Learning in an Increasingly Complex World: Teaching of Graduate Students in Research Oriented Projects

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Key words: research oriented projects, advanced teaching methods, learning by research.

ABSTRACT

Educators in Geomatics have to deal with increasingly complex and fast evolving technologies, e.g. Geographic Information Systems, Remote Sensing Systems, Radio Navigation Satellite Systems, and the coming Gravity Satellite Missions. Research on these complex matters is nowadays performed by larger research organizations and companies rather than universities. Tight university budgets and classified, proprietary developments prevent teachers from gaining insight into and personal experience with the latest techniques. The selection of relevant curricula contents is therefore a difficult task. Even more challenging is the constant adjustment of the contents.

Nowadays it is impossible to impart details of all Geomatics techniques, hence selective learning becomes important. Students need to learn, how to study a subject on their own. As demonstrated in the paper, the project seminar is an ideal opportunity for research oriented learning on the grad level by focussing on one exemplary task. This teaching method is an important part in the Geomatics education at the University of Hanover. For lecturer it provides the flexibility to choose a task oriented methodology. The regular interaction with the students gives detailed feedback on their individual progress. Students are highly motivated in the project seminar, since the projects are usually related to real research projects. The group of students works mainly on their own, the teacher basically accompanies the group. Beyond the technical and scientific problems, the students also learn the fundamentals of technical writing and presentation, of project management, and to take responsibility for the project budget. Within the seminar, the much sought after soft skills are explicitly trained.

In the paper, recommendations for planning and carrying out a research oriented course like the project seminar are given. Information for lecturers on the acquisition and cultivation of the necessary methodological knowledge is included.

ZUSAMMENFASSUNG

Lehrende an den Universitäten haben die Aufgabe, den Studierenden zunehmend komplexe und sich schnell entwickelnde Technologien wie z.B. der Geoinformations- und Fernerkundungssysteme, der Satellitennavigationssysteme oder der zukünftigen Satellitenschwerefeldmissionen zu vermitteln. Forschung in diesen Bereichen findet inzwischen überwiegend in großen Forschungseinrichtungen und privaten Unternehmen statt. Angesichts knapper Budgets und nur kleiner Arbeitsgruppen wird es für Universitäten schwieriger, die Einheit von

Forschung und Lehre zu gewährleisten. Zum einen fehlt es sowohl den Lehrenden als auch den Lernenden an Möglichkeiten, persönliche Erfahrungen mit neuen Instrumenten und Softwareentwicklungen zu gewinnen, zum anderen lassen sich im Rahmen des engen Studienplanes kaum mehr als die elementaren Grundlagen vermitteln. Die Auswahl der richtigen Lehrplaninhalte ist deshalb eine anspruchsvolle Aufgabe, ihre ständige Anpassung an die technischen Entwicklungen eine Herausforderung an jeden Lehrenden.

Da es heute unmöglich ist, die Details aller Arbeitsgebiete des Vermessungswesens gleichermaßen zu lehren, wird selektives Lernen wichtig. Entscheidend für die Studierenden ist die selbständige Wissensaneignung zur Vertiefung der im Studium vermittelten Grundlagen. Dazu müssen die Studierenden mit den notwendigen Arbeits- und Lerntechniken intensiv vertraut gemacht werden. Ein Projektseminar, wie es im vorliegenden Beitrag behandelt wird, ist für Studierende eine ideale Möglichkeit zum forschungsorientierten Lernen durch Konzentration auf eine ausgewählte Aufgabe. Im Studiengang Vermessungswesen an der Universität Hannover ist das „forschende Lernen“ im Projektseminar ein bedeutsamer Teil der Ausbildung. Es bietet den Lehrenden die Flexibilität, die Inhalte und die Methodik der jeweiligen Projektaufgabe anzupassen, unabhängig von dem durch Vorlesungen und Übungen festgelegten Studienplan. Durch die Arbeit in kleinen Gruppen ist eine enge Zusammenarbeit möglich, wenngleich die Studierenden die Aufgabe im wesentlichen selbständig bearbeiten sollen und der Dozent in der Rolle als sachverständiger Ansprechpartner die Gruppe nur betreut. Da die Projekte an realen Forschungsaufgaben orientiert sind, werden sie hochmotiviert bearbeitet. Über die technischen und wissenschaftlichen Probleme hinaus erlernen die Studierenden das Schreiben und Präsentieren wissenschaftlicher Arbeiten, befassen sich mit Projektmanagement und können dabei auch ein eigenes Budget verwalten. Die intensive Arbeit in der Gruppe bietet zugleich ausreichend Gelegenheit, die vielgefragten „soft skills“ einzuüben.

