Improving Didactics in Computer Science – The Example of the GEMIS and the QUADRO Projects

R. Pucher, M. Tesar, T. Mandl, G. Holweg and F. Schmöllebeck

***Abstract*—**Computer Science tends to be one of the studies with relatively high rates of early drop outs. This is also a problem at the University of Applied Sciences Technikum Wien. GEMIS (GEnder Mainstreaming in Informatics related Studies) and QUADRO (Methods to improve the QUAlity of teaching and lower DROpout rates of students) are two projects to improve didactics in Computer Science and consecutively to lower this high rate. Four courses, two of them on the bachelor level, two on the master level participate in the projects.

The main goals of the projects are 1) to identify the difficulties for students. 2) To introduce new methods of teaching to address different learning types. 3) To enhance the usability of the offered e- and m-learning tools.

The GEMIS project was initiated to investigate the reasons for the higher drop-out rate of female students in informatics related study programs and to develop and implement measures to counteract.

QUADRO helps to resolve that issue by providing much additional organizational information (e.g. term agenda, deadlines for tasks in different courses) in Web 2.0 environments, like Google Calendar or Facebook, thus moving beyond integrated learning management systems (LMS) and engaging students in an active use of the web as a resource for their self-governed and collaborative learning activities.

***Keywords*—** computer science, drop out, didactics, e-learning, education

I. Introduction

UNIVersity of Applied Sciences (UAS) have been founded in Austria in 1994. The UAS Technikum Wien was among the first institutions being in operation. Today UAS Technikum Wien is the largest purely technical university of applied sciences in Austria. Today more than 2,500 students are currently taking its eleven bachelors' and sixteen master's degree programs; it offers a large range of bachelor's and master's degree programs. All of the programs are based on a solid theoretical foundation, while also being practice-oriented. Most of them are offered as full-time and/or part-time degree programs. Two of them are entirely held in distance learning. The UAS Technikum Wien concentrates on the four following technical areas:

- Communication Technologies & Electronic Engineering
- Information Technologies & Business Solutions
- Engineering & Environmental Technologies
- Life Science Technologies

At UAS Technikum Wien, emphasis is not only placed on providing a high-quality technical education, but also on language training and subjects with a focus on business and personal development. The department of Computer Science organizes almost all lectures in information technology related fields in most bachelor and master degree programs.

One of the main concerns in technical subjects is the relatively low number of female students. For example in 2005 only 10% of the students in Computer Science at the UAS Technikum Wien have been females. Also the dropout rate of females is approximately twice the number of their male colleagues.

Table I: Dropouts in all Courses of Computer Science

Year	Dropout female Students [% (number)]	Dropout male Students [% (number)]
2004 / 2005	55% (9)	36% (62)
2005 / 2006	70% (10)	30% (64)
2006 / 2007	45,5% (11)	23,5% (62)
2007 / 2008	50% (8)	21% (62)

Further investigations have been carried out to identify the reasons for drop outs. Although the exact reasons are very difficult to assess, as many of them lie within the personal sphere of students, some subjects could be identified to be the most difficult for students. These subjects are mainly in the area of programming and database systems.

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R. Pucher is heading the department of Computer Science, UAS Technikum Wien (corresponding author , phone: +43 1 3334077 - 264; fax: +43 1 3334077 - 368; e-mail: robert.pucher@technikum-wien.at).

M. Tesar is with the department of Computer Science, UAS Technikum Wien and mainly responsible for the QUADRO project

T. Mandl is with the department of Computer Science, UAS Technikum Wien and mainly responsible for the GEMIS project.

G. Holweg is with the department of Information Management and Computer Security, UAS Technikum Wien and is a project member of QUADRO.

