Pair Lecturing to Model Modelling and Encourage Active Learning

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ABSTRACT
Students in our course on "model-driven software development" find it difficult to apply the models presented in the lectures to their team projects. By introducing pair lecturing we aimed to use the interaction between the teachers to model the entire process of developing consistent software models as well as to encourage students to take a deep approach to learning. The educational impact of pair lecturing was evaluated using a survey-based instrument. Most students reported that they were more active during the lectures and remembered more compared to a traditional lecture. The increase in lecturing hours was compensated by needing less time for preparing for our project supervision. And being two teachers in the lecture hall was really fun.

Keywords – Pair lecturing, cognitive apprenticeship, action research, software engineering

I INTRODUCTION

In this paper, we describe an ongoing action research project (Kember & Gow, 1992) to improve teaching and learning in the course "Model-driven software development" (Burden et al. 2011a, 2011b) given by the Department of Computer Science and Engineering. The majority of the students are third year students and after taking the course the students should be better able to analyze and specify software through models. The course is based on lectures and a team project. Over the years, we have however noticed that students have difficulties in applying the theory presented in the lectures to their projects. We therefore felt that the lectures could be improved to better prepare the students for tackling the project, and hence to bridge the gap between theory and practice. The two research questions we have decided to address in this paper are:

1. *Can pair lecturing encourage students to take a deep approach to learning in lectures?*
2. *What are the pros and cons of pair lecturing for students and teachers*?

A deep approach to learning involves "the critical analysis of new ideas, linking them to already known concepts and principles, and leads to understanding and long-term retention of concepts so that they can be used for problem solving in unfamiliar contexts" (Houghton, 2004).

Stice (1996) argues that the main reason why students have trouble applying what they know to novel situations is that the teacher seldom models the entire problem solving process, including assumptions, alternative strategies and evaluation of results. What the students get to see is often a neat solution – the *product* but seldom the *process* behind the product. Because the students "own attempts to solve problems seem more painful and often are unsuccessful, they may think that the professor is a genius (or a magician), or that they are dumb. Odds are that neither is the case" (Stice, 1996). Bain (2004) studied, over a period of fifteen years, the teaching methods of nearly one hundred successful college teachers from a variety of disciplines and concludes that: "The most effective teachers use class time to help students think about information and ideas the way scholars in the discipline do. They think about their own thinking and make students explicitly aware of that process, constantly prodding them to do the same." Or in the words of Buckley (1999) the teachers "model the competence they try to impart, forming the students by their example of interaction as much as by their words."

There is also a large body of research demonstrating that students learn more when they are actively involved during lectures (Hake, 1998; Prince, 2004). Felder (2009) defines *active learning* as "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes". Examples of well-known active learning exercises include the pause procedure, the one-minute paper, and the think-pair-share activity (Nilson, 2010). Bonwell & Eison (1991), who popularized this approach to teaching, emphasize that “to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation”. When lectures are delivered using PowerPoint slides as the main presentation medium it is easy to fall into the trap of covering too much material and moving too quickly through the material. And as Biggs (2003) has pointed out, “coverage is the greatest enemy of understanding”. Moreover, when slides serve as a fixed and linear script for the lecture, it can be difficult to adjust the flow of the lecture to the student interaction. As a consequence, there is a risk that students become passive consumers of information.

II METHODOLOGY AND METHOD

In this study, we have therefore drawn on *cognitive apprenticeship* (Brown et al. 1989) as a theoretical framework for teaching and learning. A key component of cognitive apprenticeship is that the teacher *models* and *verbalizes* the cognitive processes that experts engage in as they solve problems. This act of making thinking visible should be carried out in *collaboration* with students and by using *real-life* examples.

We wanted the software models to take form in the lecture hall in interaction with the students so that the assumptions and motivations for alternative solutions became explicit. But this immediately raised four challenges:

1. Getting students to actively participate in the lectures;
2. Finding examples from real life where the students have sufficient background knowledge;
3. Being able to correctly interpret comments and questions from the students;
4. Being able to cover the necessary material so the objectives of the lectures are fulfilled;

We believed that we would be better able to deal with these challenges through *pair lecturing.* One of us was responsible for preparing the lectures and another one carried out the drawing of the model on the whiteboard during the lectures. In this way it was natural for the one drawing the model to question and discuss with the first lecturer what the purpose and necessary level of detail of the model was, as well as the pros and cons of alternative solutions. This discussion between the lecturers could motivate students to actively engage with the material and perhaps also participate in the lecture. Moreover, if the teachers can comment on each other’s models, suggest improvements or come up with new ways of modelling the same features it could hopefully create an environment where the students are encouraged and more comfortable to do the same. And even if they do not engage in a discussion with the teachers it provides an opportunity for the students to “think about the topic rather than memorize information” (Hanusch et al., 2009).