Der Beitrag gibt Empfehlungen für die Planung und Durchführung einer forschungsorientierten Lehrveranstaltung, in der die Vermittlung von Kenntnissen und Fertigkeiten des wissenschaftlichen Arbeitens und des Projektmanagements sowie sozialer Kompetenzen gleichermaßen von Bedeutung ist und geht auf die benötigten Lehrmethoden ein.

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1. INTRODUCTION

Regular reforms of university study programmes attempt to adjust the curricula to the changing conditions of science and society. This leads always to an expansion of the curriculum content, new lectures are added without cutting back antiquated contents. Political guidelines stipulating an upper limit effectively limited the average study time in surveying engineering to between five and six years. Further pressure is put on the departments by evaluations measuring the number and the age of successful graduate students, the time they need until their final exam, as well as the drop-out rate. Since the results will have noticeable influence on the departments budget and staff, the development of a manageable curriculum is enforced.

At German universities, reforms usually concentrate on re-weighting the various technical courses. The qualifications that can be expected from a surveying engineer are considered in the first place. But they depend on the professional point of view, either the more mathematical-physical, the measurement and data processing or the legal and planning aspects are emphasised *(Gerke 1972, Linkwitz 1995, Magel 2002).* The potential career prospects for graduate students as well as the strength of the institutes involved have a serious influence. Reconciling the different interests is very difficult and sometimes it is to the detriment of basic courses in the undergrad studies or at least to the variety of elective courses meant for individual education of graduate students. The contents, however, and the most suitable way of teaching is solely at the disposal of the responsible professor.

Legal requirements and regulations by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) have led to comparable curricula at German universities. In Hanover, the study programme covers 180 hours of lectures (sum of lecture hours per week), divided into undergrad studies in the first two years (96 hours) ending with an intermediate examination, and another three years of graduate studies. They start with a large block of compulsory subjects (62 hours), later on elective courses (22 hours) can be added allowing to concentrate on individual interests. An extensive final exam and a diploma thesis finish the studies. Differences between the universities are based on the individual research profile that is reflected in the curriculum, the theory-practice ratio, the opportunities for specialization and the examination scheme *(Seckel 1998).*

Traditional forms of teaching – lectures, labs, and practical trainings – are just as little called into question as written and oral examinations. The few approaches to structural changes in the engineering studies *(Kohlstock 1997)* are little known and are rarely acknowledged. In Germany, only few centres for university didactics exist (e.g. AfH, IZHD (see references)). Their task is to develop new teaching methods, e.g. the incorporation of multi media and

internet is currently in the main focus, and to offer courses for the continuing education of universities teaching staff. The work of theses centres should not be confused with didactics divisions in some e.g. natural sciences or engineering faculties, which mainly serve for the education of school teachers, albeit this is also useful for teaching at universities. For reasons that need to be discussed later, the potential of the didactics centres could be exploited much more in order to improve the university education.

The unquestionable obligation for lifelong learning has led to the development of a diversity of methods for adult education programmes, employing the experiences of psychology, social and education sciences as well as neurology. Whereas such methods are very common in human sciences and all kinds of commercial continuing education courses, they are almost unknown or even ignored in the engineering sciences. Because of the revolutionary changes in the world of learning and work towards a “knowledge society”, the engineering education will need a structural reform and the introduction of new didactic methods in the interest of the students. With the traditional scheme of lectures and lab work the challenges of the complex and fast evolving technologies cannot be met. They might also be inappropriate for preparing graduate students to actively take on leadership and responsibility in our society.

The unity of research and teaching, this ideal founded by Wilhelm von Humboldt for the modern German university system back in 1810, can be practised today only with serious difficulties *(Neuweiler 1997)*. Budget cut-backs, limited research opportunities with an increasing share of industrial projects pushes teaching and the students into the background. Since it has also become impossible to teach all the latest details of Geomatics the training of methodological competences and of the capability – and the will – for lifelong learning is the most important task of lecturers. This applies especially to such a broad subject like surveying engineering.

