Tips and Pitfalls for Blended Learning:
Redesigning a CS Curriculum Using IT

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Abstract. This paper describes the process of introducing blended learning in a CS educational program. The methodology that has been used as well as the motivation for the choices made are given. The first results compared with results from previous courses that used a more classical teaching approach are given. These results show that the new methodology proves to be promising and successful. The successes of the new program as well as the problems encountered are discussed with their possible solution.

Keywords. blended learning, course development, didactic models in practice
Key Terms. TeachingMethodology, ICTEnvironment, TeachingProcess

1 Introduction

The rapid change in insights in how students learn and the technical possibilities has lead to innovative educational technologies. E-learning and MOOCs are examples of recent developments in Technology-Enhanced Learning (TEL). At the Utrecht University of Applied Sciences a project was started to design a new curriculum for bachelor students. There were several reasons for this project. The first reason was the fact that due to a reorganisation of several educational CS programs, there was a need for a new curriculum. The other reasons were new insights and the development of new concepts in blended learning as well as the strategic view of our university on future education. The combination of these reasons turned out to be a good starting point for the project.

One of the goals of the project was to construct this new curriculum using new concepts in higher education. Some of these concepts came into existence because of advances in information and computing technology. Nowadays all of our students have high speed access to the internet which opens the opportunity for video, and other multimedia applications that can be used by students at home in a so-called distant learning situation. By combining several kind of possibilities to learn for students a so-called blended learning environment comes into existence. This paper will discuss the approach that has been followed to use this blended learning approach in our course re-design in combination with the

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considerations and motivations for the choices made. A comparison with results from earlier courses is also given.

This paper is organised as follows: In the next section the concepts that are used will be explained. This is combined with a discussion of related work. Next the approach of curriculum re-design is presented in the section "Curriculum re-design". The section "Implementation" is dedicated to the implementation of the first part of the new bachelor program and the choices that have been made about teaching concepts. The first results are presented in the section "Results" followed by a discussion where the pitfalls and problems encountered are treated. The tips to avoid the pitfalls or solve the problems are also given. Finally a conclusion and a bibliography will end the paper.

2 Concepts and related work

The project is based on several innovative concepts in relation to education. In this section the concepts are introduced. In a later section an explanation will be given why these concepts have been used in our innovation project.

2.1 Blended learning

Blended learning [4] was introduced as a mix between face-to-face and online learning, giving rise to the challenge of virtually limitless design possibilities.

The idea of blended learning is that the learning content and subjects should be offered to the student in several ways. The student can choose the type of explanation that fits herself the best. Also a combination of learning possibilities might help a student to understand the subjects. Whitelock & Jelfs [9] opened a journal special issue on this topic with three definitions:

- the integrated combination of traditional learning with web-based online approaches;
- the combination of media and tools employed in an e-learning environment; and
- the combination of a number of pedagogic approaches, irrespective of learning technology use.

Of these, the first is perhaps the most common interpretation. For our approach the third definition fits the best, but we also heavily rely on web-based approaches.

2.2 Flipping the classroom

Flipping the classroom is an educational teaching method where lectures are replaced by self-study. This self-study is supported by moments of interaction between teacher and student where students can ask questions and put the theory into practice. In Figure 1 this situation is depicted. What is not shown in

the figure is the fact that in the flipped class students should do their homework before the moment of interaction with the teacher and other students. The reason to start using this method is mostly based on the observation that the concentration of the student is limited to a small amount of time. Working on a problem related to theory that has been studied before gets the student more involved. A definition of flipping the classroom is given by Lage e.a. [5]: *Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa.* An overview of flipping the classroom is given by [1].

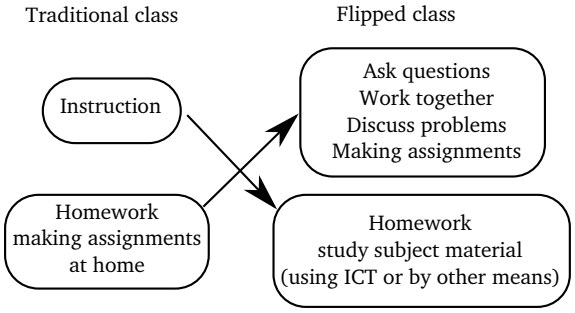

Fig. 1. Flipping the classroom

2.3 4C/ID-model

The 4C/ID-model is a didactic model that is specially suited for training students that are determined to have a professional career in the industry [6]. 4C/ID is abbreviation for 4 components instructional design. The main idea is that students will always work on real-life products that are closely related to their future professional work. In the starting phase of their training students are confronted with situations where most problems are already scoped and analysed by the teachers. Students have to fill in the gaps. Later on, students are given situations where they have to do more work themselves, while in the final part of their training they should be able to solve problems in complex situations by themselves. In all cases they are working on a real-life product fitting their educational program. The 4 components of the model are:

1. Learning task (backbone of the education program).
2. Supportive information.
3. Procedural information.
4. Part-task practice.