It is easier for the teacher who is not actively involved in the discussion at a certain point in the lecture to interpret comments/questions from the students and to sense when the direction of the discussion changes. It therefore becomes easier to discuss alternatives when two teachers are present since we can help each other to interpret and integrate student ideas into the model being developed. At the same time, two teachers have a better chance of keeping the momentum of the lecture, ensuring that the objectives of the lecture are met.

In order to encourage students to actively participate in the lectures we used a real-life example of a software model where students had sufficient background knowledge: a system for registering students to courses. This example also serves as an illustration of what we mean by a “model” in the context of this paper. In Figure 1 there are two examples of a simplified software model, the domain model (Larman, 2004). It depicts three central concepts within the educational domain (students, programs and courses) and how they relate to each other. In the left model a student can be registered to a programme at the most but it is not necessary (shown by the 0..1 notation). This is the situation for those registered as students at the University of Gothenburg. In the domain model to the right each student has to belong to a program (shown by a single 1). This reflects the situation at Chalmers

University of Gothenburg. At Chalmers each course is also part of at least one program (1..*) while the University of Gothenburg allows courses that are not part of a program (0..*).

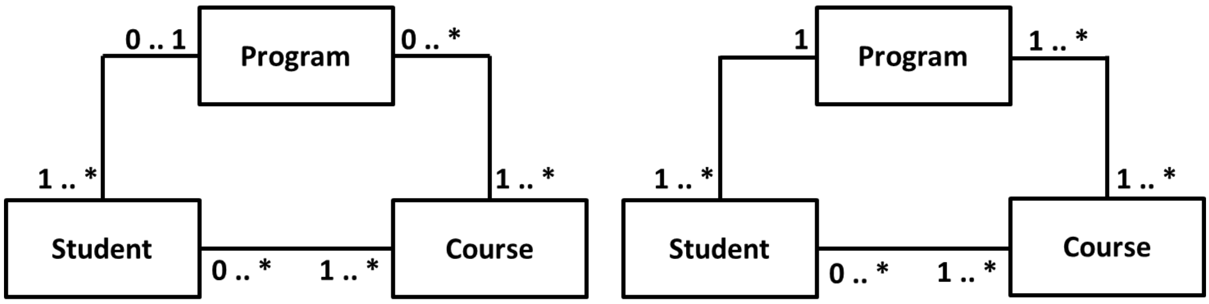


Figure 1. Two alternative ways of modelling the associations between three educational concepts

Neither solution is right nor wrong; the two models represent two different definitions of what roles programs really play and how that effects the associations to courses and students. These differences will percolate through the rest of the design and have consequences for how other concepts and associations can be defined, such as which courses that are available for a student or if we need to include universities as a concept or not. If one of the models is given as the (simplified) example of a domain model it is easy to take the concepts for granted. On the other hand, if the students have to come up with the concepts and define them during the lecture the different assumptions and alternatives are made explicit. And it becomes essential to motivate the different solutions.

In the above example, the students already have the perspective of domain experts and end-users while the aim of the lecture is to help them to take the perspective of developers and clients. With this kind of setup student participation is essential for driving the lecture forward.

To briefly summarize, in pair lecturing each lecture had well defined learning outcomes but followed a semi-structured script and contained no slides as the lecturing duo tried to model and verbalize the entire process of developing real-life software models. The models are developed and refined through the interaction between the students and the teachers in a fashion that resembles how software models are developed in an authentic setting.