An uncomplicated opportunity to establish new teaching methods is the project seminar as introduced in the next section. The seminar provides high flexibility regarding the selection of contents and methods, without requiring an extensive curriculum reform.

2. RESEARCH-ORIENTED PROJECT SEMINAR

The surveying engineering programme at the University of Hanover stands out against the study at other locations (Berlin, Bonn, Darmstadt, Dresden, Karlsruhe, Munich (TU, UniBW), Stuttgart) particularly by two special practice-oriented courses. At first, the two-week field camps after the first (cadastral survey), second (topographic survey) and third academic year (geodetic control survey), which are executed in close co-operation with the surveying authorities of Lower Saxony. The students work on a real task, whose results will be used further. Secondly, a one year project seminar during the fourth academic year. There, a research-oriented task is closely investigated with the intention to lead students to the current boundaries of scientific knowledge. The work is performed in small groups intensively cared for by the research and teaching staff. Usually in these projects external partners are also involved. This particular connection of research, teachings, and practice dates back to Professor Jordan (1842-1899), the founder of the surveying discipline at the University of Hanover, and is well-known as "Hanover school" *(Pelzer 1981)*.

Surveying is traditionally a very broad subject. It covers contents ranging from the mechanics, optics, and electronics of surveying equipment over the mathematics and physics employed in geodesy, adjustment computations, reference systems and map projections to the acquisition, management, and visualization of spatially referenced data in photogrammetry, remote sensing as well as cartography and geographic information systems up to the legal and planning aspects of land management in rural and urban areas. Due to the frequently interdisciplinary work, the students need to attend lectures in civil engineering and earth sciences, or architecture, town and regional planning. There has always been consent for such a broad education of the students among the responsible persons from universities, administration and industry.

Nevertheless, in 1982 the project seminar related to one specialization area was introduced for the fourth year students. The students should have the opportunity to focus their interests and to get actively involved in research work. The project requires the students to reflect their knowledge and to apply it to solve an exemplary problem. The project seminar is especially useful to train the skills necessary for scientific working as required e.g. for the diploma thesis. This learning-by-research method with a tradition of now 20 years is one of the distinctive features of the Hanover curriculum *(Pelzer 2001)*. Its importance with respect to the mo-

Fig. 1: Extract from the study programme

§ 12. Elective Courses and Project Seminar

Elective courses in the fourth year encourage the learning of scientific methods. Special emphasis is placed on the application and critical discussion of specialised technical knowledge.

Project work in small groups is of utmost importance in that time. The institutes of the Department of surveying engineering altogether offer five projects every year. Students can choose projects in cartography and topography, engineering surveying, geodesy, photogrammetry and remote sensing, and rural and urban development.

Such working in a project is called "project seminar" and contains group meetings three hours per week plus a practical course of eight days, where the data is collected and processed. Besides this practical work oral reports by students and teaching staff and discussions are held about the methods and the results. The students take active part in planning and organising the project work. The increasingly autonomous practical work strengthens their knowledge, develops responsibility and independency. Reports because of training and presentation of techniques and results as well as mutual critical comments and incitation in discussions intensify communicational abilities. Discussions force thinking over the expedience of techniques. By restrained specialisation within the group necessary teamwork can be trained.

To support the project work the teaching staff can assign up to six elective lectures per week […] for every ongoing project as mandatory. […]

The results of each project are submitted in a written final report. In addition the most important conclusions are presented publicly from the group at the end of the fourth year. […]

Successful participation is demonstrated by attending a final colloquium, in which also issues from the assigned elective lectures may be raised. [...]

tivation and professional qualification returned recently into the focus of university didactical discussions *(Huber 1998)*.

The intention and the course of the project seminar are described in the official study programme (Fig. 1). The first project phase in the winter term (16 weeks) is used to familiarize the students with the topic. Preparations are made for practical investigations, i.e. data acquisition and analyses. After examinations in the lecture-free period the second project phase in the summer term (12 weeks) follows, usually starting with the measurement campaign (up to 8 days). The remaining weeks are then filled with the analysis of the measurements, the composition of a detailed report and the preparation of the project presentation. The project group meets three hours a week during the term, but much more hours of independent work particularly in the summer term are necessary.

