New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Scheduled Flexibility and Individualization of Knowledge Transfer in Foundations of Computer Science

Irene Merdian[1], Oliver Burgert[2]

Abstract

The opening of the German Higher Education System for new target groups involves a heterogeneous composition of students as never before and face up the universities to new challenges. Due to different educational biographies, the students don't show a homogeneous level of knowledge. Furthermore, their access to course content and their individual learning methods are very diverse. The existing lack of knowledge and the very unequal study speed have a significant influence on the learning behavior and learning motivation. During the first semesters, the dropout rate is appreciably higher. The reform project gives an overview of a didactic restructuring from a formerly conventional teaching and learning concept to a stronger combination of digital offers, combined with classical lectures in the basic modules of Computer Science. The teaching content is adjusted to the individual requirements and knowledge. Students with different previous knowledge get the possibility to increase their knowledge in different levels of abstraction. The aim of the reform project has to point out the possibilities, also the challenges of the digital process in Higher Education. At the same time the question has to be explored, how far does an accompanied and self-directed learning in own speed and in own individual depth of knowledge have a positive impact on the motivation and on the study success of a learner.

1. Introduction

The idea of the reform project is based on the very heterogeneous constitution of students in the School of Informatics at Reutlingen University. Students of the study course Medical-Technical Informatics (METI) have the most heterogeneous educational biographies at our school, which is illustrated by figure 1.

The heterogeneous constitution of students creates certain challenges. Due to the fact that the very unequal biographies cause a quite different previous knowledge, diverse access to course content and very different learning methods, the dropout rate in the foundational courses of Computer Science above all in the beginning of the study is appreciably high.

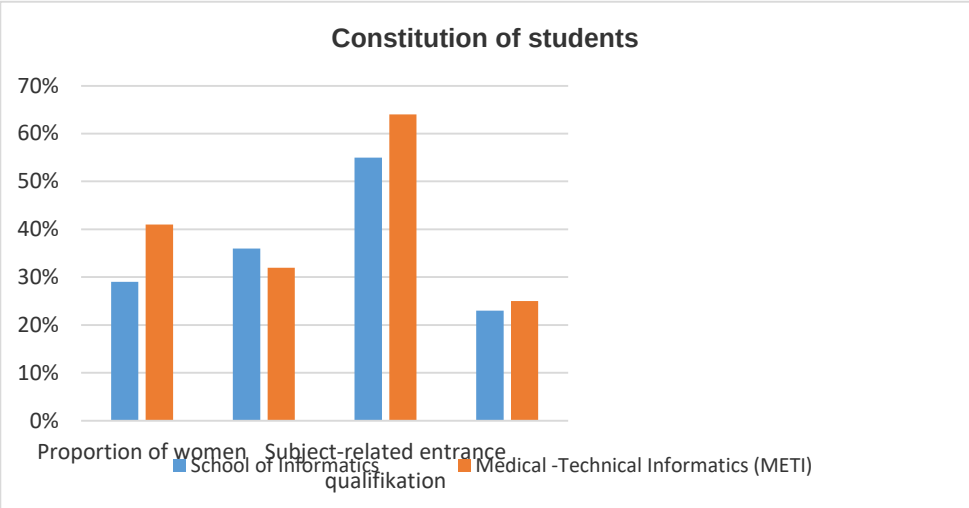

Fig. 1. Constitution of students in School of Informatics at Reutlingen University

[1] Reutlingen University, School of Computer Science, Germany
[2] Reutlingen University, School of Computer Science, Germany

Nonetheless we expect a significant portion of the dropout students might be able to finish their studies successfully, if they would have more time to approach the field of computer science, to fill gaps in their previous knowledge or familiarize themselves with an academic learning style. To foster the heterogeneous potentials of their students, the idea of the reform project to change the teaching and learning formats in Foundations of Computer Science was developed and is supported by Stifterverband and Carl-Zeiss-Foundation [1].

2. Concept

The idea of the reform project is to change the didactic concept in the Foundations of Computer Science. This course was selected because it is one of the major topics in the first semester. It consists of a lecture part (4 hours / week) which teaches the theoretical concept of computer science, and a hands-on laboratory which teaches practical programming skills. Both courses are accompanied by tutorials taught by students of higher semester. Currently, the courses are taught using classical teaching, in which the course content is taught and has to be imparted in a self-study phase. The lectures are using elements of flipped classroom techniques, peer-to-peer discussions, interactive discussion, and active working with course material (e.g. sorting numbers using a presented algorithm). The self-study phase is supported by video captures of the lecture given in a previous semester, all slides are available as pdf file at the beginning of the semester. The hands-on laboratory give a short input on each practical programming topic, and afterwards the students have to solve small task under supervision and with help of the lecturer und two tutors. Furthermore, a weekly exercise sheet containing 50% theoretical and 50% practical exercises has to be solved to support the self-study phase.

About one third of the students state, that they have significant problems with the learning speed we are expecting, because they have problems to familiarize themselves with the theoretical aspects of computer science and with the academic self-paced learning style, especially, if they don't have previous experience with programming languages. On the other hand, the best exams are often written by students without previous experience with programming languages, so the problem seems to be mainly the ability to think in formal structures and to organize the personal learning process, which needs additional time.

