PROJECT-BASED LEARNING IN GEOMATICS AT AALBORG UNIVERSITY

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KEYWORDS: Education, Learning Environments, Blended Learning, Pedagogy, Project-based Learning, Photogrammetry

ABSTRACT:
The paper deals with the education in Geomatics at Aalborg University (AAU), Denmark. Since its foundation in 1974 AAU has used Project-Based Learning (PBL) as its educational model. In each of the 10 semesters a project has to be carried out by a group of students. The paper presents the ideas behind PBL and the use of this approach in Geomatics. Some examples of project work in the field of photogrammetry and remote sensing are given. Teachers and researchers at AAU recently published a book on the Aalborg PBL model, in which progress, diversity and challenges of the approach are documented. Some of the findings in this investigation are presented. The on-campus education in Geomatics uses the Internet, and the paper informs about its application on campus. PBL is also practised at AAU's distance education programmes, which combine e-learning and weekend seminars on the campus. Experiences from using PBL in both forms of education are presented.

1. INTRODUCTION

Knowledge in the field of Geomatics has changed considerably in the last years and will change in future at even higher speed. Many new theories, methods and tools have to be studied and applied. The contents of the curriculum have continuously to be adapted and new tools have to be acquired. This requires many resources, which may not be available. The updating of knowledge becomes a life-long task. How to learn new things and how to find and access the required information becomes very important. The mapping industry and national mapping organizations need graduates who can communicate in a team and act locally and globally. Therefore the ways of teaching and learning have to consider the new conditions. The task of the universities is not only education on-campus but also off-campus. In both forms of education the Internet is an important tool, which has to be mastered by the teachers and the students.

It is the goal of this contribution to present the pedagogical concept of "Problem-Based Learning" as it is practiced at Aalborg University in the education of the "Danish Chartered Surveyor" and to analyze what impact the Internet has in both forms of the education.

2. PROJECT-BASED LEARNING AT AAU

Project-based learning means that projects are carried out by a group of students. A problem has to be defined and solved, and the solution to the problem or the search for a solution has to be documented, presented and defended. The problem is the starting point for acquisition and integration of new knowledge. The learning method is therefore also called Problem-Based Learning, which is again abbreviated with PBL. Therefore PBL has two meanings, Project-Based Learning and Problem-Based Leaning, but both methods are used in combination. Teachers have a different role in PBL; they are advisors and facilitators to the group. The evaluation of the project is in the hands of external examiners. The problem to be solved is part of a theme, and courses are given for introducing the theme and for providing an overview on the theories, methods, tools and applications. The project has to be carried out within one semester.

This way of learning is practised at Aalborg University from the first to the last semester of the study. It was introduced from the beginning of AAU in 1974. Various evaluations proved that this learning method works successfully and has advantages (Kjaersdam et al., 1994). Also other universities in the world have successfully applied PBL in their education. In the discipline of Geomatics the University of Aveiro, Portugal, also became known for using PBL (Gomes Pereira 2004).

The basic idea behind this pedagogical approach can be explained by the didactics triangle (cf. figure 1).

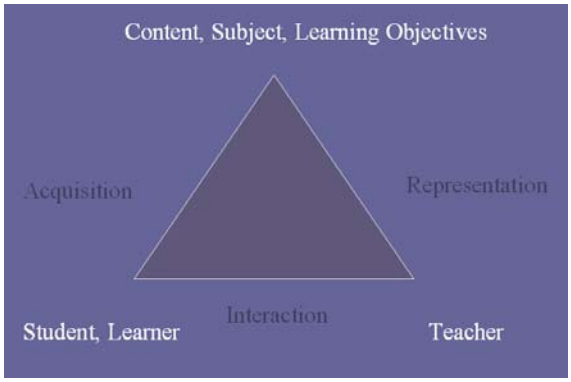

Figure 1: The didactics triangle. Source: Laursen, 2004

In all teaching we have a subject and the contents to be taught, a learner and a teacher. The sides of the triangle are the relation axes: Acquisition, representation and interaction.

The motivating forces behind PBL in the seventies were interested in changing the contents and the relation between students and teachers. The students should have influence on the contents of their learning. Later on when the production of knowledge and information grew very much, it was difficult to decide what the core competences are. Also many new theories, concepts and tools arose. Students are asking which pieces of knowledge and skills have to be acquired in order to get jobs. Teachers are many times only salesmen of certain packages of knowledge. It must be up to the customer, the students, to decide what to buy.

