An Engineering Science Experience Report on Using Competence-Based Techniques to Support Students Individually and Sustainably

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SUMMARY

The recent education of engineers, using the example of satellite geodesy at the Geodetic Institute of the Karlsruhe University (TH) resp. Karlsruhe Institute of Technology (KIT, Karlsruhe/Germany), is still suffering from time pressure as well as from heavy curriculum content loading. Within this education field, where the academic teachers have to fulfill high requests from the new generation of students as well as from the industry and from research institutions respectively, advanced satellite geodetic knowledge has to be transferred effectively and sustainably.
In order to enable the students to train newest aspects related to satellite geodesy as well as important key competencies (e.g. capacity for independent and academic work, reflection and evaluation skills, presentation skills) an innovative teaching concept was developed, tested, and evaluated. This teaching concept makes use of very different teaching techniques like portfolio assignment, project work, input from experts, jig saw, advance and post organizer. The main focus of the paper will be on the portfolio assignment. Furthermore, the concept of the competence-based approach will be presented and discussed.

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1. INTRODUCTION

The recent education of engineers, using the example of satellite geodesy at the GIK (Geodetic Institute, Karlsruhe University (TH) resp. Karlsruhe Institute of Technology (KIT), Karlsruhe/Germany), is still suffering from time pressure as well as from heavy curriculum content loading, especially. Within this field of higher academic education, where the academic teachers have to fulfill high requests from the new generation of students as well as from prospective employers (e.g. industry, research institutions) respectively, advanced satellite geodetic knowledge has to be transferred effectively and sustainably.
In order to enable the students to train newest aspects related to satellite geodesy as well as important key competencies (e.g. capacity for independent and academic work, reflection and evaluation skills, presentation skills) an innovative teaching concept was developed, tested, and evaluated. This teaching concept makes use of very different teaching techniques like portfolio assignment, project work, input from experts, jig saw, and advance organizer.
This paper will focus on one core tool of the developed teaching concept: The portfolio assignment. This teaching technique was used at the GIK during the last three years for the first time, in order to support students individually and sustainably. The lessons learnt within these teaching experiment are going to be presented and discussed.

2. MOTIVATION AND INTENTION

As a teacher dealing with topics, which built up on aspects which were taught and examined in an earlier phase of a study course, one often has to realize that only small parts of (fundamental) knowledge are existing in the long-term memory of the learners. This hinders the anchoring of new knowledge significantly, decreases the motivation of all participants, and causes a reduction of imparted knowledge. Therefore, a teacher should always try to use teaching techniques aiming on anchoring knowledge in the learner's long-term memory. These techniques have to be selected carefully and purposefully.
Furthermore, the learners are often acting like hunter-gatherers: They don't try to understand the taught aspects, they are just collecting them in order to learn them in the forefront of the holy grail of educational systems: examination resp. examination grades. This is often done without trying to learn sustainably. While preparing for examinations, learners often are choosing an economically driven strategy (LAURILLARD 1978) and are applying surface-level learning techniques (e.g. memorizing facts, reproduction) which lead to sustainability deficit (GIBBS ET AL. 1982). Therefore, a teacher should focus on sustainability during the semester.
In addition, the communication between learner and teacher is often suffering from high pressure due to curriculum load. Therefore, an appropriate and additional communication tool

would be helpful. It seemed that the portfolio assignment (DE RIJDT ET AL. 2006) could help to overcome this remedy.
In order to be able to find a job, it is important for graduates to fulfill the ambitious and heavy demands of the potential employers. Besides fundamental and highly actual special knowledge of the working field, so-called key competencies are coming to the fore, as there are for example: Problem solving, critical thinking, reasoning skills, self-management skills (e.g. time management), communication skills, team work / collaboration skills, leadership skills, language skills, and intercultural skills. Teachers should take this into account and train these skills as often as possible.

