World Transactions on Engineering and Technology Education
Vol.2, No.1, 2003

A materials engineering lecture course with a more active and responsible role for students

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ABSTRACT: This case study relates to a materials engineering course at the MSc level at the Institute of Materials Science of Tampere University of Technology, Tampere, Finland. The teaching methods and arrangements were designed to achieve student motivation, commitment and active involvement in the learning process. Pre-lecture assignments and lecture assignments were made an integral part of the course. The aim of the study was to assess how well the new approach supported student learning and helped the lecturer discover the preconceptions and potential misconceptions of his students. Questionnaires, tests, focused interviews and observations were used as research tools. The students felt that the applied teaching methods and arrangements improved their learning. Their motivation and active involvement was good as they took responsibility for their own leaning. The lecturer stated that the applied methods and arrangements helped him to perceive students' preconceptions, misconceptions and improved learning.

INTRODUCTION

The Department of Materials Engineering at Tampere University of Technology, Tampere, Finland, has initiated a development project for the years 2000-2004, the aim of which is to make teaching and learning more effective [1]. The project was initiated with the following goals in mind: to assist students towards a more holistic view of the subject matter, encourage them to take their exams speedily, minimise dropouts, shorten the time needed for the completion of degrees, increase attendance at lectures and turn the students' passive role into a more active one. This case study, which was carried out as part of an ongoing project in the Department, sought to identify whether the application of constructivist teaching and learning strategies could assist in achieving the above-listed goals.

The object of this case study was a lecture course of three credit units, titled *Phase Transformations and Heat Treatments of Metals* [2]. The lecturer was a professor and head of the Materials Engineering Department. The course comprised 14 weeks of lectures once a week, three hours at a time. Three lab sessions, timed for the latter half of the course, were included. A teaching assistant was responsible for the labs. Seventeen students were registered in the course: seven female and ten male students, 15 Finnish and two foreign students. The students had completed most prerequisite courses and intended to complete their MSc studies within a year or two.

The authors' negotiations with the lecturer revealed his concern for his students' learning. He hoped that the students would become more actively involved in, and accept more responsibility towards, their own learning. The authors suggested a more student-centred approach to the lecturing, following the principles of constructivism, where contact time would serve as a catalyst for student learning and not just involve the traditional transfer of information.

A basic principle of constructivism is that learning is generated through the learner's own activity. Students adopt a responsible attitude towards learning and become actively involved. Meaningful learning occurs when students are motivated and demonstrate commitment and enthusiasm [3][4]. Another central principle of constructivism is that new knowledge is assimilated on the basis of prior knowledge [5]. Students come to the class with their own conceptions, beliefs and assumptions, derived from their earlier studies, texts and lectures, but also from everyday life. Their theoretical perspectives may thus be quite different from those of the lecturer, who has built up his proficiency with relevant concepts over many years.

Some students' preconceptions may be misconceptions. However, it is the students' own conceptions that influence the outcome of their learning. The students' conceptions are not always what lecturers assume and lecturers may have difficulty in anticipating what they are. For lecturers to be able to deal with conceptual growth and conceptual change they must have or acquire insight into the conceptions that their students hold [6-10].

Given this, it was decided that a concept test would be administered at the beginning of the course. The aim of this test was to guide students towards taking more responsibility for their own learning and to give the lecturer a realistic view of students' prior knowledge. Students were also asked to state how confident they were in their answers. A responsible engineer must be able to evaluate solutions by asking and answering questions like *How can I justify my reasoning? Does my result make sense?* [11].

Pre-lecture assignments were introduced so that lectures could then focus on more relevant and difficult topics. The aims of these pre-lecture assignments, which the students did before the lectures, were threefold:

- Recollection by students of relevant concepts and principles.
- Orientation of students towards new topics.
- Lecturer awareness of student preconceptions and potential difficulties with course topics.

Reflecting on student answers also helps the lecturer to develop personal pedagogical content knowledge [12-15]. Such *warming up* questions have given very satisfactory results in science subjects [16-19]. Positive results were also obtained with pre-lecture assignments in a previous research project in textile engineering [20].

Lecture assignments were also adopted. These assignments were completed in the class. The aim of the lecture assignments was to encourage student interaction and to find out in the presence of a tutoring expert (the lecturer) whether they had understood the lecture content. Another aim was to give the lecturer a realistic picture of how well students had learned the new knowledge. Students worked in pairs or small groups on carefully planned assignments, which often included a cognitive conflict. In this way, both social and cognitive aspects of constructivism could be incorporated in the learning process [21][22]. Students also had the opportunity to practice their use of professional terminology and to develop communication and teamworking skills.

In order to get students to reflect on their own actions as learners and to guide them to life-long learning, a learning styles test and a self-directive learning readiness test were administered. In a learning environment, students preferentially focus on different types of information. 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* [23][24].

The Index of Learning Styles (ILS) was used to give an idea of students' learning preferences and to assess individual strengths, tendencies and habits that might affect learning. It was also envisaged that students would become more aware of their own preferences and the lecturer become aware of the preference profile of the class.

The objective of the use of the Self-Directed Learning Readiness Scale (SDLRS) [25] was to show students that personal responsibility and activity play an essential role in igniting a life-long learning process. Additionally, the SDLRS test was considered as a means to enhance study motivation.

The Research Project

The aims of this case study were to:

- Assess the lecturer's and students' responses to the applied teaching methods and arrangements.
- Learn how these solutions helped the lecturer discover student preconceptions and possible misconceptions.
- Find out whether the pre-lecture and lecture assignments supported student learning.

Special attention was paid to the motivation and activation of students and to guiding students to increased commitment. Qualitative methods were utilised to probe experiences and opinions.

TEACHING ARRANGEMENTS

The teaching arrangements were planned for the course *Phase Transformations and Heat Treatments of Metals* [2]. The goal was that the learning process should be spread throughout the whole course and that the students' traditional passive role should be replaced by a more active one. The aim was to achieve active participation of students, social interaction and elucidation and to make assessment part of the learning process. The lectures began in early January and continued every Wednesday for 14 weeks. The weekly lecture session was 3 x 45 minutes. According to the authors' suggestions, and after discussions with the lecturer, the teaching arrangements for the course were carried out as described in Table 1.

A special feature of the course was that students were given pre-lecture assignments for every lecture on the topics to be discussed. There were usually three tasks or questions per lecture. Students submitted answers and solutions through the course's WWW site no later than the day before the lecture. Only in exceptional cases could students deliver their answers on paper. Students had the opportunity to raise their grade by doing their pre-lecture assignments.

Another special feature of the course was that students were given assignments to be done in the class. The lecturer had selected problems that suited the themes of the day and were conducive to group work. Except for the lecture assignments, all handouts and pre-lecture assignments were distributed at the lectures no later than two weeks before the lecture concerned. All material, including the handouts, was made available on the homepages of the course.

Active participation and preparation were also important with regard to the excursion. In the second last week of the course, the group visited a heat treatment plant that was engaged in many of the treatment processes discussed during the course. Thorough preparations were made for this excursion. The special operations of the plant were discussed in the 12th lecture and pre-lecture assignments were tailored for the excursion. At the 14th lecture, the excursion was discussed and reflected on.

The first lecture focused on motivation and building students' commitment. The lecturer introduced himself and the teaching assistant and explained briefly the reason for the authors' presence. The lecturer introduced the course, its overall goals, general content and the relevant course materials. He also explained how and why a new approach 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 what kind of teaching methods would be applied, the focus of the research and the research methods, timetable and special features of the course (see Table 1).