Basically PBL is a student-centred approach. The teachers have to be watched if they update their knowledge too. "Who is to teach the teachers?" became a famous slogan at AAU (Kjærsdam, 1994). The answer to this question was that the teacher should do research himself and that there should be a strong connection between research and practice. The problems, which have to be found in professional practice or in research, are the best guides for the learning process. But research work is more than to acquire knowledge and to be oriented what happens in practice. It is also creativity and phantasy, which have to be developed in young students. At the place of this seminar, Potsdam Telegrafenberg, Albert Einstein did research and teaching. His famous words, "Phantasy is more important than knowledge", have to be mentioned in this context.

In these times of rapidly growing knowledge and with the many possibilities of acquiring knowledge the teacher and the student must cooperate, and the student has to take responsibility for his or her own learning. The universities have to create conditions and an atmosphere so that creativity and phantasy can develop. New thinking and going new ways were the real driving forces at Aalborg University.

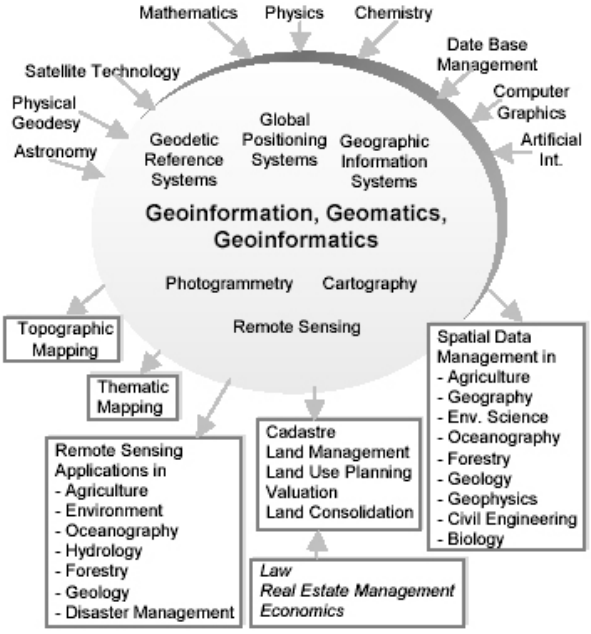

Figure 2: The academic discipline "Geomatics". The diagram shows the core subjects and the disciplines from which theories, methods and tools are used. The applications of Geomatics are depicted as boxes. Source: Konecny, 2002

3. GEOMATICS

The academic discipline "Geomatics" integrates new subjects like Geographic Information, Global Positioning, Remote Sensing and the traditional subjects like Surveying, Photogrammetry, Cartography, Cadastre, and Land Management. Geomatics relies on theories of Mathematics, Physics, Computer Science, Satellite Technology and uses tools such as Data Base Management, Computer Graphics, and Image Processing. The applications of Geomatics are in Topographic Mapping, Thematic Mapping and in Spatial Data Management for a number of fields (e.g. Civil Engineering, Environmental Sciences, Agriculture, and Geography). Special areas of professional and economic interest have traditionally been the Cadastre, Land Use Planning, and Land Management. In these tasks, subjects like Law, Real Estate Management and Economics have to be known. The integrated discipline "Geomatics" is also called "Geoinformatics" or "Geoinformation".

A comprehensive discussion of the global changes in the Geomatics education has been published in (Konecny 2002). Figure 2 summarizes these thoughts.

Konecny's thoughts are based on the situation in Germany and some other countries, which had a curriculum for Surveying Engineering for many years. Scandinavian countries including Denmark had a different starting point. Cadastre and related fields played here an important role. AAU educates therefore the Danish "landinspektør" (English translation: "Chartered Surveyor").

4. THE CHARTERED SURVEYOR STUDY AT AALBORG UNIVERSITY

The current AAU study programme for "Chartered Surveyors" is the Danish version of a Geomatics curriculum. It has been re-designed after the recommendations of the Bologna agreement of the EU member states. It consists of a three-year bachelors' programme and a two-year master's programme. Figure 3 shows the contents of each of the 10 semesters.

The **Bachelor of Science programme** starts with basic studies such as mathematics, computer science and GIS. The principle of Problem Based Learning and project-organized studies are also taught and practised. Already in the first semester a project is carried out by a group of 5-7 students. Recent topics of student projects are from the field of Spatial Planning and Land Use Management. First after finishing the basic studies the student has to decide if he or she continues within Geomatics or other disciplines within the Faculty of Engineering and Science. In the 3rd to the 6th semester skills within Spatial Planning, Land Use Management, Surveying, Mapping, Photogrammetry, and Cadastre are learnt. It is the "Learn how" or how professional work in these fields has to be done. The teachers specify the projects. After this general education within the Bachelor programme the students will now specialize and practice the "Learn why" in their projects. This means that they have to be active to find real world problems in the society or in research work and try to solve such problems or parts of it.