F. Schmöllebeck is Rector of UAS Technikum Wien.

II. GEMIS

1) Initial situation, project aims and environment

Our institution is no exception when it comes to the number of female students in informatics related study programs: in 2005 only 10% of the students in Computer Science Bachelor Program at the UAS Technikum Wien were women with a dropout rate approximately twice as high as for their male colleagues. The GEMIS (GEnder Mainstreaming in Informatics related Studies) project was initiated to investigate the reasons for the higher drop-out rate in informatics related study programs and to develop and implement measures to counteract. All activities and measures focused on the two bachelor programs *Business Informatics* and C*omputer Science*.

GEMIS aimed at addressing gender mainstreaming related topics on three different levels.

1) Project Team level. .
2) Course-level.
   We selected three courses that were reported to be major obstacles, and reason for dropout especially amongst female students. We reviewed and adapted the selected courses from a gender mainstreaming perspective.
3) Instiutrional level
   With the goal of raising awareness and spreading the results of our work in our institution, we organized and held in-house workshops for staff and faculty members.

In addition to project leader and administrative personnel, the GEMIS team was composed of the directors of the involved programs and lecturers of the courses selected for review as well as an external consultant. The GEMIS project lasted for a period of three years.

2) Research

Empirical research was aimed at identifying the main reasons for dropout, based on which we developed several activities that were then installed as pilots and evaluated. We conducted

1) Quantitative statistic analysis of male & female dropout rates at UAS Technikum Wien since the introduction of bachelor & master studies in 2005/06
2) Qualitative interviews with 7 lecturers, 37 female dropouts, 10 successful master students. Interviews lasted between 30 and 60 minutes. Interviews were later analyzed with methods of qualitative content analysis.

Results of our research revealed the highest dropout numbers in the second term. In the qualitative interviews of the female dropouts the main reason given for dropout was the lack of *prior knowledge and skills in technical fields*, mainly *programming and database systems*. From the interviews we learned that closing this *gap* is more than challenging and that they failed the exams at the end of the first semester, then they tried to repeat them, but after a second unsuccessful attempt eventually left the program, thus the peak in the second term. These findings were the main motivation to create mainly measures that aim at the entrance phase or even the pre-study-phase.

3) Activities

a) Team

The project team actively participated in a number of sessions reflecting every individual's approach and personal history with respect to gender mainstreaming issues. These sessions did not serve as a mere ice breaker but lead to deeper appreciation of the gender mainstreaming movement apart from every-day possibly prejudice-loaden conception. They were directed by the external expert.

b) Course level

Existing learning material (slides, scripts) was scanned for inappropriate or discriminating terms by gender mainstreaming experts and later extended. Pursuing a diversity approach we intended toillustrate abstract technical concepts with real-life examples and/or analogies. Our collected extensions were published institution wide as part of a 'Gender-Toolkit' document, available to the teaching staff.

We held programming warm-up courses in summer before the start of the term. These courses are open to both male and female students, targeted at absolute beginners and not graded. The course is based on the JAVA hamster model – a didactic model that allows the beginners application of programming concepts at a very early stage and without involving Math problems (as it is often the case in conventional programming primers). The summer courses serve the cause in several ways. First of all they bring about a reduction of the gap of prior knowledge. Secondly, the course format is not strictly technical due to the concept of the Hamster simulater.

We initiated a mentoring pilot program for programming beginners in the first term. The program was open to both male and female students. Mentors were recruited from higher level programming courses. In our mentoring pilot we had 10 mentor/mentee pairs. In one case, communication between mentor and mentee was problematic and eventually broke down. In all other cases the mentees' feedback was overwhelmingly positive in many aspects. Communication was fast and efficient and support was helpful. All mentees reported that the mentoring program was a suitable measure. Mentors reported that the time and effort was sometimes critical, especially in intense study periods. Only one of the mentees initially failed the programming course, but passed at the second attempt.

c) Institution level

We held two workshops for the teaching staff at our institution to present the results of our effort. The workshops also intended to serve as a forum for discussion of gender mainstreaming issues in our institution. Attendance however was rather low.