The authors summarised some constructivist views on learning in order to justify the teaching arrangements and the demands to be placed on the students. After this, a short demonstration of the teaching methods to be used was given. The demonstration helped students to realise what they would be involved in and let them experience an example of the activity level expected in class. A more detailed description can be found elsewhere [4][15]. The authors also emphasised that learning requires everyone's personal activity and participation, the authors' idea being that in a successful learning process

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

	Teaching and Learning	Researchers
1st lecture	Motivation and commitment	Observation
	Introductions: lecturer, teaching assistant, researchers	Tutoring discussions with the lecturer 7 times during the course
	Curriculum	
	Teaching arrangements and methods	Analysing of ILS and SDLRS
	Introductory questionnaire	
	Tests: concept test, learning styles, self-directed readiness (WWW version)	
	Working in pairs and groups	Demonstration of group works
	Discussion of goals	
	Demonstrations and elucidations	
	Agreeing on pre-lecture assignments	
	Agreeing on research	
	Lecturing	
2nd lecture	Motivation and commitment	Observation
	Feedback on concept test and introductory questionnaire	
	Final setting of mutual goals, rules and responsibilities	
	Teaching arrangements and methods applied as agreed at all following lectures	
3rd lecture	Lecturing	Observation
4th lecture	Lecturing	Observation
		Personal feedback on ILS and SDLRS outside lectures
5th-6th lecture	Lecturing	Not present
7th lecture	Lecturing	Observation
	Mid-term questionnaire	
8th lecture	Lecturing	Observation
	Feedback discussion on basis of the mid-term questionnaire	Personal focused interviews of the students during the next four weeks
9th-11th lecture	Lecturing	Observation
12th teaching day	Lecturing	Observation
	Preparation for excursion, pre-lecture assignments on the excursion	
13th lecture	Excursion to Bodycoat Heat Treatment Plant	Attendance and observation
14th lecture	Lecturing	Observation
	Feedback discussion on the excursion	
	Feedback discussion on the course	
	Final feedback questionnaire	
		Personal focused interviews on the teaching staff after the course

students take responsibility for their share and the teaching staff for theirs. Some course material was covered in addition to the introductions and students completed an introductory questionnaire, a learning styles test and a concept test on the subject matter, described further below.

Before the second week's lecture, the introductory questionnaire and the concept test were analysed by the lecturer and the authors. A tutoring discussion between the authors and the lecturer covered feedback to be given to students. This should serve the aims of the research, motivate students and commit them to working towards the established goals.

At the second lecture, feedback was given to students on the introductory questionnaire and concept test. The lecturer was satisfied, especially with the opinions he had been able to summon from students in the introductory questionnaire. Consequently, he was able to give positive and constructive feedback and to thank students for their responsible attitude in answering the questionnaire. He could also agree with the goals set by students, as these were well in line with the course content he had planned. He also emphasised the importance of the pre-lecture assignments and student activity as a means to improve learning. All in all, the feedback contributed to engendering good student motivation and commitment.

The feedback on the concept test was also given positively and constructively, although there were some questions that students were unable to answer in an altogether satisfactory manner. The authors, along with the lecturer, were able to observe the different backgrounds of students in their answers, most students having studied materials engineering, but some having their background more in chemical or mechanical engineering. The lecturer pointed out the importance of mastering the fundamental concepts of the preceding courses and hoped that students would recall the relevant information and theories.

A mid-term questionnaire, described later, was answered during Lecture 7. The lecturer discussed the results with the authors before Lecture 8, along with the students. The feedback on the mid-term questionnaire was given in a positive and encouraging manner that reflected the spirit of the students' comments.

The final lecture discussed the most important topics of the course (five highlights) and some issues arising out of the excursion. The pre-lecture assignments for the last lecture included a request for students' comments on the course: lectures, exercises, pre-lecture-assignments, lecture assignments, proposals for improvements, etc. An evaluative discussion was carried out on the basis of these comments during the final lecture.

An example of a typical lecture session is as follows:

- The pre-lecture assignments were reviewed. All student answers were presented anonymously on transparencies where the lecturer indicated, using blue and red pens, the good points, uncertainties and, most importantly, misconceptions. All students had copies of the answers of other students. The lecturer's comments, illustrations, summing ups and questions helped in dealing with uncertainties and misconceptions. Students were also encouraged to present comments and ask questions. There was a strong emphasis on positive feedback to students.
- The lecture was delivered with special emphasis on elucidation and concrete examples.
- A lecture assignment was introduced in the final part of the three-hour lecture. This was typically designed so that students could first reflect on the problem on their own and then discuss it in pairs or in small groups. The lecturer was available if further help was needed. In order to arrive at the correct solutions, students needed to understand the lecture, assemble known concepts, apply knowledge, make choices and justify them. The process led to dialogue in which students presented their solutions and the lecturer asked supplementary questions, commented upon and summarised the answers. Students also had the opportunity to ask questions (see Figure 1). The topics of the following week's lecture were introduced at the end of the lecture.

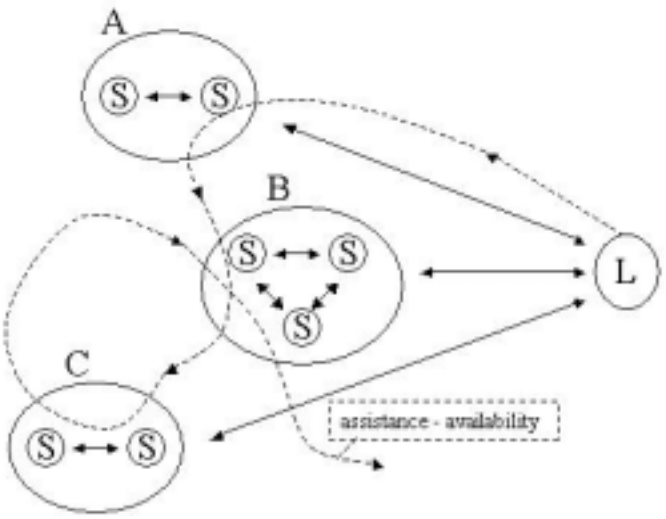

Figure 1: Combining peer instruction and cooperative learning. The lecturer (L) assists the students (S) in their group work (A, B, C), being available when needed.

An example of the pre-lecture and lecture assignments from the second lecture dealing with diffusion in solid state is elaborated on below.

An example of a pre-lecture assignment is as follows:

1. a) What is meant by the term *vacancy* in metal alloys?
   b) How does an increase in the number of vacancies influence the internal energy of metal alloys?
2. a) What is meant by diffusion?
   b) What does diffusion lead to?
3. What relations are there between phase transformations and diffusion?

A sample lecture assignment is as follows: *Do you think that, under some conditions, diffusion can transport atoms up the concentration gradient? Justify your reasoning.*

METHODS

In this case study, the authors evaluated the reactions of students and teaching staff to the teaching methods and arrangements adopted in the course *Phase Transformations and Heat Treatments of Metals*. Special attention was paid to students' preconceptions and potential misconceptions of the subject matter, their active involvement in the learning process and their motivation and commitment. Qualitative methods were utilised to collect the information.

Questionnaires

To learn more about students' hopes, feelings and attitudes, three separate questionnaires were filled out during the course:

- An introductory questionnaire at the beginning of the course.
- A mid-term questionnaire in Lecture 7 (anonymous).
- A final questionnaire in the last lecture (anonymous).