3. CASE STUDY

Within the winter semesters of the last three years the course "Selected aspects of highly precise point positioning using GNSS (5 ECTS)" was developed further. The development is based among other aspects on pedagogy knowledge of the teacher, which was gained during more than ten years of teaching as well as during a further education course called "Higher Education Teaching" (Diploma of the Center for Educational Development of the State Baden-Württemberg, Germany) lasting for three semesters.
The GNSS course is recently visited by students of the diploma study course "Geodesy and GeoInformatics" in the 7th or higher semester as well as from neighboring study courses (e.g. Geophysics, Electrical Engineering). Within the last semesters of study, the higher educated students of the diploma study course "Geodesy and GeoInformatics" are able to select their classes due to aspects like interest, future plans, and recommendations of other learners. Thus, it could be assumed that learners who are selecting the GNSS lecture course are highly motivated and have a deep interest in GNSS topics. The number of students who are selecting the lecture course under research varies between six and nine. Most of the learners are known to the teacher due to other lecture courses. In order to guarantee transparency for the learners, who are selecting the GNSS course, in the forefront of the first lesson restrictions like "Which teaching style is used?" and "How much work load has to be expected?" were communicated. These circumstances seemed to provide very good conditions for a case study carried out to improve knowledge sustainability and individually.

4. TEACHING APPROACH

Within this engineering science case study, learning theories based on constructivism (BRIGGS ET AL. 1992) were taken into account in order to create a lecture course, which is able to guarantee high sustainability of individual satellite geodetic knowledge, especially. The developed cooperative and collaborative teaching concept proceeds from the assumption that learning is a cognitive process (BLOOM 1956, ANDERSON AND KRATHWOHL 2001, KRATHWOHL 2002). Therefore, learning is the result of an individual process. Within this process each learner has to be active and has to invest effort resp. time. Furthermore, the developed

teaching concept considers that learning is based on a process of communication, therefore, additional possibilities of communication had to be taken into account.
In order to gain best teaching / learning results, the teacher has to keep the motivation of all participants as high as possible. To support the learners' motivation, e.g. all decisions should be transparent to the learners. Furthermore, the intention of the developed new teaching approach should be unfolded and discussed in detail, especially due to the fact that the here discussed teaching approach differs significantly from regular teaching concepts used at the GIK. This was done e.g. in the forefront of the first lesson by means of statement letters sent via e-mail. In addition, at the beginning of the GNSS lecture course the learners were asked to reflect and discuss their learning style. This enables the realization of missing individuality and missing sustainability as well as reduction of skepticism, fears, and risks of the radical change in teaching. The next step was enabling the learners to realize their starting point. Therefore, a detailed analyses of the learners motivation as well as their existing prior knowledge was initiated; here two aspects are clearly coming up:

- A fundamental basis of the GNSS lecture course is given by means of collaborative, constructive, open and above board partnership between teacher and learners.
- The teacher has to plan the lecture course carefully and in order to create space/time for new motivating – but often time-consuming – didactical techniques (e.g. jig saw (CLARKE 1994), advance/post organizer (DAROS AND ONWUEGBUZIE 1999)) as well as non-GNSS-specific discussions/work the amount of GNSS-related curriculum load (cognitive overload) has to be reduced (approx. factor 30%). The remaining topics have to be selected purposefully.

Based on the teachers' own high motivation and the selection of appropriate didactical techniques, deep-level learning (e.g. meaningful selection/construction of knowledge) could be guaranteed (PROSSER AND TRIGWELL 1999). Beside others (see Fig. 1), the portfolio assignment was used as the most central didactical tool.
Furthermore, the appropriate built-up of the GNSS lecture course enabled the learners to train various key competencies e.g. within a geo-informatics-related project work, which was carried out by the learners under guidance of the teacher throughout a whole semester (see Fig. 1 branch project work). Thus, the GNSS lecture course was able to make important contributions to the personal growth of the learners.

5. PORTFOLIO CHARACTERISTICS AND INTERPRETATION

The creation of a portfolio requires activity of the learners. A portfolio is an individual collection. The two key elements of the portfolio are selection and reflection. Each learner has to select purposefully and systematically representative parts of its own work. In addition, portfolios are gaining their values from continuously carried out reflections in order to evaluate the learners progress in learning. Therefore, portfolios are able to document the personal growth of the learners. The usage of portfolio within lecture courses could also improve the learners' writing skills. Furthermore, the learning skills are realizable and could also be improved. The learning tool "portfolio" could also be used to detected gaps (e.g. understanding, learning) due to the fact that the students are learning while they are creating

their portfolio. The portfolio enables the learners as well to set individual goals. This should be done under guidance of the teacher. For more details on portfolio see e.g. GREEN AND SMYSER (1996).