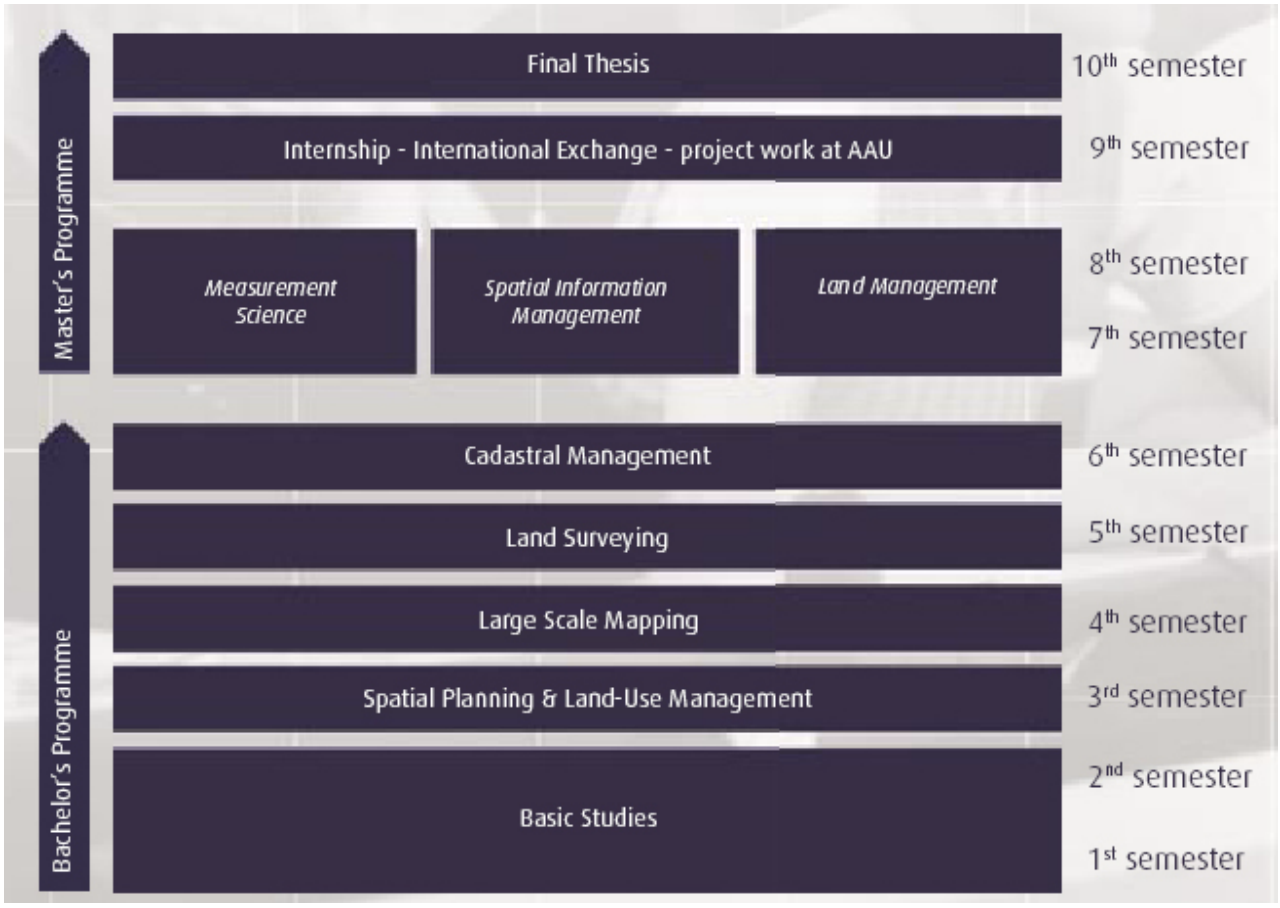

Figure 3: AAU study programme "Chartered Surveyor"

