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"Welcome to Science!" – Concepts for Activating Learning Capabilities of Students at an Early Stage

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Abstract

At universities of applied sciences, new students start with different degrees and conditions: Some have good knowledge of scientific, mathematical, and technological basics; others lack these. "Why do I have to learn this dry theory, and how do I get this many formulas into my head?" are questions that are asked by many students within the first two semesters. A dedicated teaching concept of Albstadt-Sigmaringen University entitled "Activation in the Studies Initial Phase" was implemented in six technically oriented Bachelor's degree programmes since October 2012. These projects were funded by the Ministry for Sciences, Research and the Arts of Baden-Wuerttemberg within the programme "Welcome to Science!". The aim of this programme was to support students, especially in the transition from school to university, and maintain or enhance their motivation for studying. Three essential parts of this new combined teaching concept are described in this manuscript: Teamwork, flexible organisation of the studies, and supervised self-paced learning. Firstly, students are introduced earlier to practical course content and understand why theory is relevant for professional life. Thus, semester-overlapping general and interdisciplinary projects have been implemented, promoting both holistic and integrative learning. As an example, the interdisciplinary collaboration between four departments and an industrial partner on the topic "Smart Textiles and Wearable Technologies" is presented. This project demonstrated that an innovative prototype of a product could be developed by students within a relatively short time-period of 3 months. Scientific communication between students was established by the organisation of "science slams": Advanced students presented subjects from their studies in a fancy and entertaining way to students of the first and second semester. Secondly, a more flexible study period was provided. The students had the opportunity to extend their academic studies to an additional semester. And thirdly, individual supervision and supervised self-paced learning for students with large gaps in basic subjects was offered, with a focus on mathematics. New students with deficits were recommended to participate on a course voluntarily. In individual meetings, the participants received both feedback on their performance level as well as tips on how they could cope better with the everyday student life.
Major results of a 3-year-project dealing with concepts for activating learning capabilities of students at an early stage are presented in this contribution.

1. Introduction

Albstadt-Sigmaringen University has four faculties: Engineering (E), Business Science and Management (BSM), Life Sciences (LS), Computer Science (CS). The following degree programmes were involved in the programme "Welcome to Science!":

- Business Administration and Engineering (BAE), (E)
- Material and Process Engineering (MPE) / Technical Textiles (TT), (E)
- Technical Informatics (TI), (CS)
- Textile and Clothing Technology (TEX), (E)
- Facility Management (FM), (LS)
- Food / Nutrition / Hygiene (LNH), (LS)
- Pharmaceutical Technology (PHT), (LS)

The number of students currently enrolled at Albstadt and Sigmaringen campus amounts to over 3000 persons. At present, there is almost an equal number of students in Albstadt and Sigmaringen. Since

its foundation in 1971, Albstadt-Sigmaringen University has been establishing and maintaining close contacts to local, regional and international organisations.
A substantial number of freshmen have weak basic school skills, along with a relatively low commitment to increase their knowledge, as well as a partly passive relationship with the university and the mediated content. This leads to integration problems in the scientific and academic world, and ultimately to a high number of failed exams and ultimately student dropouts. Due to the rural location of the university, it is also a major concern to obtain the possibility of the stronger exchange with other universities on new didactic concepts and to share experiences.
"Welcome to Science!", the teaching project described in this report, was supported by the Ministry of Sciences, Research and the Arts Baden-Wuerttemberg. It started in October 2012 and finished in December 2015. Support was mainly provided for personnel, two of them (M. Gerbig and H. Grochowski) co-authoring this article.

2. Concept

The idea of this concept is

1. to promote project-oriented and research-based work and learning in group form through targeted measures and to provide greater motivation for math and science foundation subjects, especially mathematics and physics
2. to make the duration of studies more flexible and to respond individually to the needs of students by adapting the order of the courses, together with a mentoring,
3. to react to changed admission requirements of the students by optimized forms of learning and to guide the students to a purposeful learning and study behaviour
4. to encourage the students in the study phase to an active motivated participation

The foregoing objectives were achieved by the newly introduced measures, built on three columns as shown in figure 1:

- group work to early introduce students to practical course content and demonstrate the professional relevance of the course content (column 1),
- flexibility of the study period (column 2),
- individual instructions for self-paced learning in particular for those students with large gaps in basic knowledge (column 3).