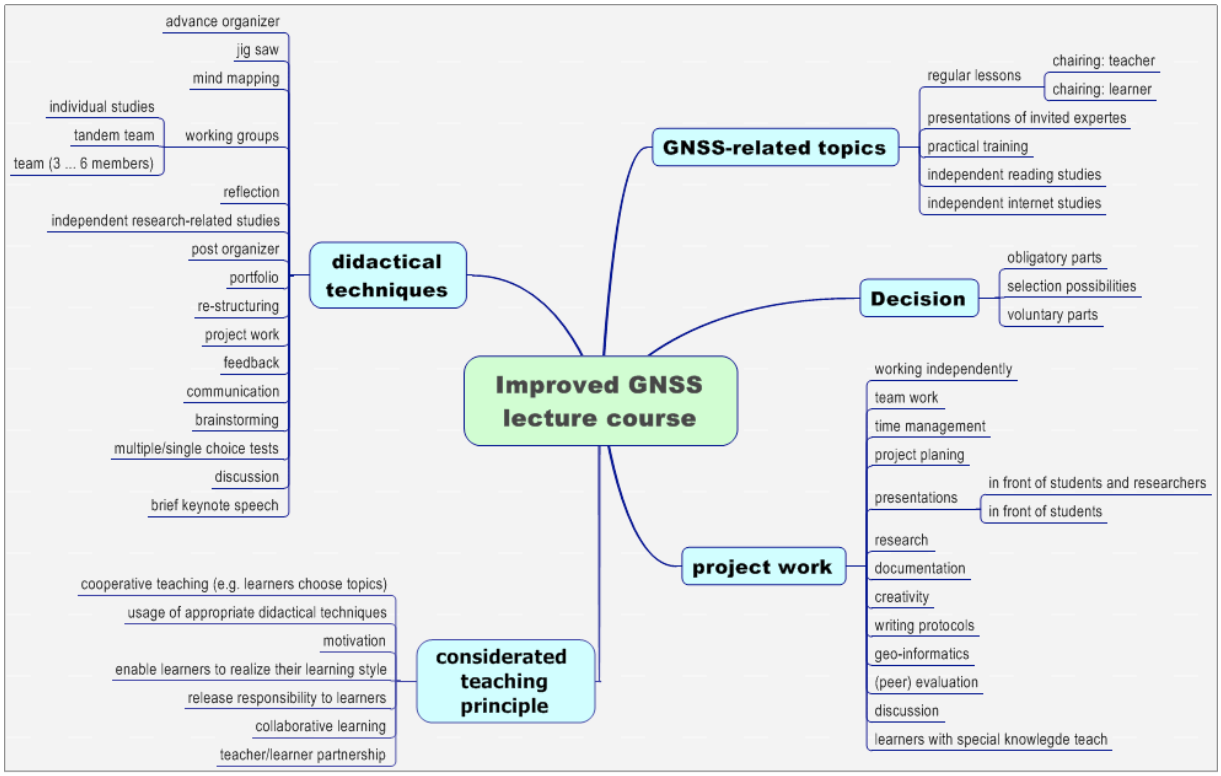

Fig. 1: Didactical principles, methods, and techniques of the improved teaching strategy.

Within the case study described here, the portfolio was used regularly (approx. once per week) as communication resp. feedback tool, too. While generating their weekly portfolio contribution (approx. 5 pages) the learners give individual feedback to the teacher (e.g. Which knowledge aspects were (not) understood? Why? Which didactical tool is (not) appropriate? Why?). After reading the individual weekly portfolio contribution, the teacher generates individual commentary (2-3 pages). By means of this strategy the teacher is able to guide/coach the learners individually, e.g. with respect to GNSS-related aspects and with respect to background, preferences, and constraints of the learners. In addition, all participants learn to take/give constructive feedback. In order to minimize skepticism of the learners and to support the learners, weekly teachers' statement letters were written during the first half of the semester. These statement letters contained questions dealing with recent GNSS-related aspects. By means of these statement letters the teacher was able to ask for detailed feedback as well.