In Figure 2 a schematic overview of the concept is shown. Students are working on learning tasks (1) represented by big circles in Figure 2. At the beginning of

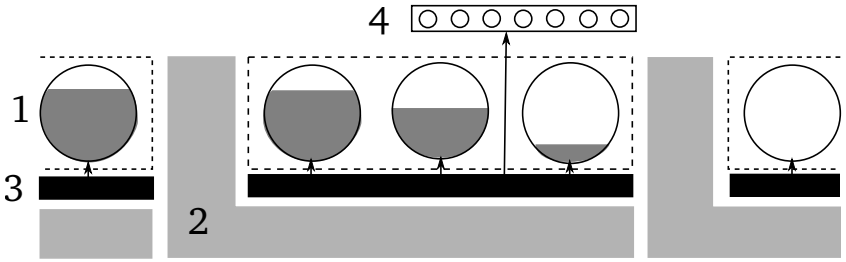

Fig. 2. The 4C/ID model [7]

their study, students start with simple tasks and students will work on complex tasks at the end. The simplicity and complexity is controlled by giving much support in the beginning and reducing this support at the end. In Figure 2 this is shown by the level the circles are "filled". The learnings tasks are part of a project (the dashed boxes, containing learning tasks) that will result in a product. The type of product the students will work on is related to their future professional career. Supportive information (2) is given at the beginning of every project. The supportive information gives the students a solid background to handle the problems they will encounter. This mostly theoretical information is also given during the time students are working on their tasks. The procedural information (3) is presented in a "just in time" manner to the students at the moment they really need it to complete the learning task. Practising with new concepts is also included in the model. In Figure 2 this is represented by small circles (4). A thorough treatment of the concept can be found in [7].

2.4 Technology-enhanced learning

Two of the concepts mentioned in this section are closely related to IT. Flipping the classroom and blended learning heavily rely on IT and internet technology, while the 4C/ID model is a concept that can be implemented without any IT support.

3 Curriculum re-design

Our main goal is to build a curriculum that uses new but proven concepts and fits in the educational concept that was chosen in the preliminary phase of the project. The concepts should be proven, because a situation where students are treated as guinea pigs in an experiment should in all cases be avoided. The quality and high standards used in the past should be guaranteed. The research presented in this paper has its main focus on the first part of this new curriculum. This first part consists of three courses of 5 European credits (EC's) [8] each. The courses are attended by around 500 first-year IT students.

3.1 Initial situation

One year ago there were four different IT-based professional bachelor programs at the Utrecht University of Applied Sciences. These four programs were:

- Software engineering (SE)
- Computer science and embedded systems (CSES)
- Business IT and management (BIM)
- System and network engineering (SNE)

These trajectories are now combined in one bachelor study with four different profiles. Combining bachelor studies was stimulated by the government for all existing bachelor studies. This will make it easier for students to select a certain study and specialize for a certain profile later. Combining these four given trajectories may seem like a simple reorganisation, but the students are offered more possibilities to select a set of courses leading to the final diploma. Cooperation between the different types of IT engineers is also more stimulated. This type of cooperation is often needed in the IT industry, so training students to cooperate during their study in multidisciplinary teams will support their professional career.

3.2 Design principles

As a design principle we used the term MOS for the three properties every course should adhere to. MOS stands for:

- Motivation - use of new technology and didactical approaches should align more with students preferences. Working on real assignments (as in the 4C/ID model) and deeper discussions should motivate students more.
- Orientation - give students a good overview over the broad IT-landscape and professional roles therein. Guide them towards choosing one of the four specializations within the Bachelor program.
- Selection - have the right level of difficulty in content and assignments so that passing 10 of the 12 courses more or less predicts finishing the study within the regular duration of four years.

Both orientation and selection are prescribed by regulations of the Dutch government [3].

3.3 Involvement of the teaching staff

At the beginning of the project, ideas and advice from the teaching team of around 40 persons were collected. Presentations and discussion sessions were organised. During two weeks discussion posters were available where all people involved could post their comments and remarks. The whole teaching and management staff was able to contribute ideas and proposals. This resulted in the following set of requirements:

- The same program for all students during the first half year.
- No instruction to big groups, but classes with a maximum of 32 students
- Showcases of real-life products as the main drive for the curriculum
- Special attention to the development of professional skills by the students during their training. Professional skills are skills that one might expect from a professional IT engineer apart from the specific domain related knowledge and skills, such as professional written and oral communication, leadership, (team)planning and ethical skills.