Introductory Questionnaire

The introductory questionnaire was used to survey students' hopes and goals for the course. It was considered that this questionnaire helped to enhance student motivation and commitment. Another aim was to elicit students' personal assessments of their prior knowledge and estimates of the time they planned to spend on the course. The questionnaire was modified on the basis of Mazur [16]. The questions included the following:

1. What do you wish to learn during this course?
2. How do you want to use the new knowledge you obtain?
3. How do you think the pre-lecture assignments, lectures and exercises will benefit you?
4. How do you think the course material and handouts will benefit you?
5. Give us your own estimation of your rate of attendance
   at lectures: _____ %
   at labs: _____ %
6. How much time do you think you will spend per week
   attending lectures _____ hours/week
   preparing for lectures and doing pre-lecture assignments
   _____ hours/week
   attending labs and doing lab exercises _____ hours/week
   studying for the exam _____ hours

7. The following courses are prerequisites for this course: Introduction to Materials Science I, Introduction to Materials Science II, and Metals. Evaluate your knowledge in these courses using the following scale:
   1 = poor; 2 = moderate; 3 = good; 4 = excellent.

Introduction to Materials Science I	1	2	3	4
Introduction to Materials Science II	1	2	3	4
Metals	1	2	3	4

8. Space for other comments.

Mid-term Questionnaire

The mid-term questionnaire was distributed in Lecture 7. The aim of the questionnaire was to gather student opinions about the methods employed, mainly the pre-lecture assignments, but also in general. The mid-term questionnaire also had a motivating and committing goal. Questions were modified on the basis of Mazur [16]. Questions included:

1. What do you like about this course?
2. What do you dislike about this course?
3. If you were lecturing this course, what would you do? Why?
4. If you could change one thing in this course, what would it be? Why?
5. How actively have you done your pre-lecture assignments? _____ %
   a) Give us your opinion about the pre-lecture assignments.
   b) Have the pre-lecture assignments helped you to learn? Explain how!
   c) How would you improve the pre-lecture assignments?
6. Your opinions on the course material: thorns and roses?
7. Space for other comments.

Final Questionnaire

Student feedback on the course as a whole was asked for in the final questionnaire (see Appendix 1). The questions dealt with the course content, the lecturer's and teaching assistant's input and the pre-lecture assignments. Students also evaluated their own motivation, learning and activities.

Concept Tests

During the first lecture, students completed a test on concepts related to the subject matter of the course. The aim of the concept test was to reveal the students' background knowledge. The questions included a few key topics and some concepts that figured in the prerequisite courses. Students were also asked to evaluate how confident they were of the correctness of their answers. The scale was from 1 (very unsure) to 4 (absolutely sure). The questions were:

1. Draw a binary eutectic phase diagram. Name and explain the phases in the diagram.
2. What is meant by diffusion? What happens in diffusion? Give an example of diffusion in metals.
3. What is meant by allotropy? Give an example of allotropy in metals.
4. What is meant by thermodynamic equilibrium?
5. What is meant by hardening? Why is steel hardened?
6. a) What is meant by solubility?
   b) What factors affect solubility?

Learning Styles and Self-directed Learning Readiness Tests

Students and the teaching staff answered a Finnish version of the paper and pencil version of the Index of Learning Styles (ILS) questionnaire [26]. The learning styles test was used to provide an indication of the students' learning preferences and assess probable strengths and possible tendencies or habits that influence learning. The authors sought to make students aware of their personal preferences and to make the lecturer aware of the preference profile of the class. This was one basis for the tutoring discussions wherein the lecturer was encouraged to continue using more student-centred lecturing methods.

Students and the teaching staff were asked to fill out a self-directed learning readiness test outside class using the Web site. The objective of the Self-Directed Learning Readiness Scale (SDLRS) [25] is to show students that personal responsibility and active participation are the keys to life-long learning. Another goal was to enhance their motivation to study and increase their self-esteem. The authors gave those students who wished it, and the teaching staff, personal feedback on the ILS and SDLRS tests.

Interviews, Observations and Discussions

The authors used focused interviews to survey students' study habits, learning strategies, background and motivation for the choice of vocation. Students' opinions on their learning environment and views on quality teaching, learning assessment methods, meaningful learning and understanding were also sought.

The authors were usually present at the lectures and always at those lectures that included feedback discussions or special preparations. The purpose for this was to study the implementation of the pre-lecture and lecture assignments and observe the learning atmosphere. The results of these observations were the basis for the tutoring discussions with the lecturer. Attending the lectures helped the authors stay in touch and also demonstrated their interest and commitment, which, it was hoped, would motivate both the lecturer and students [27].

RESULTS

Students and the teaching staff expressed their satisfaction with the teaching methods and arrangements, particularly with the pre-lecture and lecture assignments. They felt that this type of arrangement was beneficial and helped to maintain a steady pace in their studies, which also aided in understanding and internalising the subject matter covered in the lecture.

Pre-lecture Assignments

Both the lecturer and students were satisfied with the outcome of the pre-lecture assignments. Students expressed their opinions in the questionnaires, focused interviews and feedback discussions, while the lecturer presented his views during tutoring discussions and focused interview.

The interviews revealed that students do not commonly prepare themselves for lectures by reading in advance the topics to be dealt with or reviewing concepts from earlier courses. Nine out of the ten students interviewed stated that they almost never prepare for classes. This has also been the authors' experience as lecturers and teacher educators in the field of engineering

education. Faced with pre-lecture assignments, students changed their habits and began preparing for classes. Students were committed and active in doing their pre-lecture assignments. The answers and solutions to the pre-lecture assignments were not always correct or extensive but, as can be seen in Table 2, most of the answers fulfilled the aims of the pre-lecture assignments. Thus, they were accepted and the students received credit for them.

Students assumed a positive attitude towards the pre-lecture assignments right from the start. They expressed this in the introductory questionnaire and also estimated that they would be spending ½-2 hours per week (average 1.2 hours) on preparations and pre-lecture assignments. Two typical comments in the introductory questionnaire to the question *How do you think the pre-lecture assignments will benefit you?* were:

- *The pre-lecture assignments make it easier to understand the things lectured and are good preparation for the exam.*
- *By means of the pre-lecture assignments, I can keep up with the lectures and I won't have to work so hard for the exam.*

The students' motivation and commitment in doing the pre-lecture assignments continued throughout the course, as shown in Table 2. Students' earlier assumptions about the pre-lecture assignments were confirmed in the mid-term questionnaire. One typical response to the question *What do you like about this course?* Was as follows: *This is an interesting subject. The pre-lecture assignments make me read the topics of the next lecture beforehand*.

Another student evaluated the pre-lecture assignments as follows: *The pre-lecture assignments help me internalise*

Table 2: Statistics for the returned and accepted pre-lecture assignments.