Tab. 1: Comparison of pros (+) and cons (-) of lab work and project work

	Lab		**Project**
±	pre-determined solutions, creativity not needed	+	independent solutions required
±	many small assignments of little complexity	±	single, extensive, and complex task
±	usually individual exercises, little group work	±	team-work
±	practising basic principles	-	assuming basics as known
±	exercises don't change frequently, since basics are valid for a long time	+	new research objective each year, linked to current practice
-	feedback only upon request	+	feedback immediately and intensive
-	obligatory exercises, little motivation	+	elective project, high motivation

The different objectives of the project seminar are easily recognized if compared with lab exercises prevailing in the first three years (Tab. 1). For the seminar basic knowledge of the subject is required in order to lead the graduate students to much more complex problems. It is deliberately drawn up as team-work, because this is much closer to real work than the individual performance required when writing a thesis. Some further advantages of project based education are:

- identification of students with the project objective yields highest motivation of all teaching methods
- simultaneous work on different learning levels (contents, methodology, management, interaction) with the opportunity to employ different teaching methods
- scientific methodology (e.g. researching strategies, data acquisition and analysis, scientific writing, presentation) is extensively treated and applied to the project task; thus, it is an excellent preparation for writing a thesis
- introduction to project management techniques advantageous for self-organisation and future professional career
- by addressing psychological-social processes of team-work, students will gain social competence
- teaching staff serves as mentor and external expert in the project team, allowing for an open co-operation; students acknowledge the personal connection between mentor and research topic more than in lectures
- accelerated learning process due to active as well as creative learning, systematic reflections of the work in progress, and immediate response to cognitive difficulties

- encouragement to independent learning and working, that contributes to consolidation of knowledge and skills; this finally fosters self-critical thinking and the sense of responsibility

Project based teaching does have some disadvantages listed in the following. They can be solved in most cases by carefully selecting the project task and narrowing the research focus:

- complexity of project task is inadequate to the students' knowledge
  - requires specific training in the first project phase
- great efforts with respect to time; conflicts with other lectures and examinations
  - a matter of proper project management
- students are unfamiliar with the new teaching methods; sometimes they have difficulties to adjust to active and researching learning or team-work

discussion of this issues at the psychological-social level right at the start and throughout the project as soon as such problems raise again; early chances to experience success will boost the students' motivation

- directing a project seminar with a group of 10-15 students makes great demands on the professional and educational qualification of the teaching staff

further training in university didactics is highly recommended

Following a survey of the University of Konstanz, 58% of university students across all levels and disciplines of studies prefer studying in small groups, the close co-operation with teaching staff is desired by 50%. More practice is wanted by 57%, and 35% of the students would like to participate at research projects. All four requests can be met exactly by a project seminar.

3. TEACHING CONCEPT

The success of the project seminar in combination with the learning-by-research method is that it provides space to realize general human inclinations: the urge to explore, the need for changes, curiosity, and aesthetic sensation. How these favourable conditions can be created and used in order to pass on more general qualifications in addition to scientific knowledge is described in the following.

Systematic questions are the most important part of scientific work. Only by means of well-aimed questions problems can be stated and a solution be derived. Hence, it is crucial to create a climate for questions in the course of the project work. Only active students who have the courage to ask, will be able to close gaps in their understanding. It is an indispensable prerequisite for self-critical thinking. This finally is the key to strengthen the students' self-confidence and enables them to take on responsibility in their future occupation as well as in the society. If such an attitude can be imparted to students, one of the primary goals of university education is accomplished.

Using the teaching concept explicitly is one of the quite small innovations in the project seminar that will make a big difference for the students' active participation. The deliberate reflection on the methods applied makes it much easier for the students to acquire the methodology in addition to the technical contents. The varied project work enables the treatment of four different meta levels, graphically depicted in Fig. 2.