4) Experience, concluding remarks & outlook

A main result of GEMIS is the gap in prior knowledge we identified as a main dropout reason in combination with the

rather low number of female students that enroll for an informatics related program. It seems that the number of female students is below a certain critical mass below which the formation of a group appears unlikely. A comparatively small group of female students is confronted with a large group of male students who are part of a computer inside culture and seem to master the technical courses with ease – due to prior knowledge. The inside culture consists e.g. of certain (IT) terms used in language or shared interests, Women often do not feel part of this culture which leads to the notion of having chosen the wrong field of study. The non-existing peer group, the lack of female role models and the perceived outsider status lead to doubt and high levels of frustration. The mentoring program aimed at closing this gap and was found to be an effective tool.

The different learning types seem to play a role as well. Men tend to solve - especially programming tasks - with a trial-and-error strategy in combination with the general idea that spending enough days (and nights) programming will eventually let them find a solution, a notion that might be unintentionally supported by lecturers, most of which come from a background of male-dominated computer inside culture as well. We adapted course material such that a broader range of learning types is addressed. Our ideas were published institution wide in a gender-toolkit document and presented at the in-house workshops.

In the German speaking world, gender mainstreaming is often perceived as some sort of "ultra-pc language police1", which is - to say the least - very bad PR because it overemphasizes one of a variety of aspects and clearly fails to capture the big picture. This reputation could be one of the reasons of the low attendance and interest in the in-house workshops. We were confronted with a number of prejudices ranging from a somewhat Darwinist "equal rights = equal struggles" perspective to a simple, but utter ignorance towards the subject. Our ideas concerning this situation range from continued informal education (coffee-break chats) to the organization of provocative workshops, e.g. "Males Only – How to design a course that is guaranteed to scare off girls."

Gender mainstreaming is a concept and ongoing effort that requires action at many (if not all) levels of society. It is simple to make other institutions (school, family, …) responsible of status quo, indeed much simpler than taking action. The three levels of activities of GEMIS reflect the multi-level nature of the issue itself –It is necessary to act on all levels simultaneously in order to make progress. In this light we believe that GEMIS can contribute to the slow process of spreading the idea, raise awareness and eventually inspire institutions and the people of the institutions to take responsibility and action. It is too early to talk about a reduction of drop-out rates in a statistically sound fashion; however we believe that GEMIS was a first step in the right direction. The issue must and will be kept on the agenda.

[1] Gender neutral language tends to be cumbersome in German due to the three grammatical genders and the required declination. There is strong opposition from great portions of the public, maybe best demonstrated by the existence of a Firefox plugin eliminating gender-neutral terms in German web-pages.

III. QUADRO

Within QUADRO (Methods to improve the QUAlity of teaching and lower DROpout rates of students) we implemented methods to improve the quality of teaching and lower dropout rates of students using Web 2.0 services and active integration of R&D projects in teaching. There are two main goals of the project: On one hand the communication between students and teachers should be improved and simplified. On the other hand, the quality of the teaching offer should be lifted, especially the as critical (related to the dropout-rates) identified lectures. In addition digital educational media should be used in the form of e- and m-Learning.

A. Improving the communication

To achieve the first aim, the project-team developed an application, called Starface, for more efficiency in communication between lecturers, administration staff and students. Today, information is spread on many (web-) services. Based on this fact, we wouldn't improve the communication-process itself, but the way of filing and retrieving information for all participants. For this reason, one limiting fact is obligatory: We don't want to change established operational procedures. – intergration of our solution in the current communication processes is our goal.

Starface is responsible for automated collection of emails targeted to student's mailing lists, tagging and categorization of information and publishing into a weblog's environment [1]. To distribute the information over many channels, we provide RSS-Feeds and at the moment also a Twitter-Channel. An integration of more web 2.0-services, like facebook or something else, is planned in near future.

If lecturers find during their daily work some articles, websites or project-experiences, which may be of note for students and/or colleagues, but for difference reasons not directly for the course, so they should post them via starface. Hence, this is one approach to informal learning and an important step on the way to life long learning.

