaching methods were found by the students and teaching staff to be pleasing and fruitful. The integration of multiple teaching methods, which was actually the case here, clearly enhanced students' participation. This method gave the possibility for more shy and quiet students to get their opinions and questions brought forth by means of the group. The lecturer expressed this in another way: *There are personalities and characters to whom it is not the most pleasant experience to communicate as an individual in front of a group with older people, for example the teacher.*

The lecturer has a very sound idea of what he wants to measure in his exams. He wants to produce questions where he can find out if students have a holistic view of the issues covered in his courses. He always tries to include questions where the students have to combine things from several topics, analyse and evaluate and, above all, *use their brains*. Just learning a few points from here and there is not enough.

The final questionnaire revealed that the broader method of evaluation was appreciated. Some students had also revealed in their interviews that they became very stressed when having to take an exam: all work they have done for the course is hanging on just one string. The students appreciated a more extensive evaluation of their abilities and found that their knowledge improved when evaluated in this way.

The results of the ILS test (Figures 4 to 7) were well in line with other reports on this subject. The students' learning styles were in most cases somewhat heterogeneous. The lecturer's learning style was quite different from the students' on the active-reflective, sensitive-intuitive and sequential-global scale. It is not unusual that the lecturers use teaching styles that address their own learning styles. If students are taught exclusively in a manner that favours their less preferred learning style, then they feel uncomfortable and this can interfere with their learning. However, this does not mean that students should be taught solely in their preferred learning style. The teaching arrangements included lecturing, active involvement, individual and group works, introducing theory and doing laboratory work, among others. A wide range of topics and ideas was covered and most learning styles in the class must have been addressed. [12][18-20].

The SDLRS test helped the lecturer in planning his teaching so that students recognise their means of action and gave them a frame of reference, whereby they could observe their own functioning more structurally. Doing tests and gaining personal feedback also gave students some pointers. Despite the SDLRS test results, the setting of new goals can be made in order to develop skills in self-directed learning. These reasons justify the use of these tests as an instrument to help a lecturer in planning and strengthening students' learning strategies. This is despite the fact that the validity of the ILS test has not been proven [23]. Furthermore, the validity and reliability of the SDLRS test is controversial and undergoing scientific debate [24-27].

Answering questionnaires, undergoing tests, discussing and receiving feedback gave students a feeling that they were important and that the focus was specifically on their learning. This helped to motivate and commit them so that they made great efforts to do their share of the bargain. They also learned self-assessment and peer-assessment techniques and to value their strengths and develop their weaknesses.

In order for a teaching strategy to be effective, it must be well received. The authors noticed that, when tutoring teachers to apply new teaching strategies, students often require a period of adjustment to new methods of instruction before learning improves. This has also been well established in other reports [8][28]. The authors found that the time required for adjustment in this project was short and that students had an eager attitude

right from the start. This was also probably due to the input on the first day of teaching.

A clearly positive change was noted when comparing the confidence rating of the concept test with that of the exam: there was an increase in the students' confidence. It was concluded that cooperative learning and peer instruction, including the *convince-your-neighbour* discussions and motivating atmosphere, had an influence on this. The ability of being able to evaluate the correctness of an answer and having confidence in what you are doing are requisite skills for engineers.

There are many reasons why these teaching methods and arrangements turned out to be successful. However, the lecturer played an essential role; he mastered the subject matter and grew to trust and master the teaching methods he was probing. It was important that he had a sufficient pedagogical way of thinking and the ability to reflect over his actions from a pedagogical point of view. He displayed good pedagogical content knowledge, which also increased during this research project [16][29-32].

In this case, the lecturer's motivation and commitment, combined with his talent, gave an ideal background for applying these teaching methods successfully. In evaluating the results, the authors are certainly aware that the students' positive feedback is partly due to their positive attitude towards the lecturer and to their consciousness of the attempts to make improvements. This has been reported in other studies as well [8]. Furthermore, the so-called Hawthorne effect cannot be neglected. The feeling of being studied has been shown to have a positive influence on target groups [33].