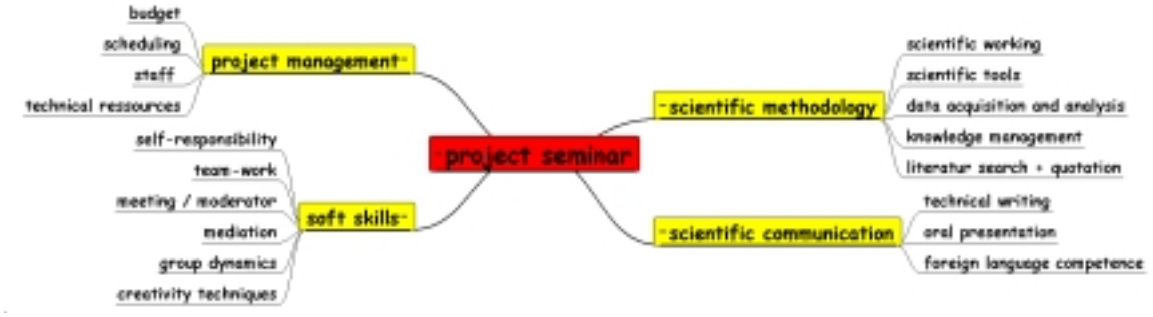

Fig. 2: Meta levels treated during the project seminar

Studying and researching for the project objective inevitably requires the discussion of scientific methodology. The research phases are explicitly defined: analysing the problem, determining the state of the current research, working out the research plan. In order to execute this plan, scientific tools like e.g. computer algebra or advanced data visualization software must be introduced if the students are not already familiar with them. Effective literature searches in library data bases and the internet and the proper quotation are also an important part of scientific working that students usually have not learned in their preceding studies.

Exchanging results from subgroups in the plenary meeting, documenting the research and presenting it to fellow students publicly touches questions of scientific communication. Regarding e.g. the project report, the overall structure of reports, the writing process itself, the presentation of facts in figures and tables, some technical considerations for graphics, and questions of style and grammar are discussed. Since most of the scientific publications are written in English, it is advantageous to familiarize the students with the unknown technical terms systematically.

People and their peculiarities are the most important factor not only in project work. Soft skills are therefore naturally expected, but rarely trained. Students can take three roles: as an individual, as a group member, but also as a potential group leader. It is well worth the effort to reflect these roles in every phase of the project. One goal of the project seminar is to foster the individual potential and the students' self-responsibility. Regarding the group dynamics, the theme centred interaction (TZI), developed by Ruth Cohn, provides effective communication rules and means to deal with conflicts. Cohn's method is definitive suitable for university teaching (*Mann, Thomas 1988)*, and provides assistance especially for lecturers *(Klemmer, Gernot 1997).* Graduates will likely become moderator of meetings and maybe they will also have to mediate diverging interests. Situations, that can be exercised in the seminar. Creativity techniques are also counted to the soft skills, that can be explicitly trained *(Ackermann 1997).*

Finally, the management aspects, important for an effective organisation of the work, are discussed in the next section. The content of two project seminars that were carried out based on the presented concepts are neglected here, since only the methodical and didactical objectives are in the main focus of this contribution.

4. INTEGRATED PROJECT MANAGEMENT

Complex ventures in the world of work are steered by project management. In interdisciplinary teams the know-how of specialists is brought together and focussed on the project goal. Carrying out several tasks simultaneously and coordinating many people effectively requires the use of project management techniques as treated in many text books, e.g. *Lock 1994*. Since the way of communication between the project members and their attitude is crucial for the project success, the integrated project management came to the fore in recent years. The behavioural aspects are considered as equally important as the organizational premises and the professional work. The integrated project management therefore integrates the systems and methods applied in the project work with the psychological-social processes determining them *(Boy, Dudek, Kuschel 1995)*.

Integrated project management can be used successfully for research and teaching purposes. The integrated approach is especially useful for teaching related projects. Nevertheless, a few characteristic differences compared with industrial projects need to be pointed out *(Litke 1995)*. Since research results are a-priori unknown, the definition of the project goal is inevitably imprecise. All participating students perform a research project for the first time, so large uncertainties need to be addressed. Such uncertainties have at first an unfavourable effect on the learning situation. From the students' point of view there are too many variable parameters. In the beginning, intensive support is thus required. Little resources are another concern. The budget covers basically only expenses for field work (shortage of money), the project is carried out parallel to lectures and exams (shortage of time), and the students have different levels of knowledge, which is often not consolidated (shortage of knowledge).