3.4 Involvement of stakeholders

From the beginning the IT industry as well as the students were involved. The plans for the curriculum were presented to representatives of the IT industry and students from all years of the four-year curriculum. By using the feedback of these meetings, the new curriculum adheres to the requirements and expectations of the software industry as well as the students. Every course under development was also checked this way.

The developers of different courses had several meetings to guarantee the coherence between the different courses that were given in parallel. All courses started with an explanation of this coherence and why this specific course had its place in the bachelor program.

4 Implementation

For the time being, only the first year will be considered. The first year curriculum consists of four periods of ten weeks. At the end of the year every student should have a personal assessment to check her knowledge and practical capabilities learned so far.

4.1 Learning model

For instruction a selection of one the following possibilities has to be made:

1. Blended learning: use all kind of teaching techniques to train the student. Let the student decide which one fits her the best.
2. Problem driven education: students are confronted with a problem en should discover by themselves what knowledge and information they need to sole the problem. When they have questions, the teacher will get involved.
3. Project based education: a project is the central part of the training and should control all other educational methods involved.
4. Classical approach, giving theoretical training supported by practising the learned material.

Considering the new possibilities in IT, the blended learning option has been chosen. By definition, all other methods could be included, but the problem driven possibility had been used is the past and turned out to be not so successful.

A pure classical approach is not apt for our education, because the type of student in our institute is more interested in practical problem solutions, than pure academic knowledge. Pure project based education that has been used in the past, seems to be missing some essential aspects. It turned out to be difficult to find a set of projects that covers all end-goals of a professional IT engineer. A choice has been made to combine blended learning with flipping the classroom. This approach did not need the instruction sessions for a huge number of students, that turned out to be not so successful in the past.

Next a choice has to be made between 4C/ID and the classical approach. In our case the 4C/ID model has been chosen because our institute focusses on training bachelor students to act as a professional worker in the IT industry. The teaching team had the experience that these students are more motivated when they are working on real products [6]. This in contrast with the pure academic approach where the student is trained to be a scientist. In the academic approach the coherence with the work in the IT industry is less evident. The 4C/ID also fits well in the concept of blended learning and flipping the classroom. Students are working on projects and will also be instructed to guarantee their theoretical knowledge.

The choices made also fit well with the design principles regarding motivation as explained in Section 3.2.

4.2 Selection of courses

To give the students the possibility to orient on the possibilities in a later phase of the bachelor program, all three courses should more or less be tied to the final four tracks the student has to select during the first half year. Table 1 shows the relationship between the courses and the four tracks. The orientation on the

Table 1. Relatioship between track and course

Education	Computers	Programming	Organisation
BIM			✓✓
SE		✓	✓
SNE	✓		✓
CSES	✓	✓	

tracks is now guaranteed. A mark means that the course has a significant relation with the track mentioned. A missing mark does not mean that the course is not significant for the track, but that it is not a main focus. Another reason why these three courses are combined in the first block of the study is that it is a nice way to demonstrate the layered structure that plays an important role in many IT concepts. At the top is IT in organisations, The middle layer is presented by programming and finally the bottom layer (hardware, operating systems and

networking) is covered by computer systems and networks. Having a model and three courses to start with, we will present the results in the next section.

5 Results

The new program started in September 2016 and the first period consisted of the three aforementioned courses. These courses had the same learning goals as courses we had in our old model so a comparison with courses in the previous year is legitimate. Some minor differences exists that will be discussed later. As mentioned and motivated in the previous section the courses are:

- introduction in programming
- computer systems and networks
- IT in organisations

In Table 2 the results for the three courses are given for both the blended and classical learning (previous year). Nb is the number of students doing the final exam for the blended course, Nc is the number of students doing exam for the previous classical course, pass is the number of student that passed the exam (including a second chance exam) and avg. is the average score for the exam on a scale from 1 to 10. The average score has not significantly changed, while the percentage of students passing the exam has increased.

Table 2. Results

Course	Nb.	pass	avg.	Nc.	pass	avg.
IT in organisations	474	372	5,7	413	247	5,7
Programming	486	399	6,1	425	330	6,2
Computer systems & networks	490	351	5,4	454	293	5,3

Figure 3 shows the results of the percentage of students that successfully completed the course in the regular time after a second chance had been offered. In our institute, every course will have a second exam every year. In the same figure, the results for the previous year have been added. From the figure it becomes clear that the yield has significantly increased for all courses. The most successful course so far was programming, though this course was also the most successful one in the previous year. There is also a slight difference in the content of the program, mainly due to the fact that Python has been used instead of PHP or Java may have influenced the outcome. The learning goals did not change, so it is fair to state that the new blended course was more successful than the year before. All other courses show a better outcome than the year before. The other two courses are quite similar in content and learning goals, so the results can be compared. One should keep in mind that the new curriculum was not