As a consequence students developed voluntary an iPhoneApp for the Campus-Information-System (CIS) of the UAS Technikum Wien (CISApp). At the CIS students and faculty staff will find information about courses and many course materials for download, also all members of UAS Technikum Wien will find their personal timetable within. This App should simplify and improve the information search for all participants. At the moment, they work on the porting of this App to Android and Symbian for serving the most popular mobile phone operating systems. Figures 1 and 2 show some sample screenshots.

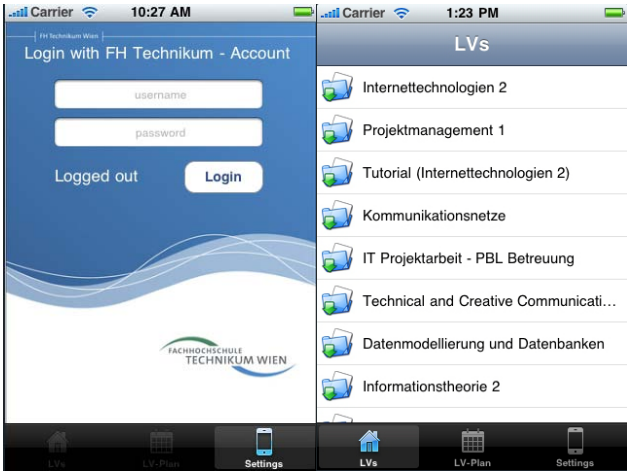

Fig. 1 Login and Select-Screenshot of CISApp

B. *Improving the teaching methods*

For the second goal of this project, the faculty staff improved the methods of teaching and enhanced teaching with new methods.

Fig. 2 Timetable-Screenshot of CISApp

1) *Database Course*

The new concept for the database course combines multimedia-based learning with problem-based learning. The students try to solve subtasks of a project in groups supported by the course book, podcasts, videos and even the Internet. Then the groups present their solutions in a coaching session to the lecturer and they get a direct feedback from the lecturer to their results. This group examination leads to an implicit Mentoring system where the weaker students get supported by the better ones.

2) *Fundamentals in Programming*

The course "Fundamentals in programming" consisted of a lecture and weekly hand-ins. Converting the traditional course into an on-line course required to provide a way for students to verify as early as possible how good their programming solution actually is. As criteria relevant for judging the programs written by beginners, we consider the input/output behaviour excluding error conditions to some degree, and the use of specific language constructs as part of an exercise. The input/output behaviour can be verified by students with a provided set of test cases. Additionally, we offer a re-hand-in. This combination contributed significantly to the acceptance of the system.

3) *Fundamentals in Programming for Business-Informatics*

The beginners' course in programming for business-informatics has been reviewed and the three main learning activities (1. traditional lecture, 2. finishing of programming exercises, 3. presentation and discussion of those exercises) have been identified and adapted/extended for online activities. Ad 1. content is made available online in the form of videos, this way students can study at their own speed and re-watch more critical sections of the lectures. Ad 2. open, but moderated forums offer short-response-time support for programming exercises. Ad 3. students are given feedback by both tutors and peers through a code review activity.

4) *IT-Projects*

The aim of the lecture, called ITP, is the students gaining experience in software development projects. We focused on ITP to improve the quality of projects outcome and increase student's intrinsic motivation. So a project guide, predefined processes as well as objective criteria for benchmarking the projects will help to reach QUADRO's goal.

To support project-members on the way to developing software solutions, we provide a collaborative communication web-service. On this platform, all involved people can upload documents, write forum entries, generate wikis or synchronize code via SVN. This provides a transparent project-environment for students and lecturers - they act in a mentor-mentee-relationship.

C. *An agile E-Learning-Framework*

Like O'Sullivan and McGlynn [2] states "a key role of the higher education instructor is to communicate enthusiasm to their students. […] teaching has changed from the traditional didactic lecture to use of active learning strategies." So, the role of a teacher shifts from being a tutor to being an online coach [3]. This is demanded to guide learners through the entire learning process.