One lesson learnt within years of teaching is: Extrinsic motivation is needed to motivate learners. Therefore, in order to keep the level of discouragement low, in the beginning (2nd portfolio contribution) the learners were asked for topics, in which they are highly interested. After this evaluation, the learners had to carry out non-voluntary learning (e.g. write portfolio

contribution, study research-related) during the semester dealing especially with the selected topics.
Due to the fact that the learners invested much effort into the portfolio, the received grades did take these efforts into account (in total: 33%; evaluation scheme: teacher/peer/self: 55%/25%/20%)

6. CONCLUSION AND FUTURE WORK

Within the here described teaching approach highly modern satellite geodetic knowledge was imparted competency-oriented based on collaborative, cooperative, and team-oriented teaching techniques and problem- and project-based principles.
Based on the principles of knowledge constructivism, a lot of time and additional effort (teacher: approx. 200 h per semester; learner: 60-100 h per semester) was invested in order guarantee improved sustainability of satellite geodetic knowledge individually. Most of the time/effort was invested in the portfolio. As an important side effect the GNSS lecture course was able to improve the learners' key competencies (e.g. learning competencies, time management, team working). Even though the invested effort was very high, nearly 50% of the learners are actually working in the field of GNSS (e.g. study/diploma work, research assistance, job).
Due to the fact that approx. 35% of the learners were foreigners, the intercultural competence of the learners were trained as well.
Hopefully, the great results (evaluation, feedback) of the carefully planned, tested, and verified teaching strategy could initialize a more (time-consuming) sustainable and individual way of collaborative and cooperative learning/teaching at the GIK.
In order to keep in contact with the highly active learners various networking aspects were used after finishing the GNSS lecture course (e.g. GNSS-related newsletter, Geocaching).
The modification/development of the GNSS lecture course will go on. The next steps will be: Switching from portfolio to e-portfolio as well as integration of e-learning modules.

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REFERENCES

BLOOM, B.S. (1956): *Taxonomy of Educational Objectives, Handbook 1: Cognitive Domain*. Addison Wesley Publishing Company; 2nd edition.

ANDERSON, L.W. AND KRATHWOHL, D.R. (Eds.) (2001): *A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives: Complete edition*. New York, Longman.

BRIGGS, L.J., R. GAGNÉ, AND W.W. WAGER (1992): *Principles of instructional design*. 4th edition, Harcourt, Brace & Javanovich, Orlando, Florida, USA.

CLARKE, J. (1994): *Pieces of the puzzle: The jigsaw method*. In S. SHARAN (Ed.): *Handbook of cooperative learning methods*. Westport CT: Greenwood Press.

GIBBS, G., A. MORGAN, AND E. TAYLOR (1982): *A review of the research of Ference Marton and the Göteborg group*. Higher Education (11), pp. 123-145.

GREEN, J.E. AND S.O. SMYSER (1996): *The teacher portfolio: A strategy for professional development and evaluation*. Technomic Publishing Company, Lancaster, Pennsylvania, USA.

KRATHWOHL, D.R. (2002). *A revision of bloom's taxonomy: An overview*. Theory into Practice (41), pp. 212-218.

LAURILLARD, D. (1978): *The Process of Student Learning*. Higher Education (6), pp. 395-409.

PROSSER, M. AND K. TRIGWELL (1999): *Understanding Learning and Teaching*. Buckingham: Open University Press.

DE RIJDT, C., E. TIQUET, F. DOCHY, AND M. DEVOLDER (2006): *Teaching Portfolios in higher education and their effects: an explorative study*. Teaching and Teacher Education (22), pp. 1084-1093.

DAROS, D. AND A.J. ONWUEGBUZIE (1999): *The Effect of Advance Organizers on Achievement in Graduate-Level Research Methodology Courses*. National Forum of Applied Educational Research Journal-Electronic (12/3), pp. 83-91.

BIOGRAPHICAL NOTE

Dr.-Ing. Michael Mayer received his doctoral degree in 2005 from the Karlsruhe University (TH), when he was investigating the appropriate modeling of the deformation network Antarctic Peninsula. He is actually head of the GNSS working group of the chair of Prof. B. Heck (Physical and Satellite Geodesy, Karlsruhe Institute of Technology (KIT), Karlsruhe/Germany). He is interested in mitigation of atmospheric and site-specific GNSS effects with a special focus on continuously operated GNSS reference sites. Furthermore, Michael Mayer received a diploma in higher education pedagogy in 2008.

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