Returned pre-lecture assignments																
Lecture no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	S	
Student no																
1		3	3	3	3	3	3	3	3	3	2	3			32	
2			3	3	3		3	3	3	3					21	
3			3	3	3	3	3								15	
4		3	3	3	3	3	3	3	3	3	2	3			32	
5		3	3	3	3	3	3	3	3	3	2	3		1	33	
6			3		3		3	3	3	3					18	
7		3	3		3	3	3			3	2	3			23	
8				3	3	3	3	3	3	3	2				23	
9		3			3	3	3	3	3	3				2	23	
10		3	3	3	3	3	3	3	3	3	2	3		2	34	
11		3	3	3	3	3	3	3	3	3	2				29	
12		3	3	3	3	3			3	3					21	
13		3	3		3	3	3	3	3	3	2	3		2	31	
14		3	3	3	3	3	3			3	2	3		1	27	
15		3	3	3		3			3	3	2			1	21	
16		3	3	3	3	3	3	3	3	3	2			2	31	
17		3	3	3	3	3	3	3	3	3	2	3			32	
Sum		39	45	39	48	45	45	36	42	48	24	24		11		
Accepted pre-lecture assignments																
Lecture no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	S	%
1		3	3	3	3	3	3	3	3	3	1	3			31	91
2			3	3	3		3	2	3	3	1	3			24	71
3				3	3	3	3								12	35
4		3	3	3	3	3	3	3	3	3	2	2			31	91
5		3	3	3	3	3	3	3	3	3	2	1		1	31	91
6			3		3		3	2	3	2	2	3			21	62
7		3	3		3	3	3			3	2	3			23	68
8				2	3	3	3	3	3	3					20	59
9		3			3	3	3	3	3	3				2	23	68
10		3	3	3	3	3	3	3	3	2		1		2	29	85
11		3	3	3	3	3		3	3	3	2				26	76
12		3	3	3	3	3			3	3					21	62
13		3	3		3	3	2	2	3	3	1	2		2	27	79
14		3	3	3	3	3	3			3	2	2		1	26	76
15		3	3	3		3			3	3	2			1	21	62
16		3	3	3	3	3	3	3	3	3	1			2	30	88
17		3	3	3	3	3	3	3	3	3		3			30	88
Sum		39	42	38	48	45	41	33	42	46	18	23		11		

things. When I come to the lecture I have some basic knowledge and I do not have to start from scratch.

When asked for critical feedback regarding what should be changed, nobody had anything negative to say about the pre-lecture assignments. When the *thorns* and *roses* were distributed, the pre-lecture assignments were given *roses*.

The final questionnaire revealed that the students' original opinions about the pre-lecture assignments were sustained. Students estimated that they had spent ½-2 hours per week (averaging one hour), on the pre-lecture assignments. All those answering the final questionnaire had completed most of the pre-lecture assignments. When asked in the final questionnaire how active they were in doing their pre-lecture assignments, students rated their effort as four or five out of five (Appendix 1, Q.7).

No student's motivation declined during the course; rather, motivation increased (Q.17, Q.18). One student claimed her increased motivation was due to the pre-lecture assignments. Students also gave the pre-lecture assignments credit for their learning. Responses to the question *How did the pre-lecture assignments influence your learning?* included:

- *They helped.*
- *Positively, I even looked for answers outside the handouts.*
- *By means of the pre-lecture assignments I got a good grasp of the course right from the start. My motivation increased.*
- *Made internalising significantly more efficient.*
- *They helped; I familiarised myself beforehand with the subject of the day. This helped me follow the lecture.*

One positive sign of students' confidence and commitment was that 13 students out of the 17 enrolled took the course examination just a few days after the course ended. According to the lecturer, the usual number is one-third with the rest taking the examination much later.

Students expressed their satisfaction in the interviews with, and commitment towards, the pre-lecture assignments. They felt that the assignments helped in many ways and took in more from the lectures, which, in turn, motivated them to attend. It was easier for them to learn and internalise knowledge. The pre-lecture assignments gave them motivation and determination. Every lecture began with an analysis and feedback discussion on the subject matter of the pre-lecture assignments. This helped to facilitate students' broader and deeper perspectives on issues.

Representative comments from the interviews are as follows:

- *They are actually very good, I have never really prepared myself for attending lectures. Now they make me prepare and then the lecture is somehow repetition of what I have already read. At least it makes things easier: things stick in your mind. So, I sort of read things beforehand all through the course.*
- *I am now able to pick up relevant details. When I read by myself I was not able to see all of the important things at once; some things passed straight through my head when I read. Now when things turn up again, I am able to recall much more.*
- *So far, I have done them all … In doing them I looked for some background information, it has been easier to follow the lecture … It's quite different when you know what it's all about, rather than when you go to the lecture and don't know anything beforehand … They are good like this, if they were more complicated they would not get done. If, for example, you had to write an essay of half a page … Now it is very much based on what has to be recalled from earlier courses, so that you master the basics before new things are introduced.*

Most students considered the level of difficulty of the pre-lecture assignment suitable and the number of questions appropriate. One student would have preferred simpler assignments, but nevertheless did the assignments and received the points he/she hoped for. Two students wished for somewhat more demanding assignments, one of whom even suggested that a bonus assignment could be included now and then, which would be more difficult, requiring extensive application and integration of knowledge to demonstrate deeper comprehension.

The lecturer described in his interview his experiences with the pre-lecture assignments. He recalled the fears he initially had and which he had discussed with the authors when the project was being planned. He did not harbour any great expectations since students were not accustomed to pre-lecture and lecture assignments. This is probably why he had thoroughly thought things through when planning the course. Finding a suitable level of difficulty in the assignment had, at first, been a problem. It helped that students picked up on the idea so well. Preparing the questions then became easier.

Some comments from the interview revealed the lecturer's thoughts:

> *At first, I actually found the situation somewhat difficult; I wondered how the students would accept the idea … If I made the questions too difficult the whole thing would fall apart. So I gave the first questions a lot of thought in preparing my lectures. … Then, when the students' appreciation was so good, it made things easier.*

He was enthusiastic in explaining how the pre-lecture assignments became so well integrated in his preparation for the lectures. In preparing his lectures, he gradually developed the habit of also reflecting on suitable pre-lecture assignments and this actually, as he expressed it, … *brought a new perspective to my work.*

The lecturer answered the question, *Was it difficult to find suitable questions; did it take an unreasonable amount of time and effort?*, as follows:

> *Having developed the habit of reflecting on suitable questions when preparing my lectures, it was no big deal, it became second nature … questions that turned out to be good and instructive seemed to pop up from nowhere.*

He was quite frank in his self-criticism. Having lectured for 30 years, he had developed certain routines that actually bothered him, as indicated by the following statement: *Usually you just grab your pile of transparencies and go and deliver the lecture, finding an excuse for this in always being so busy.*

He was happy to break away from this routine and said that this project was a refreshing experience. The new methods also helped him to change his attitudes and develop some interaction in the class. He was very specific about trying to continue this work in the future.

Over several discussions, the authors had sensed his fears concerning student motivations; however, when the course was well underway, he felt pleased and relaxed. He stated that:

> *It is so gratifying that the students grasped the idea and came along. They have chosen to make a serious effort in their learning and to participate in this process. I was really surprised at their motivation.*

Having evaluated all the solutions to the pre-lecture problems, the lecturer estimated that:

- 25% of the students had used other sources in arriving at their solutions, in addition to their normal course material and handouts.
- 50% of the students had solved the problems using their normal course material and handouts, and given the matters serious consideration.
- 25% of the students had supplied solutions directly from the course material without processing the matters further.

Thus, he concluded that 75% of the students had approached the pre-lecture assignments in the right spirit. He commented that *The students have really taken responsibility for their own learning and shown commitment.*

Lecture Assignments and Lectures

Students appreciated the lecture assignments as a good means of working. The assignments were challenging and assessed their understanding and ability to apply information from the lectures. Students also stated that the assignments brought variations to the lectures. In the final questionnaire, (Q.22) two students wrote about the lecture assignments:

- *Good idea! Forces you to think about the things taught and the causes and effects. It brings a nice break to the lecturing.*
- *Very good. They help you see if you really have understood the lectures correctly.*

One of the students described his reactions to the lecture assignments and said in the focused interview that the lecture assignments were a good idea but that the idea was quite new in this environment. As such, educators must understand that there may be some initial difficulties in getting students motivated. He continued his analysis and affirmed, *At first we were dumbfounded and silent, it was a bizarre situation. But now we dare to answer; after having learned something, we are no longer so uncertain about what we know.*

Students found it difficult to concentrate on the entire three-hour lecture and suggested in the questionnaires that more elucidative examples should be included and more assignments should be discussed in groups.