In the current situation of teaching, there are requests for interactive and dynamic learning offers at a high quality level and increasing flexibility of tutors in designing learning scenarios. To foster dynamics the change from process- and phase-oriented procedures to agile approaches has proven itself [4].

In analogy to the agile manifesto [5], there are four key facts of agile e-learning scenarios, as described by Tesar and Sieber in [6]:

1) *Personalised Learning Processes*

Learning is an individual process. The organisational setting of our UAS deals with a predetermined timetable and curriculum for our students. So they have insufficient possibilities to choose an individual sequence of courses. Students' needs can be taken into consideration, if a course

offers alternative ways to pass with individual strengthenings and interactions. Consequently, students can take line of individual learning ways. A transparent environment with general rules of the course is needed to ensure the quality of teaching and for every participant to know what is expected of him. The guideline deals with the subjects organisation, assessment, exam modalities, copy right, communication, and collaboration [18].

2) Usability of Learning Utilities

For a good usability of learning utilities, online tutors need some prerequisites, like experience in creating materials, high degree of media literacy or plenty of creativity. Some guidelines for a high usability (learnability, rememberability, efficiency, reliability, experience/satisfaction of usage) [7, 8. 19, 20, 21] will help to create good materials. A concentration on content helps too [9], also an adjustment to learner‘s context [10].

3) Learner Centred Design

A consequentially close collaboration of tutors and learners allows a target group specific design. Enthusiasm for the subject and enjoyment of work with students are aspects fostering motivation on both sides [2]. And, most important, learners should be in the centre of every course design.

4) Flexible Course Concepts

Presence and active participation of tutors in online parts of courses help to recognise occurring problems. A rapid and no bureaucratic reaction to unexpected occasions (e.g. non-functioning e-learning-servers) allows a timely finish of the course and contributes to a positive attitude amongst learners.

The combination of agile approaches with crucial soft skills (communication, creativity, and enthusiasm) can be of significant help to overcome parts of everyday difficulties in teaching. An exemplary detailed description of our experiences can be found in [11] and [12].

IV. User Experience and Learning Management Systems

One main aspect of a university is the distribution of knowledge and information. These are not only teachers who endeavor to pass their knowledge on to students, there is a lot of other information students need to complete their courses as for example timetables, news, documents, guidelines, quality management, exercises and results, communication techniques like webmail, blogs, chats, forums. To fulfill a students’ needs (as well as those of teachers and administrative persons) a system is required that assists in collecting and spreading information and gives a high level of user experience. According to the ISO 9241-210 [13] user experience extends usability (functionality, intuitive use of an application or website) by two very important terms: look (authenticity, harmoniousness) and feel (joy of use). Following up-to-date research from the neurobiology *enthusiasm* decides as an essential factor on good versus bad success in learning [14]. Emotions in general (either good or bad) have a large influence on the learning process. Applying such insights to software for learning confirms the need of well designed applications. As a consequence students might fail in case they cannot handle the software that is essential for their studies in an appropriate way.

A. CIS and Moodle

The Campus-Information-System (CIS) of the UAS Technikum Wien was developed as a central platform for representing all kind of campus relevant information. Due to the continuously increasing need for electronic support (equally for administrative and teaching purposes), the system was continuously extended during the last years. Partly the enhancements in functionality also went at the expense of clarity and usability. About two years ago the Learning Content Management System Moodle was integrated into the CIS platform to take account for the increasing desire for eLearning in terms of presenting learning material in a smarter way as well as using collaborative applications like forums, chats, wikis and Web 2.0 applications. Also eTests became available as a welcome add-on. Many learning management systems do have critical usability deficits [17].