S	Measurement Science	Spatial Information Management	Land Management
7	**Positioning**	**GIS Theory & -Technology**	**Real Estate**
	Surveying & Terr. Laserscanning Global Positioning Systems Advanced Photogrammetry Adjustment Theory Statistics Data Libraries & Data Quality Methodology & Science Theory System Development Free Study Activity	Geospatial Analysis I Geocommunication I Data Security and Copy Rights Data Libraries & Data Quality Methodology & Theory of Science Digital Administration System Development	Property Law Property Economy Case Work Legal Method Valuation Data Libraries & Data Quality Methodology & Theory of Science Digital Administration
8	**Sensor- & data integration**	**GIS design & -development**	**Land Management & Planning**
	Sensor Integration in Surveying Sensor Integration in Phm. & RS Data Integration & Image Analysis Co-ordinate Transformations Modelling of Point Clouds Free Study Activity	Geospatial Analysis II Geocommunication II GIS/IT Implementation GIS from a Social Point of View Standards & Exchange Formats	Spatial Planning Urban Management Growth management EU legislation Implementation Theory Legal sociology Nature&Environmental Protection

Table 1: Overview on the themes and courses of the "Chartered Surveyor" study at the 7th – 8th semester
(L-studienævn, 2004)

The **Master of Science programme** has two semesters with new themes in three specializations: Measurement Science, Spatial Information Management, and Land Management. Project relevant courses and other courses are given. A few mini-projects are carried out as free study activities.

Table 1 gives an overview on the themes and courses for the 7th and 8th semesters for the three specializations. About 25% of the student's time is used for courses and free study activities ('mini-projects'); the rest is used for project work and other activities. There is only one examination at the end of the semester, where the group (consisting of 3-4 members) presents the results of the projects. The students will receive individual marks for their achievements in the project and in the oral examination.

The ninth semester will focus on further professional development. There are four choices:
The students can either carry out a project in a company or organization, study a semester at another university, start a one-year project at AAU carry out a project in the 9th semester followed by a final project with another topic in the 10th semester. This freedom of choice will allow for individual development, for example to study at a foreign university or to participate in research work of the Division of Geomatics.

The Chartered Surveyor education is organised by the School of Surveying and Planning, which recruits the teachers from the "Division of Geomatics" with its four research groups (Geoinformatics, Geographic Information & Media Technology, Land Management, and Cadastral Development). The Division is part of AAU's Department of Development and Planning. The School of Surveying and Mapping (also named the 'L-study board') also organises part-time studies in Geoinformatics. Both educations are placed under the Faculty of Engineering and Science of Aalborg University.

The teaching in Geomatics at AAU is carried out in Danish, but in recent years English has been used as well. Danish students are capable of understanding English due to their training in schools and in the everyday life (TV programmes, movies, travels, etc.). Project reports and examinations in English have so far, however, been seldom in the studies of Geomatics. The study at another university is recommended for a period of one semester, but only a few students take advantage of this opportunity.

Internationalization within the studies and research is one of the prime goals of AAU. Several Master of Science programmes in English have been created at AAU in the last few years, among others 'GPS Technology'. In 2004 1333 students (or 10% of all students) came from other countries in order to study at AAU.

5. THE SUBJECTS "PHOTOGRAMMETRY & REMOTE SENSING" AT AAU

The general education in Photogrammetry at AAU's **Bachelor of Science programme** starts in the 5th semester. This first course in Photogrammetry includes lectures and exercises (cf. Table 2), which amount to four credit points in the European Credit Transfer System (ECTS)[1]. The project comprises aerotriangulation and ground control determination. This project will be replaced with another project where photogrammetric mapping comprising orthophoto production and data collection for DTMs and topographic databases will be practised. Photographs have been taken by means of a digital camera and the mapping is to be carried out by modern digital stereoworkstations (see figure 4).

Lectures and tasks
Image geometry and orientation
Stereoscopy
Rectification
Photography and scanning
Project planning, flight planning, navigation
Mathematic concepts in photogrammetry
Orthoimaging and monoplotting
Introduction into digital photogrammetry
Stereomethods and stereo workstations
Selection of control points
Aerotriangulation
Topographic mapping
Exercises
Measurement of parallaxes
Rectification
Relative and absolute orientation
Stereocompilation
Orthophoto production
Automatic measurement in images
Image processing
Aerotriangulation

Table 2: Content of the course "Basic Photogrammetry"at AAU's Bachelor's Programme in Geomatics (Status spring 2005)

Figure 4: Digital stereoworkstation "Intergraph Image Station SSK"

[1] One credit in ECTS is the equivalent to 30 hours of student's workload.