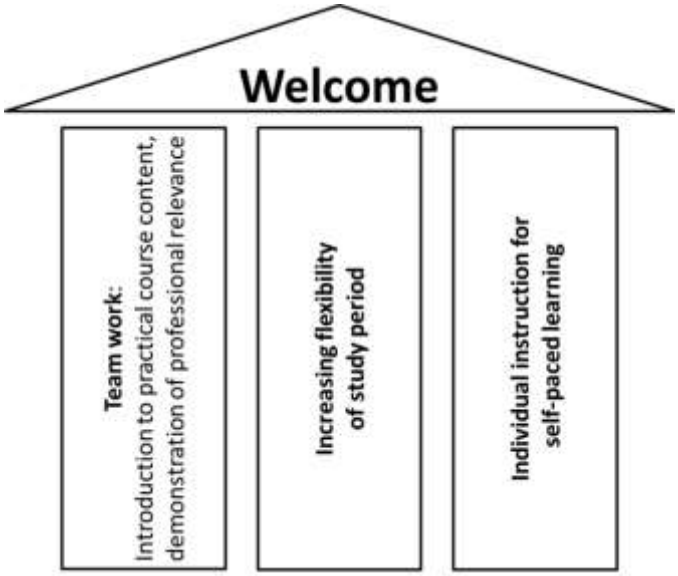

Fig. 1: Three columns to increase the success rate of learning

2.1 Teamwork

Column 1 includes an early introduction to practical course content and a demonstration of professional relevance. This objective should be achieved by semester-border interdisciplinary project work.

Objectives: Scientific, thematically oriented, application-oriented and interdisciplinary problems should be formulated and solved in team-oriented cooperation of students coming from different semesters and implemented. As a result, the motivation for the chosen course of study is increased and strengthened the student`s identification with the to-learn course content.
Methodology and learning methods: The development of ideas, thinking and implementation through group work [1] and at regular departmental and semester overarching meetings. Find, react, recite: learning through visible (= publicity) action

2.2 Flexible organization of the studies

Column 2: Model of individualized study speeds
Objectives: Students who have significant gaps, particularly in mathematics and science fundamentals, are given the opportunity to continue their studies to extend to an additional semester to rework basics. Powerful students get the opportunity to complete their studies quickly successful.
Methodology: flexibility of course content and duration of study; individual adjustment of the length of study or content to meet the needs of students. Academic advising and formulation of recommendations for further course of study.

2.3 Supervised self-paced learning

Column 3: Individual supervision of students; "Instructions for self-paced learning"
Objectives: Motivation and activation of students with significant deficits in basics in mathemattics and science to work independently ("self-paced learning").
Directing to target-leading learning and studying, thus promoting the ability to study. Identifying and working up of specific deficits of school knowledge on mathematics and physics.
Methodology and learning methods: Offer to performance level diagnostics and display (on study entrance test and (voluntary) between tests). Individual tutoring, guidance to (supervised) work group.
Orientation of role models, creating learning successes and positive study environment.

3. Selected project descriptions

3.1 Teamwork

Projects on different semester levels and interdisciplinary projects promote both holistic and integrative learning.
All in all 11 industry and research-oriented projects were performed on Albstadt campus during the complete period of the project (three years). While most of the projects took place within a single degree programme, there was even one project in which 4 different degree programmes participated [2]. This has been documented in an internal report. In the interdisciplinary project "Smart Cushion", 22 students from the sixth semester of the Bachelor's degree programmes Technical Textiles, Textile and Clothing Technology, Technical Informatics and Business Administration and Engineering were involved. The aim was to develop a heated cushion with fabric cover for a children's wheelchair, which is suitable for incontinence and contains sensors that detects the dampening level and the temperature.
Thirteen operators in the textile programmes Technical Textiles and Textile and Clothing Technology worked parallel in two groups on different solution concepts. Both groups put their innovative solutions for the cushion in multi-layer concepts, which have a high absorption capacity for moisture (incontinence problems), good air circulation guarantee (sweat reduction) and are both non-slip and comfortable. In about three months, the students developed prototypes. They had to deal with, for example, the choice of materials, investigate the processability of materials and check the textile properties.
Five students of Technical Informatics provided practical and modern solutions for the collection and dissemination of humidity and temperature information via Bluetooth to a smartphone. They integrated accumulator-operated heating elements in the seat cushion. The temperature control is made possible by app-controlled active temperature regulation.
Four students of Business Administration and Engineering took care of the project management. They accompanied all different steps of the project from start to finish, organized teleconferences, recorded conversations and meetings, and documented the outcome on the website.
Two scientific assistants, Martina Gerbig and Heinrich Grochowski, accompanied the project. Both are "Welcome to Science!" employees at the university as part of the country's development programme.

They supported the project members professionally and also involved students of the second semester in the project.