Such integration is not without problems, particularly since two more or less independent systems can be used now to provide learning material and to grade students work. In addition data exchange between the systems is limited (Moodle automatically imports group allocations and exports given marks at the end of a term). This “service” which makes sense for teachers, because they can choose the system which they prefer, doesn`t make it easy for students to decide where important, relevant information is to be found. In addition, Web 2.0 offers a lot of standalone systems on the Internet (blogs, forums, tools for data exchange and collaboration, wikis, calendars), which many students like to use for self-organization besides the two systems of the UAS Technikum Wien.

This variety of possibilities provides a good opportunity to make exactly that kind of information available to the learning person, which best fits to his or her learning type. However, exactly this variety is also a reason for upset for many students who are less experienced in informatics or show weaknesses in self-organization. In addition, for budgetary reasons it is not practicable to create different versions of teaching material for different platforms.

B. What students say

An opinion survey among all students of the UAS Technikum Wien, which was carried out in SS 2010 as part of the QUADRO activities[2], showed the result that by the majority of students a uniform system is appreciated which serves as a central platform for all kind of information, i.e. a single place for uploads and downloads, examinations, grades,

[2] The survey “Evaluation of the use and acceptance of electronic media for learning at the UAS Technikum Wien” was carried out in SS2010. The results are currently not fully worked out and will be published in the near future.

time schedules, exercises, learning material, access to the library and others. Students ask for a single access point to all kind of information with SingleSignOn. Especially for Moodle the survey unveiled that a clear content representation and straightforward usability is of great importance. The importance for the optical appearance and the freedom of barriers is classified as subordinate. In general the satisfaction with the offered electronic learning documents rather feels well in the UAS Technikum Wien.

Figures 3 and 4 show graphical representations of the above given results.

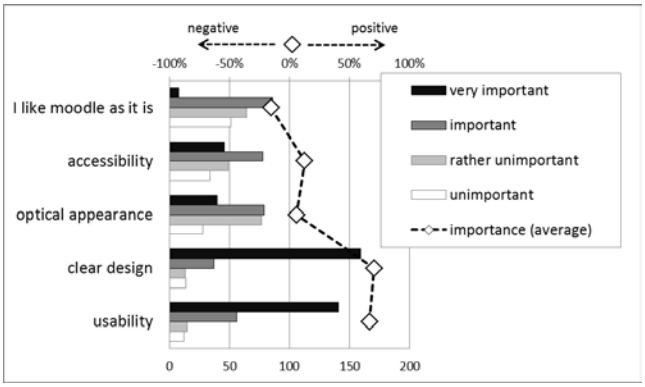

Fig. 3: Important aspects of Moodle

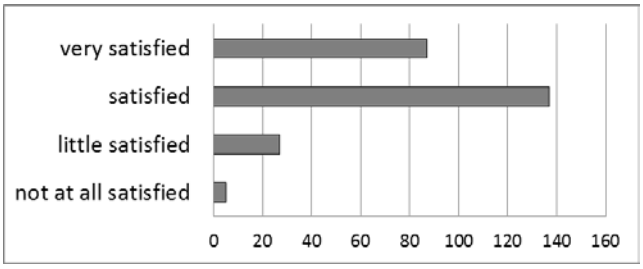

Fig. 4: Satisfaction with the offer of electronic learning material

C. Measures to improve the quality

On some points measures could be identified to increase the quality of the learning material offered as well as the Learning Content Management Systems themselves.

1) Seamless integration of Moodle into the CIS-platform
- Elimination of „double features“
- Similar look and feel
- Increasing the usability
- Uniform layout

2) Development of eLearning guidelines
- Guidelines for creating electronic learning content to obtain similar look and feel

3) Giving support and training to teachers creating learning material
- Only teachers with knowledge in eLearning can create adequate content
- A center for eLearning and contact persons with a well defined range of functions giving support to teachers whenever needed

4) Gender sensitive representation of learning material
- Learning material and didactics used during lessons should be best suited independent of sex, culture, learning type and disabilities

5) Use of uniform document formats which can be viewed on different operating system
- In case of doubt documents should be doubly offered (e.g. Powerpoint and PDF).