The education in the **Master of Science programme** includes the courses Advanced Photogrammetry, Terrestrial Laserscanning, Data Libraries & Data Quality, and free study activities ('mini-projects') about point determination by means of terrestrial digital photogrammetry, and data collection and modelling by means of terrestrial laserscanning in the 7th semester. Courses on Sensor Integration in Photogrammetry and Remote Sensing, Data Integration & Image Analysis, and a free study activity ('mini project') about Automated DTM Derivation including Quality Control are part of the education in the 8th semester.

Advanced Photogrammetry
Analytical photogrammetry
Aerotriangulation techniques
Terrestrial photogrammetry
Calibration of non-metric cameras
Industrial photogrammetry
Automation of photogrammetric processes
Terrestrial Laserscanning
Principles, instruments, methods & applications
Data Libraries and Quality of Data
Image libraries and their characteristics
Quality of DTMs and orthoimages
Sensor Integration in P& RS
Imaging sensors in P&RS
Platforms of sensorer
Addtional sensorer
Direct georeferencing
Mapping from space imagery
Airborne laserscanning
Combined restitution of laserscanning and aerial images
Data Integration & Image Analysis
Operations at integrated raster data
Automated georeferencing of images
DTM&DSM production
Production of true orthoimages
Automated extraction of houses, roads, trees, etc.
Automated Quality Control of Orthoimages and DTMs.

Table 3: Contents of the courses in Photogrammetry and Remote Sensing at AAU's MSc programme in Geomatics

Altogether, the students can obtain 15 ECTS credit points from courses and free study activities in the 7th and 8th semester in the subjects Photogrammetry, Remote Sensing and Laserscanning. The lectures are complimented by a few guest lectures, excursions, and presentations of companies.

Table 3 shows the contents of the courses in Photogrammetry and Remote Sensing for the 7th and 8th semester. Recent projects regarding Photogrammetry, Remotes Sensing and Laserscanning are listed in table 4. The topics of projects are often initiated from contacts of students with persons outside the university. Participation in research projects, for example in the ones of EuroSDR, has also attracted student groups.

Year	Topics
2003	Automated close-up photogrammetry in medicine
2003	Automated 3D models of buildings from airborne laserscannings data
2003	Automated change detection in the topographic database TOP10DK
2004	Surveying of a ship by terrestrial laserscanning
2004	Design of a hand-held mapping system
2004	Photorealistic 3D city models
2004	Mapping by means of high resolution satellite images
2005	Data reduction for laserscanning data
2005	Modelling of laserscanning data
2005	Mobile mapping with a linear laserscanner
2005	Determination of volumes by means of laserscanning data

Table 4: Topics of student projects in Photogrammetry, Remote Sensing and Laserscanning between 2003 and 2005.

6. USE OF THE INTERNET IN GEOMATICS

The education in Geomatics at AAU takes very much advantage of the Internet. Homepages of the study board inform about the syllabus, course contents, timetable, guidelines and announcements. Learning resources such as lecture notes, literature and computer programs are available for the students for reading and storing on their own computers. Distribution of hard copies of learning material is thereby considerably reduced. Each project group sets up a homepage, where working papers, minutes of meetings, diary, etc. are available for group members, teachers, and external partners. Learning resources are also interactive learning programs. They are designed after the principle "Learning by doing". Table 5 lists such learning programs with regard to the subjects Photogrammetry and Surveying.
The production of such interactive learning software requires many resources, but many students can use them in large PC rooms at the same time. They also enable self-studies and e-learning. Details on designing such courseware are published in (Höhle 2004). Freeware from Internet sources are used in the Remote Sensing courses, for example the learning material from NASA and the Canadian Centre for Remote Sensing (see website references 1 and 2).

The communication with the students on campus is done face to face, but it is supplemented by e-mail communication. The communication in the 9th semester (where a stay outside AAU is possible) can with advantage use a conference and communication software package. At AAU the conference system "FirstClass" has been applied in e-learning for many years. This software package connects a group of students and teachers to a virtual classroom. Questions and answers can be activated and monitored by all participants.

All the mentioned items (homepages, learning programs, lecture notes, etc.) form AAU's Learning Lab Geomatics, which is continuously extended and improved by teachers, students and secretaries.

The distance learning at AAU, for example for a master degree in Geoinformatics, uses the Internet and a few seminars at weekends. This blended e-learning has been

practised for the last 10 years, but on the Danish market only. This part-time study lasts two years and two projects have to be carried out. That means that PBL is applied in distance learning as well. Experiences in another AAU master degree programme, Industrial Information Technology, revealed that in distance learning significant changes have to be made for the PBL approach (Knudsen et al. 2004). A small pilot project should be established at the beginning of web-based distance education. A project free period had to be created so that the students could concentrate on the courses. A strong correlation between courses and projects had also to be realized. It is essential for off-campus education that the students frequently experience success.