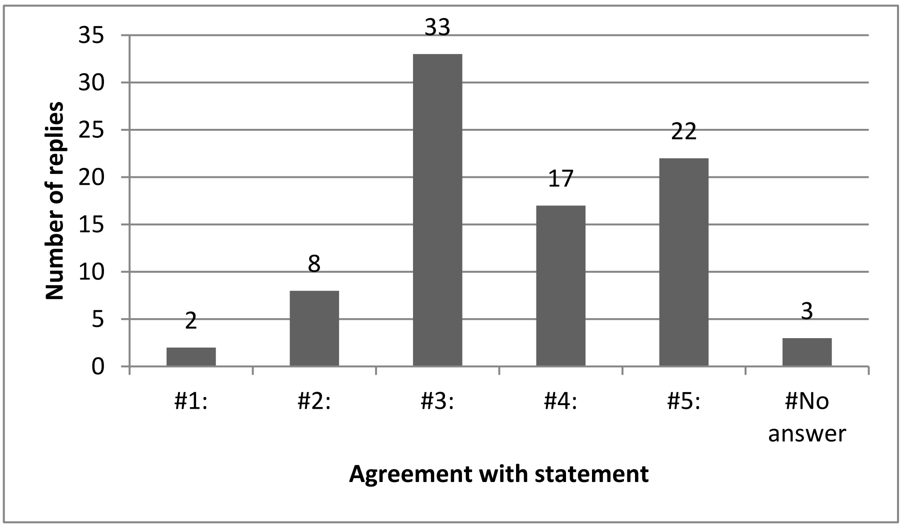
III RESULTS

The educational impact of pair lecturing was evaluated using a survey-based instrument. The survey contained a number of statements on a 5-point Likert scale: students circling 1 fully disagreed with a statement while those that circled 5 fully agreed with the statement. The survey also contained one open question: *"What was the greatest value of pair lecturing?"*

The answers to the first statement, *"I was more active during the lectures than in traditional lectures"* are presented in Table 1. In this survey a traditional lecture was defined as one teacher relying mainly on slides to present the lecture content. Two students fully disagreed with the statement while 22 fully agreed. The mean score was 3.6. Concerning the value of pair lecturing one student wrote that *"it feels easier to ask questions"*. Other students claimed that *"the lectures come to life with the discussion, the arguing and the class interaction"* and that *"pair lecturing helps you stay focused on what the teachers are doing"*. All in all, 39 out of 85 students claimed that they were more active during pair lecturing than they usually are while 10 students did not agree.

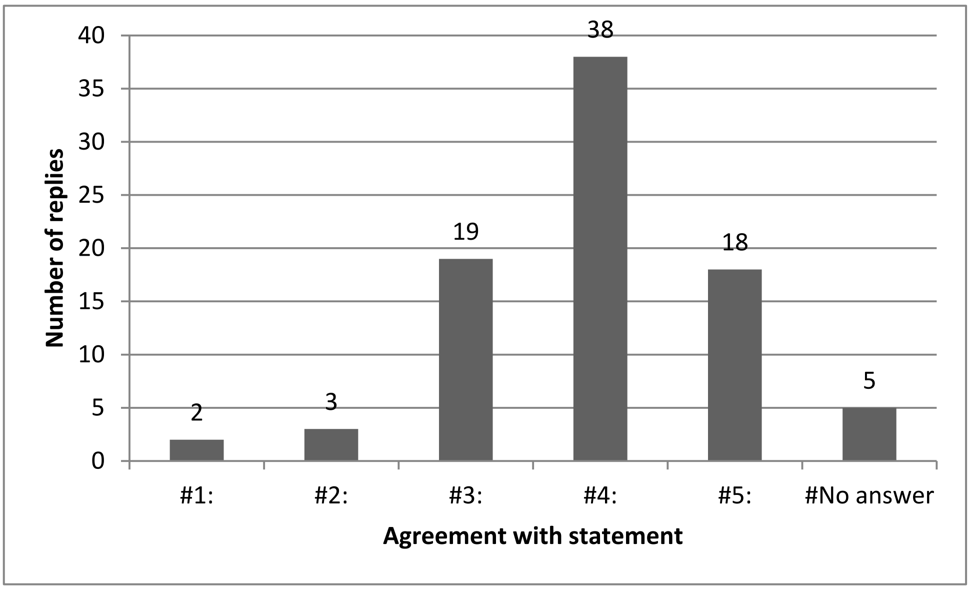
The statement in Table 1 does not define "active". To be more precise, we were interested in a more flexible lecture structure to let the students influence the lecture content. A question reflecting this issue is presented in Table 2. If we address what the students find interesting and challenging, this will hopefully help them to find their own way to accommodate the new knowledge. In addition, we wanted to create a situation where the students had to actively reflect upon the different ways to use the software models. Hopefully this implies that they will be more focused and remember more from the lectures. This aspect of active learning is addressed in Table 3.