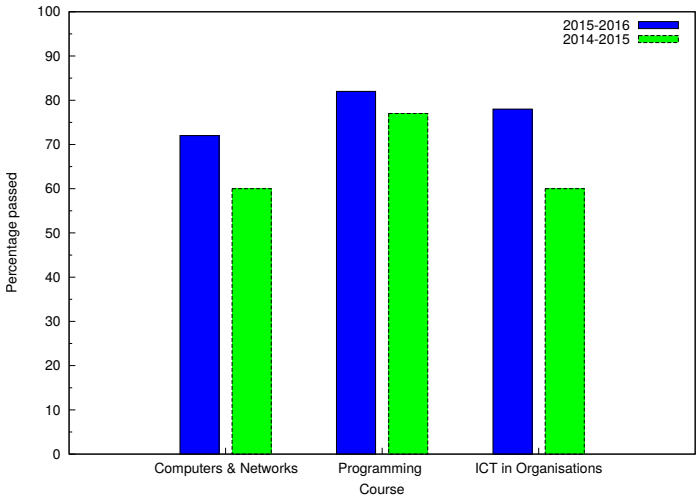

Fig. 3. Success rate per course

only based on blended learning and the 4C/ID model, but also based on the fact that we did not separate the different specialisations from the start. Also the fact that there were no classes with more than 32 students should be mentioned here. In the previous year there were instruction classes for over 100 students. So the positive effect should be considered as the consequence of all changes in the curriculum.

6 Discussion

In this section, some of the problems encountered during development and introduction of the new curriculum are discussed as well as the successes achieved.

6.1 Pitfalls

Though the concepts presented were supported by the majority of teachers in our institute, some remarks should be made here:

1. The amount of work for the developers of the courses was much more than expected in the beginning. Selecting good online material took much more time, because the developers should check the quality and adequateness carefully [2]. Also the match of the online material with the learning goals turned out to be cumbersome. The alternative would have been developing material at our institute, but that would have cost even more time.
2. The flipping the classroom concept only works well if there is a possibility to monitor the self-study phase of the students. Students should study in advance and do some self tests. The results of these tests will give a clue

to the teacher which parts of the teaching material should be treated at the beginning of the classroom meeting before students will work on instructions and tasks related to the material. In our situation monitoring was not yet possible, so we had to ask the students what problems they encountered. This might lead to the situation that a group of students decides to pay less attention to the self-study, knowing that the teacher cannot check and almost certainly will explain the difficult parts at the beginning of the meeting.
3. There was quite a big difference in applying the concepts as proposed by different persons teaching the same course. Many more meetings would have helped to solve this problem, but this would also put a burden on the people involved.
4. Students were not used to the new educational concepts. More effort should be taken to introduce students to the new environment as well as explaining the system.

The problems mentioned here are solvable. In the situation described under number 1 and 3 it means making more time available for the teaching staff to prepare the courses and having the possibility to discuss the method and help each other to use good practices. Currently the solution for the problem described under number 2 is under development. Monitoring activities per individual student is necessary and as an Institute of ICT we are strongly involved with the software used to create the blended learning environment. The problem described under number 4 should be solved by explaining the students the concept more carefully. The fact that students know that their home-activities for the course are monitored may also help to activate the students.

6.2 Successes

There is also a number of successes to report on the new program.

1. The new learning paradigm turned out to help a bigger number of students to complete the courses within due time. Given the fact that some important improvements still can be made, we expect an even better result for the years to come.
2. Most students in IT expect an IT training to be IT-based. Older ways of instruction are sometimes considered by students to be outdated or belonging to the previous century. This fact also motivates students.
3. Another positive point is the fact that from the beginning both students as well as representatives from the software industry were involved in the construction of the new curriculum. This resulted in a curriculum that was a wide support both by industry as well by the student community.
4. A feature of the new course is multidisciplinary cooperation between students in project. This help students in getting a broader view on the IT domain and getting a better understanding of what other disciplines in that field mean and accomplish.

5. In the new situation students will select a specific specialisation after half a year of their study. This makes it much easier for students to find out what specialisation fits the best with their interest and capabilities. In the older setup there was also a half year with almost similar programs, but the switch to another discipline was more complicated. Actually the student had to switch while in the current course she only decides what specialisation she will choose after half a year.

Given the fact that the pitfalls we encountered are solvable, the switchover to the new educational approach can be considered as a success so far.

7 Conclusion and discussion

In this paper we described a project to renew a CS curriculum. In this curriculum concepts like 4C/ID, blended learning and flipping the classroom play an important role. The concepts that have been used are introduced and explained as well as the implementation and first results. The first results are promising.

IT-based solutions offer great opportunities for educational renewal, but care has to be taken about the way the they are used. Also the time and work involved was in our case underestimated leading to a result that is not yet at the level that we had in mind at the start. However, as mentioned before the results so far are promising and give support to the idea that this is a good approach to keep students involved and motivated with their study at the educational institute.

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