Based on this observation, the course shall be re-designed to allow flexibility and individualization of knowledge transfer. To achieve this, each content of the lecture will be presented at different levels of abstraction and be offered by e-learning tools. These, in turn are supplemented by lectures, in which the new knowledge will be connected and applied to new competences. In the presence lectures the topic fields are deepened, examples of application discussed, incorrect handling of the contents or wrongly classified subject contents are corrected and the professional content is thereby internalized again in a methodically modified form. This design can also be used to transfer key qualification, such as interaction, presentation or linguistic competencies. Students with different preconditions and knowledge get the chance to adopt their new knowledge in computer science in their own deep of knowledge and their own speed.

The use of e-learning tools in Higher Education is not a new invention. But our experience in using and practicing digital teaching and learning formats is, that especially students who are already proactive and self-organized are profiting from those teaching formats. Students who haven't develop these skills so far are often overworked in the beginning of their study. They need more support and introduction to get used with the digitals proposals.

Within this project, there are two main goals: The first is the practical implementation of the new course concept. This involves not only the re-structuring and enhancement of the teaching material, but also solving organizational challenges like having flexible presence lectures without significantly enhancing the teaching work load, or modifications of the examination plans and regulations which are necessary due to the potentially semester overlapping course selection due to the higher flexibility. The second goal is research on whether the new course concept leads to an improvement of the learning outcome and reduction of the drop-out rate. Furthermore, is shall be evaluated, if the new concept motivates good students to become even better since they get an outlook on more challenging topics, or they can speed up their competence acquisition because the material is always available. We hope to find best practices, which can be transferred to other courses, e.g. to foundations of mathematics or higher level courses.

3. Practical implementation

The implementation of the reform project is structured in two steps. The first step is that a group of students from different semesters of the study course Medical-Technical Informatics has to separate the content of the course in different levels of abstraction. The following description shows an idea of the purpose.

Content: *Tree/ Data Structure*	
Learning target/ Skills	• To implement binary trees in a programming language • To determine the runtime of tree algorithm • To know different search trees
Preconditions/ Preknowledge	• Knowledge of fundamental data structure • Knowledge of controlling structure • Knowledge of programming languages
Levels of knowledge	• Middle level • Derivative level • IT-Specialist
Connection with other topic areas	• Running time calculation • Graphs
Reprimands	• Digital learning contents • References
Additional topics	• Complex tree algorithm • Derivation of upper and under bounds on the execution time
Exercises/ Case studies	• Programming assignment in different programming languages

Table 1. Example of a description of the abstraction categories

The second step is to analyse the different e-learning tools already used in the teaching like learning platform, web conference system or E-Assessment methods. Besides the technical and content related conception of the teaching and learning fields has to be a didactical restructuring of the contents in digital offers and the lectures. In addition, the students have to be supported using the new learning concept [2].

4. Research interest

The research interest is based on the competence model and on the didactic of the constructivist learning theory [3], [4], [5], [6]. The focus is to find out, if the abstraction of the learning contents on the different levels has a positive effect on

- An independent, individual responsible and flexible developed learning
- Development of digital competences
- And at last but not least the learning motivation and related academic success.

Furthermore, the question how much support do students need in the beginning of their study to get used with e-learning tools.

5. Conclusion and outlook

We strongly believe that the scheduled flexibility and individualization of knowledge transfer in Foundations of Computer Science has a positive impact on the learning process of adults and moreover of the academic success which still has to be proved. At present the project is in his first step of implantation. A group of students works on the contents and their different levels of abstraction. Interesting will be also the analysis how far does the experience of the students to abstract the content initiate a learning process during the implementation. At the same time we reflect already our used digitals e-learning tools. The application in the study course of Medical-Technical Informatics is planned for the winter term. The resulting teaching material will be published using an Open Education Repository.

Acknowledgement

This project is funded by the Stifterverband and the Carl-Zeiss-Foundation within the funding scheme „Curriculum 4.0“.

References

[1] Curriculum 4.0 “Consequences of Digitization for Study Reformations on German Universities”, https://www.stifterverband.org/curriculum-4-0, last checked on 2017/01/13.
[2] Barthelmeß, H. „E-Learning – bejubelt und verteufelt. Lernen mit digitalen Medien, eine Orientierungshilfe“, Bertelsmann Verlag, Bielefeld, 2015.
[3] Behrmann, D. „Bildung, Qualifikation, Schlüsselqualifikation, Kompetenz. Gestaltungsperspektiven pädagogischer Leitkategorien, Verlag für akademische Schriften, Frankfurt am Main, 2006.
[4] Gnahs, D. „Kompetenzen – Erwerb, Erfassung, Instrumente“, Bertelsmann Verlag, Bielefeld, 2007
[5] Gesellschaft für Informatik e.V. (GI): Empfehlungen für Bachelor- und Masterprogramme im Studienfach Informatik an Hochschulen. Stand: Juli 2016. Available online at https://www.gi.de/presse/detailansicht/article/gi-veroeffentlicht-empfehlungen-zum-informatikstudium-1.html, last checked on 2017/01/12.
[6] Blatter, M. „Konstruktivismus“, Blatter, M., Hartwagner, F. (Hrsg.) „Digitale Lehr- und Lernbegleiter. Mit Lernplattformen und Web-2.0-Tools wirkungsvoll Lehr- und Lernprozesse gestalten“, hep Verlag, Bern, 2015, p. 68-71.