Table 1. ***"I was more active during the lectures than in traditional lectures."***



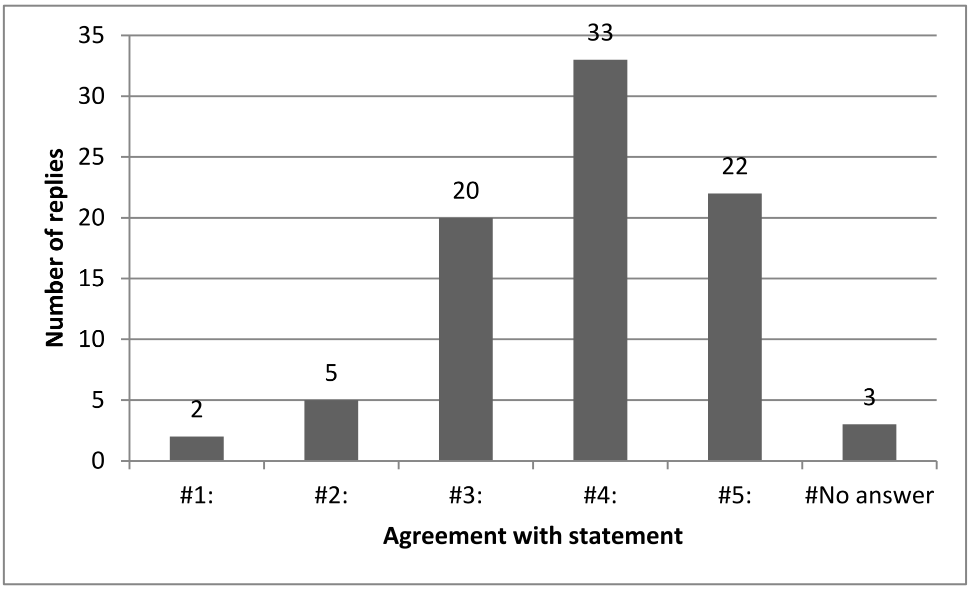
In Table 2 the reply frequencies are shown for the statement *"Pair lecturing lets the students influence the content of the course more than traditional lectures."* The mean score was 3.8, with 18 students fully agreeing with the statement, and 56 out of 80 replies were on the positive side. There were no comments on this statement.

Table 2. ***"Pair lecturing lets the students influence the content of the course more than traditional lectures."***



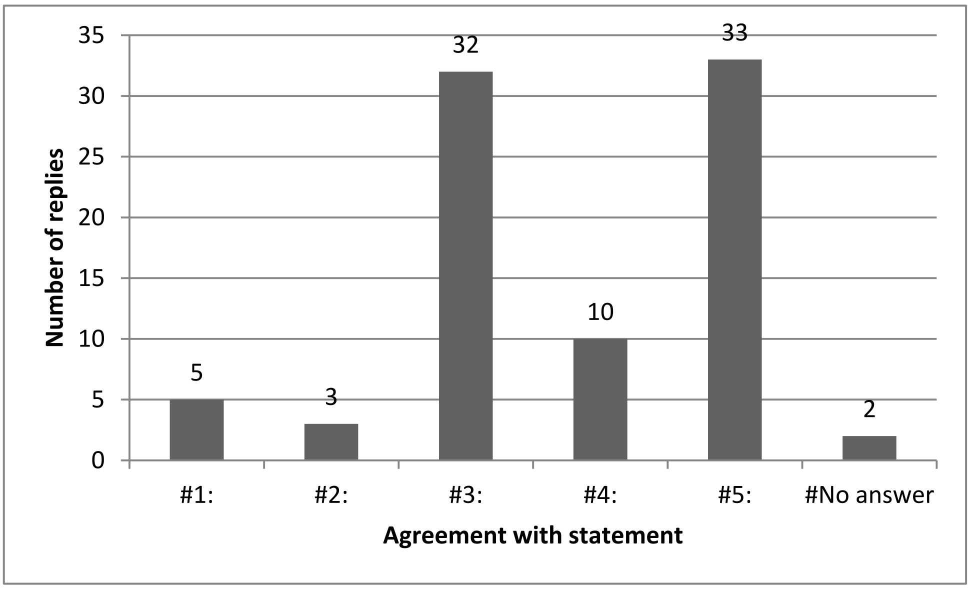
If there were no comments for the previous statement the situation was different for the statement *"I remember more after a lecture with pair lecturing than after a traditional lecture."* One of the comments was that *"it is more interesting seeing two opinions, it gives a deeper (instead of broader) understanding"* while another student claimed that *"complicated things got explained twice."* Many students appreciated that the teachers had different opinions about the models but a few stated that it became confusing and that it requires more reflection on their behalf when there are conflicting opinions about the models and how they should be used: *"while different views can be enlighting, it sometimes causes confusion"*. 55 students out of 82 claimed that they remembered more from the lectures than they usually do. The mean score for this statement was also 3.8.