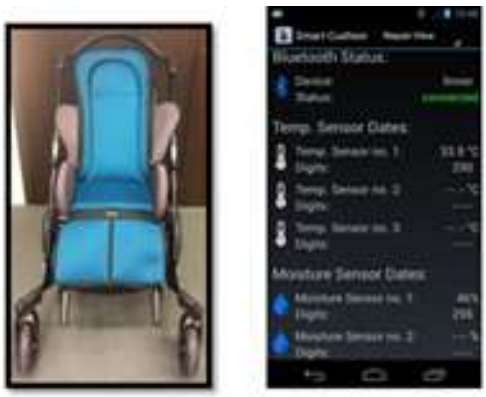

Fig. 2: One project - two products

- Seat cushion for children Buggies (left)
- App for remote control of the heating and sensoring of the humidity (right)

The major benefit of this team work was an interdisciplinary and different semester levels cooperation and networking.
To increase the enthusiasm, motivation and initiative of the students, science slams (= entertaining scientific talks) were introduced as one special tool to bring students of different semesters and disciplines together.
In the context of "Welcome to Science!", students in higher semesters (6^{th}-7^{th} semester) introduced subjects from their study in an entertaining way to the students of the first and second semesters (see Fig. 3.). Our students presented their own topics in a given time frame of 10 minutes in front of a non-expert audience. The focus was to teach current science to a diverse audience in an entertaining way. The presentation was judged by the audience and an independent jury which measured the applause with a sound level meter.

Fig. 3: Science slam of students in higher semesters in front of audience (students of all semesters)

12 active students (MPE/TT, TEX, TI) and spectators of the lower semester participated since summer semester 2013. Local newspapers reported about the event [3, 4, 5]. The benefit for students was to get certificates/proofs of participation in projects, signed by professors or the rector.

3.2 Flexible organization of the studies

Additional courses in science (mainly physics), technology, engineering, and mathematics (STEM) and events in the first three semesters allowed different abstract levels of learning and the fit to individual learning situations and individual knowledge:
1. semester: Supervised self-paced learning, projects
1.+2. semesters: Open classroom.
2. semester: Supervised teaching of physics.

2.+3. semesters: Advanced methods.
The open classroom provided the opportunity to learn in study groups together with fellow students or alone. The special feature: In addition to working independently, it was possible to ask specific questions related to mathematics, computer science, physics, chemistry and engineering mechanics here. Lecturers and staff were on site to answer questions and give advice.
This allowed both weaker and stronger students an adapted - to the current state of knowledge - studying and strengthened networking between semesters through joint events (positive peer orientation, "learning by teaching").
Depending on the success of the first semester, the possibility of splitting the second semester into two semesters was introduced. Students with larger gaps in mathematical and scientific foundations were actively guided to this splitting with the intention to reduce the psychological barrier for students to concede to themselves a prolonged period of study. The splitting was supported by special courses for learning and studying, in which problematic learning strategies were broken and students were better integrated into the university world. Furthermore, the possibility was offered to complete parts of the basic scientific internship in the first semester or during the semester time between 1st and 2nd semesters.

3.3 Supervised self-paced learning

An entrance test for the determination of prior learning and individual deficits in mathematics (1st semester) and possibly physics (2nd semester) was developed. Feedback was provided to the students on the results of math tests and recommendation for voluntary participation in the "assisted self-paced learning" was given. Exercises were designed (if possible via e-learning), which promote the reworking of typical gaps in mathematical literacy. The scientific assistants (teachers) corrected these exercises weekly and offered regular (e.g. every 14 days) personal interviews to the students, with the content (see Fig. 4):

- feedback on results of the exercises and guidance for proficiency in studies
- mediating assistance to independent work by discussion of, for example, weekly working plans and structuring of operations
- suggestions and instructions for learning, equity and study organization

Fig. 4: Action cycle for students and teachers

Supervised self-paced learning “mathematics” was offered continously since fall semester 2013/14. Ca. 50% of the freshmen (MPE/TT, TEX, TI, FM, LNH, PHT) joined this educational offer. The participating students evaluated the offer and expressed their enthusiasm about the programme. The success rate of the participating students was evaluated as well, and the correlation of students participating in the programme and passing physics and maths exams of the first two semesters was strong. For a statistical assessment of whether it has led to a significant increase in the success rate over the whole course of the study, the duration of the programme was too short.

4. Conclusions

In summary it can be said that the projects have brought numerous benefits to students:
The access to the STEM fields in the first 2 semesters was improved. Learning in practice led to deeper insights, understanding of procedures and promoted teamwork and communication between

students, staff and industrial partners. The interdisciplinary industrial and research projects created meaning for the basic studies and prepared the freshmen for their further studies. With an early introduction into routine mathematical tasks, students better coped with maths lecture exams. Special happenings such as science slams enhanced the enthusiasm, motivation and joy of studying and signaled: Welcome to science!

5. Acknowledgement

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