Project management is a means to balance the competing parameters (Fig. 3) so that the project goal can be achieved within the pre-determined time frame with the available resources. For the project seminar some simplifications are allowed. More important than advanced management techniques is to pass on the fundamental methods. A thorough situation analysis is an essential starting-point. All participants must be fully aware of the task and the overall goal of the project. The structuring into phases and the definition of milestones is usually quickly accomplished. More time is needed to become clear, which resources are available. To fill the structure with contents and the allocation of duties takes the greatest effort, often it is an iterative process involving intensive discussions among the students.

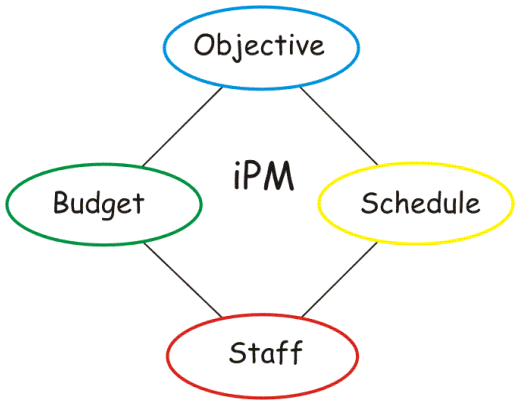

Fig. 3: Competing parameters in integrated project management (iPM)

Most instructive for the students are intermediate as well as final project reviews. They receive feedback directly from their fellow students and they can compare their contribution with the project progress. Delays and tensions within the team are rarely related to a lack of motivation. They are mostly based on larger knowledge differences or they are due to coordination problems. In the end, both can be traced back to communication problems. This finally proofs the importance of an integrated project management approach.

The essential project phases can be divided up into theoretical and practical training, a measurement campaign, the data analysis phase, and the project end including the compilation of a final report, a one hour presentation and a colloquium. In Fig. 4, an outline of the project phases for the project seminar "Satellite Geodesy" in 1999/2000 *(Willgalis 2000)* is presented. In addition to the project phases the time is shown, that was used on the meta level for imparting scientific working skills and project management knowledge as well as for discussions of psychological-social aspects. With the increasing thematic level grows the independent work of the students proportionally.

Students should work on their own as much as possible. Learning by research includes repetitive searching, questioning, trying out, and last but not least - making errors. It is to the advantage of the learning progress, if searches are futile, experiments fail, and mistakes happen. The teachers responsibility is to lead the project group gently so that the course of the project (objective, schedule etc.) is maintained without sacrificing the students' independent work.

The project seminar is the first opportunity for students to work under practical conditions (even if it is the practice in university research). A serious change is caused by thinking and acting in much larger dimensions (potency step), i.e. to resolve a task that requires seven month of hard work and can only be managed by team-work. Foresight planning and good organization becomes crucial if tasks exceed a critical size, a problem that is usually not discussed in lectures. In the same way students are not explicitly prepared for taking on leader-