Table 3: ***"I remember more after a lecture with pair lecturing than after a traditional lecture."***



To get an overall picture of what the students thought about pair lecturing we asked them to what extent they agreed with the following statement: *"Pair lecturing should be used in more courses"*. 33 students replied that they fully agreed. One of the comments was that *"I realized that the subject requires that you develop your own point of view"*. Another student had grasped the process from the lectures and wrote: *"I could use it to improve how I interact with my project team"*. Again the mean score was 3.8.

Table 4: ***"Pair lecturing should be used in more courses."***



IV DISCUSSION

We are encouraged by the fact that 55 out of 82 students said that they remember more after a lecture with pair lecturing than after a traditional lecture. Moreover, 40% of the students fully agreed that pair lecturing should be used in more courses. If we add those that agreed to some extent, over 50% agreed. On the other end of the scale we only have 10% who disagree. In fact, there are fewer students who disagree than there are students who did not pass the course.

Each lecture had well-defined learning objectives while still being flexible enough to adjust to the students' questions. However, some of the students felt that the lectures were unstructured; *"I was more active but lectures lacked structure"* and *"I think you should have a clear plan"*, were two comments. This might be a consequence of having to deal with several different viewpoints at the same time, as indicated in these comments: *"Try to agree more often"* and *"I found it difficult to understand important points when opinions differed too often"*. These comments are better understood in light of a scheme of cognitive development described by Perry (1970). According to Perry, college students move through a sequence of stages in which they hold different views on the nature and acquisition of knowledge. In his scheme, there is a progression from a simple *dualistic* view of knowledge, in which there is always one right answer, to a view that can embrace a multiplicity of viewpoints. "Learning does not just affect what you now; it can transform how you understand the nature of knowing" (Bain, 2004). It is therefore important to expose students to different viewpoints (and uncertainty) to help them to realize that there can be more than one solution to a problem (Nilson, 2010), and hence to facilitate cognitive development. But at the same time we do not want to make the lectures more complicated than necessary. Getting the balance right is not trivial and will take time.

Active learning can sometimes take students out of their comfort zone. While some students enjoy that teachers care enough to do something different, others get stressed when they are expected to learn a new subject in a new way. As Felder & Brent (2003) point out, it is therefore essential to explain *why* you are using a new and non-traditional teaching method. Since we now have some experience of pair lecturing it will be easier to explain to the next group of students what we want to achieve and how it works.

While one teacher was busy drawing or explaining a model the other one had time for reflection: What are the practical implications for the students? What is missing in the drawing or explanation? How does our lecture fit in with industrial practice or the literature? This meant that we could give two perspectives or explanations for the same model or phenomena. For us this was an important gain since it is often easier for the teacher who has been listening to understand questions and comments from the students and then improve or elaborate on the answer given by the other teacher. When teaching alone it is very difficult to find the time to reflect – in real-time – on what you are saying and doing in the classroom. In his seminal book, "The reflective practitioner", Schön (1983) introduces the twin notions of *reflection-in-action* and *reflection-on-action*. Reflection-in-action can be described as "thinking on your feet" while reflection-on-action is done later, after the lecture. It is only after the lecture that you usually have the time to take a step back and reflect on what really happened during the lecture; to evaluate the events and the decisions you made. And, in our experience, it is often only after the lecture that you fully understand the meaning of a student question or comment, and what a more appropriate answer would have been. But that "teachable moment", that just-in-time opportunity to connect with the students is lost. One of the greatest benefits of pair lecturing is therefore the potential to enhance reflection-in-action. It also means that by being two teachers in the lecture room we do not only create more opportunities for teacher-student interaction, as expressed by Little and Hoel (2011), we also make better use of the interaction.