Both the lecturer and the laboratory technician reported that they had some excess work in planning and carrying out this course. However, they also said that they had enjoyed it and that the work was rewarding. In many instances, they had observed that the students had stayed after class to do their tasks. They had not experienced such a good level of interest and atmosphere with earlier courses.

Teaching always teaches learning. What makes teaching worth doing better and better are the experiences students have. Students' comments on the efforts made, as in the extract below, are the most rewarding feedback we, as educators, can ever dream to have:

> *And what then has been the benefit of this all? How many times have I not gone to an exam having read a lot, but learnt nothing? When school started in fall, I felt as if I had never been to any school and all learning was gone with the wind. This was probably not the case, but I am pretty sure that before my learning technique was rote learning and that way things don't stick to your mind. Now I believe I can use my* hard disk *much more efficiently.*

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Appendix 1: Student feedback sheet

TAMPERE POLYTECHNIC STUDENT FEEDBACK
Textile Engineering 12.12.2001/K&S-R
Weaving Technology 1 5 cu

Read first all the questions in order to get a general picture of what is asked. Give your opinion by circling the number, which corresponds to your opinion. Your feedback is important, in order to further develop this course.

I used _____ hours in total to prepare for class doing my pre-class tasks / homework during this course.

The best way for me to learn during this course was (attending class, studying on my own, during laboratory exercises, reading books/relevant literature, using the Website, reading my own notes, etc):

Scale: 1 =very poor/very little, 2 = poor/little, 3 =average, 4 = good/much, 5 = very good/very much

(NB: Number of students representing an opinion is shown in brackets and italicised)

Question	Very Poor/Little				Very Good/Much
1. The teaching corresponded to the curriculum	1	2	3	4 *(7)*	5 *(2)*
2. The lecturer's teaching efficiency					
a) in class	1	2	3	4 *(5)*	5 *(5)*
b) during laboratory works	1	2 *(1)*	3 *(4)*	4 *(4)*	5 *(1)*
3. The lab technician's efficiency	1	2 *(1)*	3 *(3)*	4 *(5)*	5 *(1)*
4. My prior knowledge was	1 *(1)*	2 *(5)*	3 *(3)*	4 *(1)*	5
5. I used time preparing for class	1	2 *(2)*	3 *(5)*	4 *(3)*	5
6. I did the pre-class tasks	1	2 *(1)*	3 *(4)*	4 *(5)*	5
7. My own activity					
a) in class	1	2	3 *(4)*	4 *(6)*	5
b) in laboratory works	1	2	3 *(4)*	4 *(5)*	5 *(1)*
8. Integration of lectures and lab works	1	2	3	4 *(3)*	5 *(7)*
9. Students' and lecturer's interaction	1	2	3 *(1)*	4 *(3)*	5 *(6)*
10. Teaching proficiency of the lecturer					
a) in class	1	2	3	4 *(7)*	5 *(3)*
b) in laboratory works	1	2 *(1)*	3 *(5)*	4 *(4)*	5
11. Laboratory technician's proficiency during laboratory exercises	1	2	3	4 *(8)*	5 *(2)*
12. Amount of new topics	1	2	3 *(2)*	4 *(7)*	5 *(1)*
13. Level of difficulty	1	2	3 *(5)*	4 *(5)*	5
14. Clarity and comprehensibility of the teaching	1	2	3 *(1)*	4 *(7)*	5 *(2)*
15. Usefulness of the teaching arrangements from learning viewpoint					
a) in class	1	2	3 *(1)*	4 *(6)*	5 *(3)*
b) in laboratory works	1	2 *(1)*	3 *(2)*	4 *(4)*	5 *(3)*

16. In what way do suggest that your knowledge should be evaluated in this course? (The way it is done now, in some other way, etc.)
17. What were your goals in this course?
18. Describe how you achieved your goals.
19. What did you like most in this course? What was most awarding?
20. What was most troublesome in this course?
21. Space for free comments, positive and negative.