Students expressed their general satisfaction in the final questionnaire. They were happy with the lecturer's efficient use of time in the class (Q.2), the interaction between lecturer and students (Q.10), the lecturer's teaching skills (Q.11), clarity and comprehensibility of the teaching (Q.15) and the usefulness of the teaching arrangements from a learning point of view (Q.16.a). The mode in all these answers was 4 on a scale that ranged from 1 (very poor/very little) to 5 (very good/very much). These results match well with the students' opinions when asked in the focused interviews, *How do good lecturers act?* Some representative answers were:

- *They keep their listeners awake, they do not drone on boringly; there are different situations and topics. Every once in a while there are some assignments for the students, not just teacher talk from beginning to end.*
- *They stimulate the students; they don't just keep on talking for hours from transparencies. Now and then there are some problems to think about and some examples from real life or something…*
- *They know how to inspire, they make people really interested in the subject and make them think; they don't just relate things monotonously, stand up in the front and placidly tell how things are. They use metaphors and then sometimes give some nuts to crack, to see if the knowledge has stuck or not.*

The lecturer was satisfied with the results of the lecture assignments but he was also realistic as the methods adopted were not familiar in this environment. Finding the essence of the lecture was a major challenge in the lecture assignments. In drawing up the questions and problems, his target was to make students think, discuss, find and compare solutions, justify their reasoning and convince their peers. He reflected over the pros and cons and concluded:

> *The students were well disposed towards these methods. Of course, the interest demonstrated in the pre-lecture assignments was the biggest surprise … but also the lecture assignments … Of course, the discussion was not all that lively but, little by little, it will liven up. The more you practice it, the better it will get.*

The lecturer emphasised the importance of lectures: the aim should definitely be to help the students internalise knowledge; non-attendance increases the risk of students formulating inadequate concepts – or even misconceptions. With 30 years of lecturing behind him, he justified his opinion by saying:

> *You can often see that those students who don't attend lectures very regularly - they read for a couple of weeks on their own for the examination - you can see that they have read and they do pass the exam, but you can also see that internalising of the subject matter is poor.*

The lecturer expressed his appreciation of the new methods and hoped that he could apply them in the future as well, and so to encourage a better attendance at lectures. He especially emphasised that the main points of the lecture and applications should be dealt with in interaction with the students from several directions and in a broad manner; *This is very important.*

Concluding from the number of students who attended the lectures, did their pre-lecture assignments and passed the examination, the authors have a reason to believe that the

lecturer achieved his goals. Of the 17 students, only one did less than 50% of the pre-lecture assignments, seven did between 50% and 75%, while nine did more that 75% of the pre-lecture assignments. It was noted that 60% of the enrolled students attended the lectures on a regular basis. In the authors' opinion, this indicates their commitment and diligence.

The concept test, the pre-lecture assignments and the lecture assignments helped to reveal students' preconceptions and possible misconceptions and the lecturer was able to take these into account in his lectures. This has improved meaningful learning.

The Concept Test

Students conveyed some of their thoughts with regard to the concept test in the focused interviews and expressed both positive and negative reactions. They felt positively about having to reflect on their own knowledge of the necessary basics. They were also hopeful that the lecturer would obtain a realistic view of their knowledge and would take advantage of this in preparing his lectures. The negative feelings were due to some embarrassment that they felt because they had forgotten so much of what they studied in earlier courses. On the whole, the assessment was more on the positive side.

The following two responses give a representative sample:

- *When I got the concept test in front of me I felt, oh no! I don't remember these things, I felt my basics were poor, It was a bit upsetting … You start to examine things differently, and you even think about having to do the pre-lecture assignments and everything. All the same, you want to remember things and learn them. Maybe someone even looked up things after the test.*
- *Oh, how I have forgotten things! In many cases I could tell you in which course they have been explained and in which handouts they can be found, but I don't necessarily remember the answer. It is, of course, good that you know where to find them. But many of the concepts were ones that I know I've heard them somewhere and could give some sort of answer but other concepts were totally lost. … I think it is useful for the lecturer to be aware of our initial knowledge so that he does not start from too high a level.*

The results of the concept test are shown in Table 3. Students were accorded 0, ½, or 1 point for each answer. Their confidence in their answers is shown in italics below the points assigned. The table also shows their total score (sum) and their own estimation of their prior knowledge from the three prerequisite courses. Students evaluated their knowledge from the previous three courses on a scale of 1 to 4 in the introductory questionnaire. This scale was modified linearly to the scale used in the concept test (0 to 7 points).

Comparisons were made between the points allocated to the students in the concept test and the confidence the students expressed in the correctness of their answers. It can be seen that one student (8) was often confident in many questions about his/her knowledge. He/she had many 0 or ½ point answers, but the confidence ratings were 3s and 4s. Two students (2,9) had some deviation in their estimation of the correctness. However, most students were well aware of what they did and did not know. For five students, the total score in the concept test was well in line with their own estimations of their knowledge (1,2,4,6,9). There was some deviation in the case of four students (5,7,10,11).

The students were asked in Question 1 to draw the phase diagram of a binary eutectic system. Although the answers were not bad (see Table 3), many students failed to point out the eutectic point and name the axes. Further, students could visually recall the phase diagram, but were not sure about the details.

They were asked in Question 2 to explain what is meant by diffusion and what happens in diffusion, students knew this well, but many failed to give the example requested and scored only half a point.

Table 3: Results of the concept test.

Student:	1	2	3	4	5	6	7	8	9	10	11	12	13
Question no.	Given points/expressed confidence												
1	½	1	na	½	½	½	½	0	1	½	½	1	½
	2	*4*		*4*	*1*	*2*	*2*	*3*	*2*	*1*	*3*	*3*	*2*
2	½	1	na	1	½	½	na	½	1	½	1	½	½
	3	*3*		*4*	*3*	*2*		*4*	*3*	*1*	*3*	*3*	*2*
3	na	na	na	½	na	1	na	na	0	½	0	1	1
				3		*3*			*3*	*1*	*2*	*3*	*4*
4	1	1	na	1	½	0	na	0	0	0	1	1	1
	4	*3*		*3*	*1*	*2*		*3*	*3*	*1*	*2*	*2*	*2*
5	1	1	na	1	0	1	1	½	1	½	1	0	½
	3	*4*		*4*	*1*	*3*	*2*	*2*	*4*	*1*	*3*	*3*	*2*
6a	0	½	na	1	0	0	0	½	½	½	0	0	½
	2	*4*		*3*	*1*	*1*	*2*	*4*	*4*	*1*	*1*	*1*	*3*
6b	½	0	na	½	½	½	½	½	½	1	½	0	½
	3	*3*		*3*	*1*	*1*	*2*	*4*	*3*	*1*	*1*	*1*	*3*
Sum (max 7 p.)	3½	4½	na	5½	2	3½	2	2	4	3½	3½	3½	4½
Previous studies	4	4.7	na	5.2	3.5	3.5	4	#	3.5	2.2	5.2	#	#

Note: na = no answer; 0 = incorrect answer; # = students whose previous studies did not include courses comparable to those of other students.