The teacher that did not prepare the lecture could use the lecture itself as recapitulation of the models, reducing the time spent on preparing for supervision. This had the added benefit that each teacher knew what the other teacher had said during the lectures. It also increased the "status" of the teacher that earlier was mainly involved as a course assistant.

We think that it is important to ground pair lecturing in an existing collaboration. We used the same mutual reasoning and interaction with the students as we have in our own research to come up with suitable models for our running example systems. It also meant that we were comfortable in not having a fixed lecture plan since we knew from experience that we can handle these kinds of situations. One student commented in the survey that *"you complement each other"* which we believe is an important factor for pair lecturing to work.

We were initially concerned that we would have to lower the tempo in the course since drawing a model takes longer time than showing it on a slide. It turned out that we could keep the same tempo as previous years. It does take longer time to draw the model but this is compensated by the fact that we could introduce many of the details on-demand instead of showing a new slide with corresponding information. As a result the lectures were driven by the students' questions. At the same time we think that we managed to keep the lecture structured enough to cover what the students needed to know to get started with their own modelling.

There were two occasions when we opted to use slides. The first occasion was to show how the information encapsulated in several complicated models that were developed in previous lectures could be used when developing a new type of model that enhanced the information while still being consistent. This would have taken more time than the designated lecture time to draw by hand. The second slide show used the animation property to show how an instance of a model changes over time. We feared that the redrawing of a model would make the presentation messy and there is no easy way of rewinding the changes when recapitulating the process.

Many of our old examples relied on showing a new slide for each new aspect or detail that we wanted to discuss. When drawing the models this is not feasible so we had to come up with new examples that were reusable throughout a lecture. This meant an increase in preparation time this time around that we will not have next year, since the new examples will be reusable next time we give the course. So, changing lecturing style had the additional effect of enforcing a more stringent and efficient way of showing examples and presenting the course content.

V CONCLUSION

The aim of this study was to answer two questions:

1. *Can pair lecturing encourage students to take a deep approach to learning in lectures?*
2. *What are the pros and cons of pair lecturing for students and teachers*?

By a deep approach to learning we follow the definition of Houghton (2004) meaning that the students should be able to critically analyze new ideas and connect them to what they already know, which in turn leads to an increased understanding and long-term retention of the concepts.

To answer our first question the students were asked to comment on three separate statements, reported in Tables 1 to 3. From Table 1 we can conclude that pair teaching enabled the students to be more active during lectures, thus encouraging critical analysis and connecting new ideas to what they already have learnt. For the students to transform their new insights into a deeper understanding there has to be opportunities for them to reason about issues they find challenging during the lectures. The possibility for the students to influence the course content was reported on in Table 2, where the students state that there were more opportunities to influence content than usual. Finally, in Table 3 the students report that pair teaching helped them in remembering more of the lecture content than they usually do.

In answer to the second question we will first consider the student aspect. The negative comments from the students were about too many opinions confusing more than helping to understand the course subject. The positive comments mentioned complicated aspects being explained twice, better focus during lectures and deeper understanding. To determine if pair teaching is in conflict with what the students perceive as a constructive learning environment we asked them to comment if they recommend the use of pair teaching in more courses, Table 4. The response from the students regarding pair teaching was overall positive. As teachers we experienced a sensation of sticking out our necks a bit, but being two teachers in the lecture hall made us more comfortable and confident. Our way of doing pair teaching has benefitted from the fact that we have an established research collaboration, we know each other's strengths and weaknesses as well as how to cooperate and tackle challenges together. The increase in teaching hours was compensated by an equivalent cut in preparing for supervision, though there was an increase in time for preparing the lectures since our old examples had to be adjusted to fit with our new lecture plans. We found that pair teaching gave us a better opportunity to reflect "in-action", which enabled us to handle student initiatives in a constructive way to drive the lectures forward. All in all, as educators we found pair teaching to be a positive experience. The simple fact is that lecturing is much more fun in pairs.

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BIOGRAPHICAL INFORMATION

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