6) Offering alternatives to eLearning content wherever possible (to meet different learning types)
- For example a topic can be offered as Powerpoint, PDF, video, podcast, chapter of a book, link to the web, …
- An alternative should be marked “as such” in order to avoid confusion by the students who cannot decide what is important and what not.

7) Creating and updating operating instructions and guidelines for students as well as giving support on how to use new media at the UAS Technikum Wien
- Success in learning shall be no matter of inadequate use of software

8) Encouraging the usage of collaborative learning methods

D. Future improvements

Some results from the GEMIS and QUADRO projects seem to contradict the opinion poll among students. On the one hand, there are efforts to give students more and better structured information which can be offered via different media and channels, such as the calendar on CIS, Moodle or Google. Thus different learning styles and learning preferences of the students can be addressed. On the other hand there is the students’ desire to unified structures and clearly defined access points where information can be found. This goes with the students’ fear to miss important information or learning material when distributed on different channels. The contradiction is difficult to deal with and a solution satisfying all participants is currently out of sight. One possible explanation is the excessive demand of students in terms of self-organization in learning.

Particularly through the growing use of distributed learning content, as is common for Web 2.0 techniques, it will be increasingly necessary to offer enhanced support for the organization of learning with electronic material. One possible approach could be the use of Personal Learning Environments (PLE). As contrasted with Learning Management Systems, where learning material is offered by teachers, PLEs assist students in searching, sorting, organizing and handling with learning assets as proposed by Graham Attwell et al. [22]. According to the paper PLEs (in addition to organizational features) should also offer aspects of collaboration with fellow students, networking, sharing and presenting of newly generated content. PLE is currently controversialy discussed in literature but expects to have great potential for future research.

V. RESULTS

The impact of the projects is very difficult measure. One possibility of measurement is a change in the dropout rate.

Table II: Drop outs in the bachelor program "Computer Science"

Academic year	Dropout female Students [% (number)]	Dropout male Students [% (number)]
2007 / 2008*	50% (13)	17% (29)
2008 / 2009	21% (4)	15% (9)
2009 / 2010	24% (5)	7% (13)

Due to the low number of involved students no clear statistical evidence for a significant reduction in the rate of dropout could be stated. However, the data gives evidence that there is a reduction right from the beginning of the project GEMIS, which started to be effective in 2007. Still it remains a difficult task to interpret the data in table II. Many parameters influence the rate of drop outs. It seems to be possible, that already the involvement itself into programs which deal with the needs of students does have a positive influence onto the effected teachers and onto the subjects.

Table III: Drop outs in the Master Program "Multimedia and Software Engineering"

Academic Year	Dropout female Students [% (number)]	Dropout male Students [% (number)]
2007 / 2008	0% (0)	0% (0)
2008 / 2009	0% (0)	0% (0)
2009 / 2010	0% (0)	3% (2)

Even more complicated is the situation in the Master degree program "Multimedia and Software Engineering". The total number of students in one semester is 45 persons; the duration of the program only is two semester. A "drop out" is rather difficult to spot, because students are allowed to stay in the program for years until they eventually finish.

However, as stated previously the rate of dropouts is a function of many parameters and most of them are very difficult to assess. For example, a student might have difficulties in the lesson introduction to programming, and puts all his efforts in mastering this course. As a result he gets relatively good grades in the specific course but might fail in another course, because the lack of time to study.

The authors believe that the results of the projects can be more easily found in the two following areas:

1. Communication between students and faculty changed to the better a lot. Students get needed information more easily. For faculty members it became easier, to trace when which information was distributed to whom.
2. Teachers became more aware, that students have different approaches to the learning process. Different didactical methods have been introduced to many teachers. Students benefit from the broader spectrum of these methods [15, 16].

However medium- and long-term effects are going to be investigated continuously.

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