Students were asked in Question 3 to explain what is meant by allotropy and to give an example relating to metals. Even though allotropy is a common phenomenon in phase transformations, students were unfamiliar with this concept. Six out of 13 students left this question unanswered. Perhaps the term had not been commonly used in their prior studies.

Question 4 also caused some problems. The concept of thermodynamic equilibrium was confused with chemical equilibrium, and thus no points were awarded.

The question about hardening - what does it mean and why is it done - was well answered. There were some inaccuracies in the answers but, overall, the answers were correct. Two students confused the concepts about working and hardening a metal.

The sixth question (6a), where the students were asked to explain solubility, was difficult to evaluate. The answers were inaccurate and many students used circular arguments. The second part of the question (6b) asked for factors affecting solubility. While answers were better to this question, they were by no means perfect.

Pre-lecture Assignments

The pre-lecture assignments, as with the concept test, revealed students' existing conceptions and permitted the lecturer to take these into account and, in the case of uncertainties and misconceptions, try to guide students to improve their comprehension and mastery of the concepts.

The second lecture, which dealt with diffusion in solid state, provides a representative example of the pre-lecture assignments. The lecturer planned to deal with phase transformations by first covering diffusional phase transformations and then diffusionless phase transformations. The assignments were designed to guide the students to recall the basic principles of thermodynamics and the necessary concepts such as diffusion, as well as familiarise students with the new topics.

Question 1a asked *What is meant by the term vacancy in metal alloys?* The answers from the 13 students revealed that all of the students did not comprehend the term vacancy in the same manner. Seven students defined vacancy in a satisfactory way, three students defined it inaccurately or only in some part correctly, while three students gave a somewhat incorrect answer. Some of the students did not clearly express that vacancy refers to a point defect in the lattice or that a lattice site that is normally occupied is, in this case, vacant. Some misconceptions were revealed as well: two students thought that a vacancy is elsewhere than at a lattice point, while one student wrote that a vacancy is a disturbance field.

Question 1b asked *How does the number of vacancies influence the internal energy of metal alloys?* In this question, students also showed that they had difficulty in expressing themselves accurately; there were some misconceptions and wrong conclusions. There were seven correct answers and six incorrect ones. There were difficulties with the thermodynamic concepts and interdependencies. Some students correctly concluded that, as the amount of vacancies increases, disorder also increases, which leads to an increase in internal energy.

Examples of incorrect deductions included:

- An increase in disorder leads to a decrease in internal energy.
- When the number of vacancies increases, the atoms need less energy when moving from one vacancy to another and so the internal energy decreases.
- The increase in the number of vacancies decreases the interaction between atoms, which leads to a decrease in internal energy.

Question 2a asked *What is meant by diffusion?* The answers did not reveal misconceptions. Although Question 2 was very general, the answers were mostly limited to metals and phase transformations. This is understandable given the context. Not all the answers made it clear that, in practice, diffusion involves the movement of atoms over long distances. Rather, the answers suggested in a more limited perception that diffusions involve atoms moving from one lattice site to the next.

Question 2b queried *To what does diffusion lead?* This question was well answered. All, except one, student said that diffusion leads to a decrease in free energy and/or a diminishing of the concentration gradient.

Question 3 asked *What relations are there between phase transformations and diffusion?* Eight answers were satisfactory, but five students answered the question incompletely and copied from handouts something that related slightly to the question, yet not giving much thought to the question or the answer.

Examination

The examination showed that the level of learning was clearly better than in earlier years. The results were more homogeneous and even and there were no poor grades among the students who had enrolled for this course. However, one student gave up and did not attempt to answer any questions. The lecturer said that the students demonstrated more understanding in their answers than in previous exams he had administered. The answers did not reveal serious misconceptions or misunderstandings, which was often the case before (Table 4). The exam comprised eight questions, of which six were to be answered. Table 4 shows that Questions 1, 2, 4, 5, 6 and 7 were most popular. It is interesting to note that the few who answered Questions 3 and 8 obtained slightly better grades than average. Question 5 turned out to be most difficult: where 57% of the answers either did not quite correspond to the question or did not present a clear enough picture.

In analysing the results of the exam, the lecturer was pleased to note that the students had a more holistic grasp of the subject matter. In reading the examination responses, he would normally see that some students had studied a few topics selectively. Yet he found no evidence of this in the present case. Clearly, studying topics selectively cannot lead to meaningful learning.

Test Results

The results of the ILS test are shown in Figures 2a-2d and those of the SDLRS test in Figure 3. The results show that very versatile learning styles were represented in this group. More detailed descriptions on the interpretation of the graphs can be found elsewhere [24][26]. The scale for the SDLR test is from 41 to 205. The left end of the axes refers to those learners who want to be taught and consequently do not enjoy independent studying. The right end refers to those learners who are self-directed and enjoy taking responsibility for their own learning.

Table 4: Statistics for the final examination.

		Question No.							
Student		1	2	3	4	5	6	7	8
1		A	A	A		A	A		A
2		A	A**	A	A	A*		A	
3		A	A		A	A*	A	A	
4		A	A	A	A			A	
5		A			A	A	A	A	A
6		A	A		A**	A*	A	A	
7		A	A*		A		A	A	A
8			A		A	A	A	A	A
9		A	A*	A	A		A**	A	
10				A**	A	A**	A	A	A
11		No answers							
12	Not included in statistics	A*		A	A	A		A*	A
13		A		A		A	A	A	
Number of answers (max. 11)		8	8	5	9	7	8	9	4
Answering (%)		73	73	45	82	64	73	82	36
Insufficient answers (%)		0	38	20	11	57	13	0	0

Note: The marks mean: A = answered, A* = answered, but not really answering the question asked, A** = answered, but not well. The exams for students 12 and 13 included slightly different questions and their results are not included in the statistics.

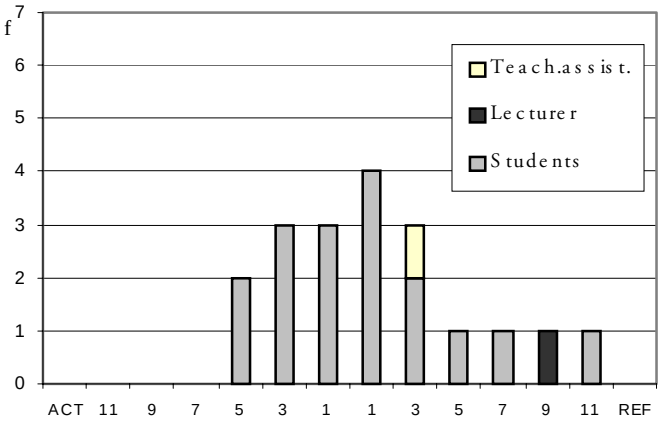

Figure 2a: Learning styles dimensions – active-reflective.

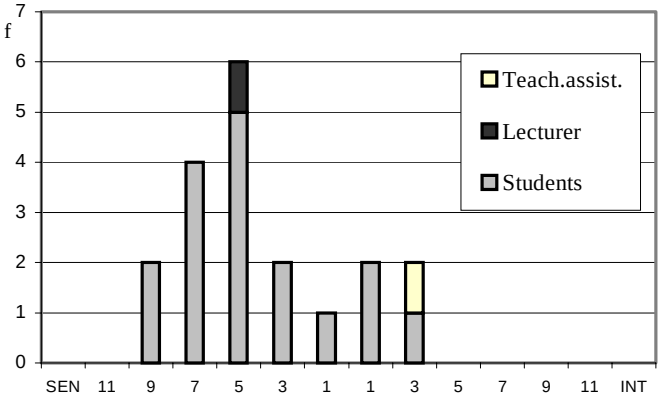

Figure 2b: Learning styles dimensions – sensitive-intuitive.