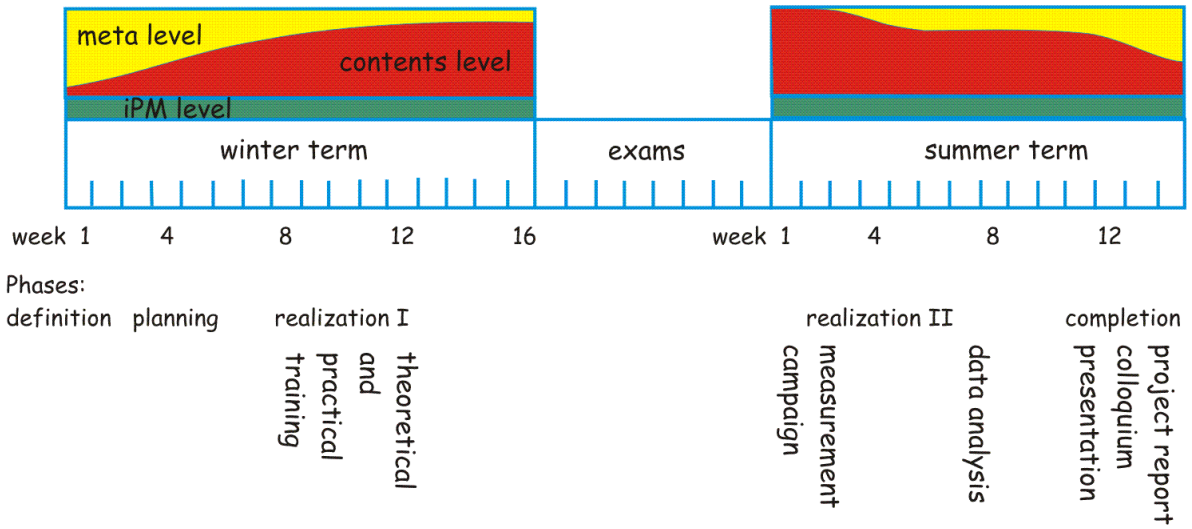

Fig. 4: Project phases for the project seminar Satellite Geodesy in 1999/2000

ship although questions of communication and motivation are often of vital importance for economic success. The project seminar makes the students at least aware of the problems related to the practice. It finally provides some useful means to write the thesis and to finish the extensive final examinations –studying is last but not least a management problem *(Badiru 1996).*

5. CONCLUSIONS

In view of the rapidly decreasing half-life of knowledge our current university system with relatively long study times will reach on a long-term basis an impasse. Therefore the reduction of the study programmes is necessary. The introduction of Bachelor and Master degree programmes is a first step in this respect, but highly problematic since the Anglo-Saxon university system cannot be compared with the German education system. More important is the establishment of an advanced continuing education system and the awareness of its importance. During the primary phase of university education a broader general education and training of methodological knowledge should be emphasized. Further education in subsequent phases should be tailor-made to the participants' needs, considering modern teaching concepts developed for adult education.

This contribution does not demand such a completely new curriculum structure yet. Their implementation would take too much time and there are too many resistances to overcome. Instead it is plead for some space in the curriculum that can be used individually by teaching staff and students. The research-oriented project seminar is a good, practical model, if the different competence levels shown before are properly addressed.

The largest difference between the project seminar and conventional teaching methods is that the learning process, the interactions between students, and the student-staff relation is explicitly treated. As a result, a much stronger feedback between all participants occurs. The students have to take over an active role. They are expected to develop a sense of responsibility for learning to learn on their own and for developing the ambition to dwell deep into a problem in order to develop a substantial solution. In this way, the aim of "learning-by-research" is achieved.

Becoming aware of learning and working processes is much more valuable than simply absorb contents which becomes obsolete quickly and is probably only marginally related to the future occupation. By comparison, the methods acquired in the seminar and the insights actively gained by experiments as well as team-work will be important in the long term. The openness to continuously reflect on methodological and social questions is even more crucial for the professional career.

Lectures are the easiest way of teaching large groups of students. In comparison, seminars are time consuming and labour-intensive, which is especially true for a project seminar with a complex research task. The learning-by-research method requires more openness by students and teachers than conventional teaching methods in the engineering sciences. Especially for teachers it is much more demanding to work simultaneously on all three levels with active,

i.e. very much challenging students. It should be reminded that “teachers” in this case are engineers in the first place, most of them never received any didactical training. It is therefore easily explicable why they simply reproduce the teaching methods they experienced themselves, instead of using modern techniques based on results of adult education. For the benefit of the students and our society, for future lecturer a further training of about 1-2 years in university didactics is recommended. Unfortunately, such qualification is irrelevant with respect to a scientific career since only individual research performance matters for an application for a university position.

As long as qualified teaching does not get higher standings in personal careers and in university evaluations, no teaching scientist will spend valuable time for his further training. This situation may change with the controversial introduction of tuition fees at German universities. Students will probably express much higher expectations on the quality of research and teaching. If in doubt, they will opt for the institution where they get the best training for their fees, and this could be in extreme cases private institutions.

Finally, the realization of Humboldt’s ideal, the unity and freedom of research and teaching, is demanded. Even if research performance is much higher valued as teaching qualification, the few people committed to modern university didactics should have the opportunity to deviate from traditional teaching methods. For such freedom, it is desirable to include flexible usable courses like the project seminar in every curriculum.

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BIOGRAPHICAL NOTES

Stefan Willgalis received his Dipl.-Ing. in Geodesy from the University of Hanover, Germany in 1995. Currently employed as research and teaching associate in satellite positioning and geodetic astronomy at the Institut für Erdmessung, his research is focused on precise real time GNSS positioning networks. Involved in teaching of graduate students and practitioners in continuing education programmes, he developed strong interest in questions related to university didactics and scientific methodology.