Blended e-learning after the AAU model has also been used for the distance learning courses of the European Organization for Spatial Data Research (EuroSDR, formerly OEEPE), which disseminates the knowledge gained in EuroSDR research projects in Photogrammetry, Remote Sensing and GIS by means of e-learning courses. The participants come from many different countries. The first three courses were carried out in 2002 and an introductory seminar took place at AAU. The conference system "FirstClass" was used for the communication. At the introductory seminar its use was presented together with the learning material.

As the same learning material is used on-campus and off-campus, both forms of education influence each other. The Internet is used in both cases and with great advantages.

7. ADVANTAGES AND DISADVANTAGES OF THE PBL MODEL

In the PBL model - as it is practised at AAU's education in Geomatics - the students have a very active role. This type of education contributes to independent action of the students and strengthens their self-confidence. There is a short distance between teacher and student – both physically and concerning the power. Group rooms (or student offices) lie near the teachers' rooms, and students can get help at all times of the day. New knowledge and information flow both ways. The teacher is forced to update his knowledge continuously, also in areas which are not his specialty or interest. The students concentrate on the projects, but they reduce participation in courses. This may result in gaps in the students' knowledge. The approach is very vulnerable when the number of students increases. Group rooms and equipment are then lacking and teachers are overburdened if no extra resources are granted. The project-based and group organized learning produces goal-oriented team players. Dropout rates and extension of study times are reduced.

7. CONCLUSION

Universities have to produce can graduates, which can solve problems in the society and in research. Such graduates have to be able to know how to learn new knowledge and to access the available information, and this life long. The outsourcing of production to areas with low labour costs creates a lot of unemployment. These losses of jobs must be compensated by innovations and new skills. Graduates, who are creative, with imagination, with self-confidence and initiative, are required in the present situation.

Name	Subj	Contents	Base
LDIPInter1	Phm.	AutomatedMeasurements	Internet
AutoOrient	Phm.	Georeferencing	Internet
LDIPInter2	Phm.	Matching	Internet
TMK	Sur-vey ing	Levelling, Co-ordinate calculation GPS	MatLab

Table 5: AAU learning programs with regard to the subjects Photogrammetry and Surveying

Also skills in communication across borders of culture and language are required. The problem-based and project-based learning in groups can create such persons. Teachers for such students have to be experienced in research and to be motivated to act as advisors and facilitators for the student groups. From the teachers it requires a high degree of flexibility to adapt to new projects and to learn new things. Much information can today be found on the Internet and the Internet can be used as a learning tool and a source of knowledge. Photogrammetry, Remote Sensing and Laserscanning are important subjects of the discipline "Geomatics". These subjects have changed a lot in the last years. The innovations have to be mastered in the education. The content of the courses have to be modified, instrumentation and tools have to be updated.

REFERENCES

Gomes Pereira, L.M.et al., How to attract students to Geo-Information courses: A different Approach, International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXV, Part B6, Commission VI, pp. 63-67, 2004

Höhle, J., Designing of course material for e-learning in Photogrammetry, International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXV, Part B6, Commission VI, WG VI/2, pp. 89-94, 2004

L-studienævn, studieordning landinspektøruddannelsen 7.-10.semester, 2004

Kjærsdam, F. et al., The Aalborg experiment, 1994 (see references from website, #3)

Knudsen, et al., Project-based collaborative learning in distance education, in: Kolmos et al., The Aalborg PBL model, pp.303-317, 2004

Kolmos, A. et al., The Aalborg PBL model, Aalborg University Press, 2004

Konecny, G., Recent global changes in Geomatics education, ISPRS Commission VI, IntArchPhRS, Com.VI, San Jose dos Campos, Vol.XXXIV Part 6, 6p, 2002

Laursen, E., Problem-based Learning as a way of organizing learning and teaching at the university, In: The Aalborg PBL model, pp. 57-71, Aalborg University Press, 2004

REFERENCES FROM WEBSITES

1 http://rst.gsfc.nasa.gov/start.html

2 http://www.ccrs.nrcan.gc.ca/ccrs/learn/learn_e.html

3 http://auaw2.aua.auc.dk/fak-tekn/aalborg/engelsk/