DISCUSSION

In this case study, the authors evaluated the responses of students and their lecturer to the new teaching methods and arrangements adopted in the course *Phase Transformations and Heat Treatments of Metals*. In the authors' assessment, the teaching methods and arrangements helped the students keep up with the lectures and brought more dedication to their study habits. In applying these methods, the lecturer worked in closer interaction with his students and became aware of some learning difficulties at an early stage of the course.

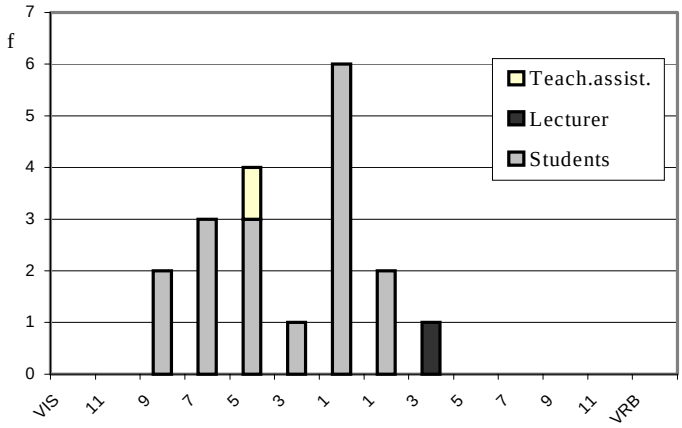

Figure 2c: Learning styles dimensions – visual-verbal.

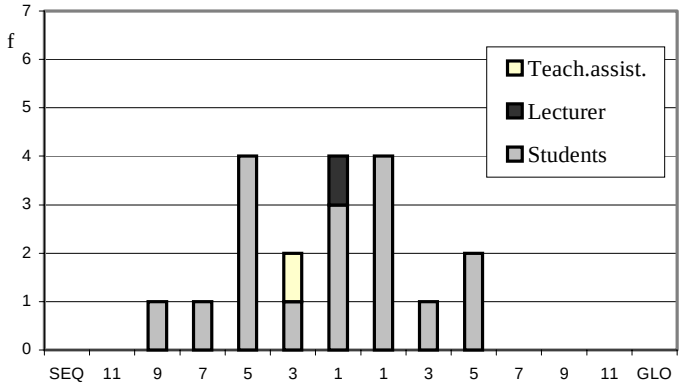

Figure 2d: Learning styles dimensions – sequential-global.

University students in Finland enjoy academic freedom. This means, in practice, that they have great liberty in making their

own choices. This often also means that they have the choice to attend or not to attend lectures. This case study found that the students appreciated that their learning was important to the lecturer and they demonstrated commitment, they were resolute in doing their pre-lecture assignments, attending the lectures and taking the examination at the end of the course.

The concept test was important to both the lecturer and students; students became aware of the importance of mastering the basics, while the lecturer realised that almost no concepts were clear to all students. The concept test also asked students to estimate their certainty about their answers and knowledge. It is important for engineering students to see what they have and have not mastered. Certain questions should be routine, such as *Does it make any sense?* or *Can I prove my point?* [11].

Figures 2 and 3 show students' different learning preferences and habits. It was observed that the adopted teaching methods and arrangements seemed to address most of the learning preferences in the group. The tests, and the personal feedback given on the tests, also helped students to become aware of their strengths and predispositions. The feedback also included suggestions as to how students could improve their skills in both their preferred and less preferred modes of learning [28][29]. These tests contributed to further positive adjustments in the course. The focused interviews indicated that students recognised their learning styles and did not object to the profiles presented to them – despite the fact that the validity of the ILS test has not been proven [30]. It should be noted that the validity and reliability of the SDLRS test are contested and the subject of scientific debate [31-34].

The pre-lecture assignments improved students' commitment to the course and motivated them to attend the lectures. The pre-lecture assignments and discussion of the answers in the class brought continuous guiding feedback to students. The lecturer was also able to pinpoint students' preconceptions and items of difficulty, and to perceive misconceptions. One example (Lecture 2, Question 1b) illustrates that some student conceptions were such that difficulties could be predicted, when new knowledge was to be built on this basis. There will be unnecessary confusion in students' minds if they start to consider the stability of metal alloys before they understand the basic principles of thermodynamics; they will not be able to make sense of what is taught. Dealing with students' answers to the pre-lecture assignments in the class brought transparency to the assessments, which has proved to be important in supporting deeper understanding [35]. Students were guided to reflect on their own knowledge and ways of thinking and, through this, to improve their metacognitive skills.

The lecture assignments were carefully planned and appropriate for working in pairs and small groups. The example from the second lecture on solid state diffusion in metal alloys was the first cognitive challenge for students, asking them to determine whether atoms could travel uphill against a concentration gradient. Was this not against all learned principles? Some students needed slight assistance, some suspected from the question that it might be possible. After recalling Fick's Laws, where *net flux of atoms* was mentioned, they began to process the question further. Some students recalled that diffusion should be understood as a statistical phenomenon. After reaching the correct conclusions (ie *uphill diffusion occurs in certain phase transformations*), students began to discuss those situations in which this could occur. Chemical interaction is an internal factor. Both uphill and downhill diffusion occur along the chemical potential gradient but uphill diffusion takes place against the concentration gradient. Some external factors were also discussed.

The excursion, including the preparation achieved through pre-lecture assignments and the review discussion afterwards, drew on and realised topics included in the course. Students became familiar with the heat treatment plant through the firm's Web site in the pre-lecture assignments [36]. Students also prepared questions on relevant and interesting topics.

The lecture assignments allowed students to test on their ability to apply the knowledge they obtained in the lectures, and allowed the lecturer to see how students had internalised knowledge. Despite some initial difficulties, the lecture assignments activated student learning.

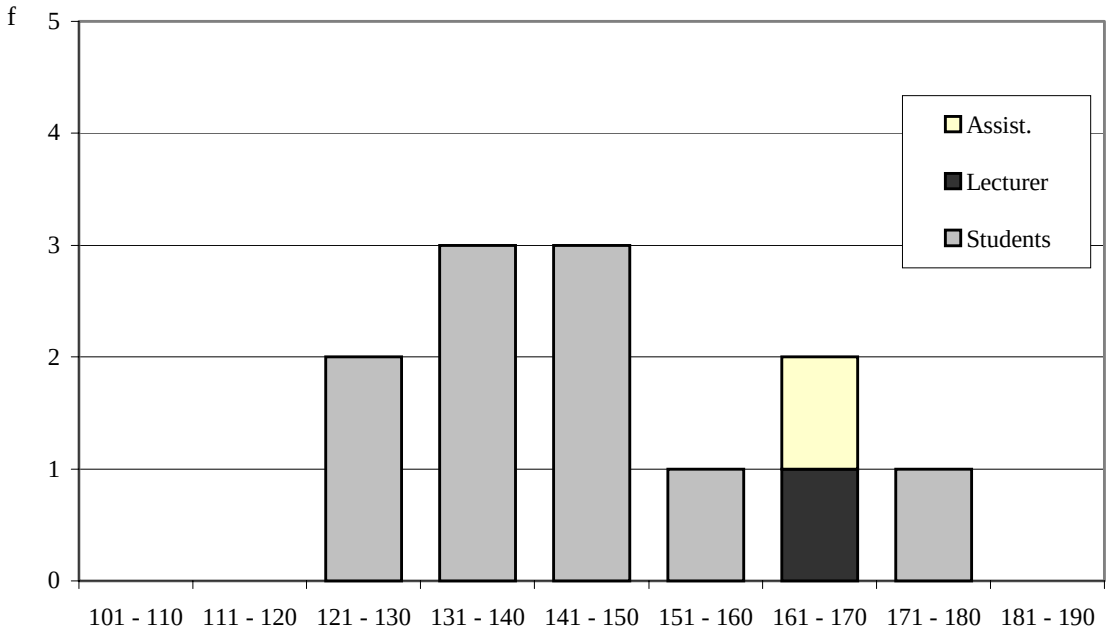

Figure 3: Results of the SDLRS test.

In the final examination, students exhibited a more even and sure command of the subject matter than did earlier students in the course. They also exercised less delay in taking the examination. It is believed that, with the help of the methods and arrangements described above, student commitment can be improved and more students encouraged to undertake their examinations at the conclusion of the course.

The lecturer explained that he had developed many routines during his 30 years of lecturing. He was delighted that he had succeeded in dropping some of these routines during this project and was able to take his students more into account than before. He has now created an interactive, two-way process instead of just transferring information to his students.

Interviews with students revealed that they were not accustomed to such diverse teaching and learning activities during lectures. The traditional method of lecturing, the one-way street, easily leads to students taking a passive role. However, there are explanations for this kind of approach. Research work and administrative duties are so demanding of a professor's time that little time is left for a pedagogical development. The traditional manner of lecturing, that is basically to transfer information to the students, sufficiently meets the demands set on teaching; the students' apparent wish to assume a passive role fits this model well.

The authors learned in this case study that both students' and lecturers' descriptions of good students and good lecturers were very much the same. However, when more active and interactive roles were introduced, it was not so easy to adopt them as might have been expected. Getting discussion going called for patience and persistence. The language of the lectures, mainly English, was partially to blame. Students did not feel so free having to communicate in a foreign language. However, students could ask questions and could do their group work in Finnish and the lecturer succeeded in creating a warm and confidential atmosphere so that, in time, he managed to catalyse dialogue.

The authors observed that these teaching methods and arrangements pleased both the lecturer and students. Further, the lecturer's thorough preparations proved worthwhile. Planning the pre-lecture and lecture assignments became a part of his normal preparations and, eventually, he did not feel that the new tasks were in any way overwhelming or too time-consuming. Students realised that the pre-lecture and lecture assignments promoted their learning and this increased their involvement. They found that attending the lectures was much more rewarding than before. The lecturer was surprised at the students' positive and accepting attitude towards the pre-lecture and lecture assignments. However, there is still a need for improvement, especially in the case of discussing the lecture assignments in the class. Both the lecturer and students need to become more familiar with collaborative working.

It can be concluded that the teaching methods and arrangements adopted in this case study did, indeed, have an activating influence on students. They also resulted in a more thorough grasp of the course material by most students. On the basis of the authors' observations, it can also be said that both the lecturer and students experienced moments of success during this course. As researchers and engineering educators, the authors felt particular satisfaction when reading the following from a student:

> *The pre-lecture assignments are good. I recommend that they be used in other courses too. They led you to ponder things, not just carry out calculations, where you merely focus on finding the correct numerical answer.*

When the lecturer was asked: *Was this all beneficial and will you do it again?*, he responded *YES.*

RECOMMENDATIONS

On the basis of this case study and the authors' experiences as lecturers and teacher educators in the field of engineering education, it is recommended that the following points be taken into account when pedagogical change is pursued.

In introducing changes:

- Make plans thoroughly, but leave time for reflection and be prepared to make adjustments.
- Justify the choice of methods and arrangements to the students and set clear rules that are easy to follow. All parties should be informed.
- Proceed systematically and resolutely but recognise that there is always some resistance when changes are introduced. It is important to be transparent and be ready to discuss difficulties openly.

In applying pre-lecture assignments:

- Present and discuss the students' answers and solutions, but be sure that they get a clear message of what the correct and desired solutions are. Also, be specific when dealing with uncertainties and misconceptions, make sure that the correct solutions prevail.
- Use some open-ended questions and encourage students to adopt a broad point of view, even if the answers are short.
- Ask students to draw up questions on the material not yet discussed that they have found difficult.
- Exploit the opportunity to communicate in two directions during the lecture with dialogue outside the lecture period, for example via e-mail.

In applying lecture assignments:

- Plan the assignments so that they are challenging. Incorporate cognitive conflicts and open-ended problems and plan them to suit working in pairs or small groups.
- Inspire student-teacher and student-student dialogue.
- Use demonstrations and the Predict-Explain-Observe-Discuss-Explain (PEODE) method [37].
- Use two to three lecture assignments in long lecture sessions.

When labs are included:

- Integrate lecture and labs thoroughly, both content-wise and time-wise. Refer to the labs in the lectures, and refer to the lectures in the labs.
- Discuss results in the class and exploit the expertise of the lecturer. Survey the reasons for success or failure and include the lecturer, teaching assistant and students in the discussions on labs.
- Include pre-lab assignments.

ACKNOWLEDGEMENTS

The authors would like to thank the lecturer and the teaching assistant of the course *Phase Transformations and Heat Treatments of Metals* at Tampere University of Technology for their contribution and cooperation, as well as the students for their participation. Their commitment and the time given were most appreciated. The authors are grateful to their employers, Tampere Polytechnic, Tampere, and Helsinki Polytechnic, Helsinki, for giving the possibility to conduct this research. Financial support was provided by the Academy of Finland.

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Appendix 1: Student feedback sheet

TAMPERE UNIVERSITY OF TECHNOLOGY STUDENT FEEDBACK
Department of Materials Engineering 24.04.002/K&S-R
Phase Transformations and Heat Treatments of Metals **3 cu** Male Female

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 totally ___ hours in this course to prepare myself for the lectures and doing my pre-lecture assignments. *(6-20 hours); average 12 h*
This would be approximately ___ hours/week *(½ - 2 hours/week); average 1 hour/week*
Estimate, which was the best way for you to learn during this course. Scale: 0 = not at all, 1 = slightly → 5= very much/mostly

Attending the lectures	0	1 *(1)*	2 *(1)*	3 *(1)*	4 *(4)*	5 *(1)*
Doing the pre-lecture assignments	0	1	2 *(1)*	3 *(1)*	4 *(6)*	5
Studying the handouts on my own	0	1 *(1)*	2	3 *(4)*	4 *(3)*	5
Studying the book on my own	0 *(5)*	1	2	3 *(1)*	4 *(1)*	5

Some other way, What? *(No comments given)*
I attended the lectures: *(average 75) %* I attended the exercises: *(average 90) %*

Scale: 1 =very poor/very little, 2 = poor/little, 3 =average, 4 = good/much, 5 = very good/very much
(Number of students representing an opinion in brackets and italicised)

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

18. Did your motivation change during the course. If so, how and why?
19. How did the pre-lecture assignments influence your learning?
20. How would you improve the pre-lecture assignments?
21. What were your goals in this course? Did you reach them?
22. Your evaluation about the lecture assignments, on which you pondered in class as group work? Suggestions for the future.
23. What did you like most in this course? What was most rewarding? Why?
24. What was most troublesome in this course?
25. Space for free comments, positive and negative; suggestions for the future.

This form is also available on the Web at
http://www.eng.monash.edu.au/uicee/member/MembershipForm.html

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