EXEMPLARY STUDIES AS A MEANS OF DEVELOPMENT OF STUDENTS' PROFESSIONAL COMPETENCE IN THE COURSE OF GEODESY

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Abstract: The study is designed with the aim to assess the usage of the principles of exemplary studies and students evaluation of the development of professional competence in the course of geodesy. The principles: genetic, dialogical and exemplary are analysed in laboratory works and outside the university environment. The didactical model of geodesy was used to develop students' professional competence. The findings are analysed within the frame of the geodesy course programme for the land survey speciality first year students. The method of questionnaire was used to investigate the students' self-evaluation on the development of their professional competence of geodesy. The main conclusion of the study is that exemplary studies improve specific professional, social and cultural skills, critical and analytical thinking.

Keywords: the course of geodesy, exemplary studies, professional competence.

Introduction

Teaching exact sciences is a problem because of students' analytical thinking difficulties and knowledge usage in practice in various settings (inside university: lectures and laboratory works, study practices; outside university: professional (field) practices, internet, local authorities). It means constant revision of teaching practice and looking for new aspects. One of them is genetic learning brought forward by German scientist, educator, mathematician, and physicist Martin Wagenschein (1896–1988) and recognised particularly in natural sciences. The principles of genetics, dialogue and exemplary help to cope with large quantity of information promote critical and analytical thinking and understand totality in relevance with the subject matter of the course and science development of the age. The usage of the principles is widened and related to the following environments: laboratory works, internet, study and professional (field) practices and local authorities.

Geodesy course programme for the land survey speciality students of Latvia University of Agriculture (LLU) is chosen as an example for demonstrating the exemplary studies principles usage at higher education institution. The course of geodesy content has been revised according to the principle of exemplary in two year period. The course delivering didactics is being developed considering the principles of genetics, dialogue and exemplary by means of the didactical model of geodesy.

Materials and methods

History of genetic learning relates to the theory of recapitulation. The term 'recapitulation' Darwin (1964) used already in 1859. Haeckel in 1866 defined biogenetic law (initially in German 'Biogenetisches Grundgesetz', *later* 'Biogenetische Grundregel', in English 'theory of recapitulation', 'embryological parallelism'*)*. The essence of the law - ontogeny recapitulates phylogeny (Scott, 2006).

Darwin's theory of evolution and Haeckel's recapitulation theory had an impact on Hall's explanation of psychological development up to adolescence mainly in terms of the biological theory of recapitulation (Hall, 1904). Hall basically argued that every developing adolescent 'recapitulated' the cultural history of the human race. Scott (2006) mentions that even more than in biology, Haeckel's biogenetic law was adapted uncritically by many of social sciences. Getting knowledge will be true to nature, i.e. following humans historically cultural development (Pólya, 1981).

Wagenschein describing learning as a genetic process used the term *genetic learning* (genetische Lernen) with the following features: usage of bright phenomena (subjects, events, phenomena) and expositions; presence of reality; presence of emotions, motivation and adventure (Wagenschein, 1999, 75). Genetic learning means finding out basic principles of a definite theme and then use them for discovering further coherencies.

Genetic learning involves three basic principles: genetic, Socratic (dialogic), exemplary. The basis of the genetic principle is that the teaching/learning course develops on the ground of problems which developed historically. Wagenschein explained the meaning of genetic learning that it place pupils in a situation where an intelligible problem manifests itself in thus it was for mankind when it was not able to solve it (Wagenschein, 1968, 14).

As regards the students of geodesy genetic learning means involvement them into discovery of the theme with insight into its basics/history, link it together with nowadays theory, practice and ordinary concepts and use the knowledge got for discovering further coherencies. Petrik (2004) comments the process of discovery as a success of the genetic principle. Petrik (2004) also stresses Wagenschein's idea that the genetic principle helps to learn how to systematize things and to avoid learning of definite knowledge by heart without real understanding their sense and impact on other phenomena.

The didactical model was made as a means of implementation genetic learning with the purpose to develop students' professional competence starting from the first year of studies. The model helps to deliver the course of geodesy as well as to valuate results.

The questionnaire on the development of students' professional competence was had been carried out. The questionnaire of the course of geodesy was designed for longitudinal researches in several higher education institutions.

Siniscalco and Auriat (2005) describe guidelines for writing questions as keeping the vocabulary simple and the questions short, avoiding of: double-barrelled, hypothetical questions and double negatives, overtaxing of the respondent's memory and overlapping response categories.

Cohen and Manion (1994, 96) mention that questionnaires should encourage respondents to co-operate and they have to be easy and attractive. They also comment on Moser and Calton's conclusion that central tasks in the questionnaires editing are completeness, accuracy and uniformity (Cohen, Manion, 1994, 101).

A well-known method of data triangulation (Haasbroek, 1968) is used gathering them through several sampling strategies. So the data at different times, social situations, and on a variety of people are gathered (Denzin, 1970). The data are gathered in three groups of respondents in different times of the particular study.

Surveys on the development of students' professional competence in the studies of geodesy, delivering of the study course *geodesy*, etc. were carried out in three years period from 2008/2009 to 2010/2011. Totally 232 students were questionnaired (Table 1), i.e. 117 – from Latvia University of Agriculture (LLU), 49 – Riga Technical University (RTU), 40 – Moldova Agricultural University (MAU) and 26 – Czech University of Life Sciences (CULS).

Distribution of four statements in each question is the following: 4 – agree, 3 – moderately agree, 2- moderately disagree, 1 – disagree.

Results and discussion

The didactical model of geodesy studies is focused on student centred approach. It means that the students, a lecturer and competence development process makes the core of the model. Studies are the process of constructive interaction and co-operation among the students and the lecturer.

Cognitivism theories and constructivists cognitions make the theoretical basis of the model. Emphasis of study environments/settings, unity of the geodesy course aim, objectives and outcomes, substantiated choice of the course delivery methods and content as well as types of valuation (lecturer assessment, student mutual evaluations, self-evaluation) make a systemic device where all elements are used and mutually interact (Fig. 1.).

Novelty of the model (Fig. 1.) is the following:

- integrate all the elements of geodesy course delivery elements (comprising the course aim, objectives, outcomes, content, teaching/learning methods, valuation methods, study environments/settings) in a system with student and a lecturer's cooperation in the centre of the model with the purpose to improve getting of profession competence of geodesy;
- arrangement of the content of geodesy according to the principles of exemplary studies (exemplary, genetic, dialogue principles);

- the model is implemented in various environments and the implementation is based on the three principles of exemplary studies.

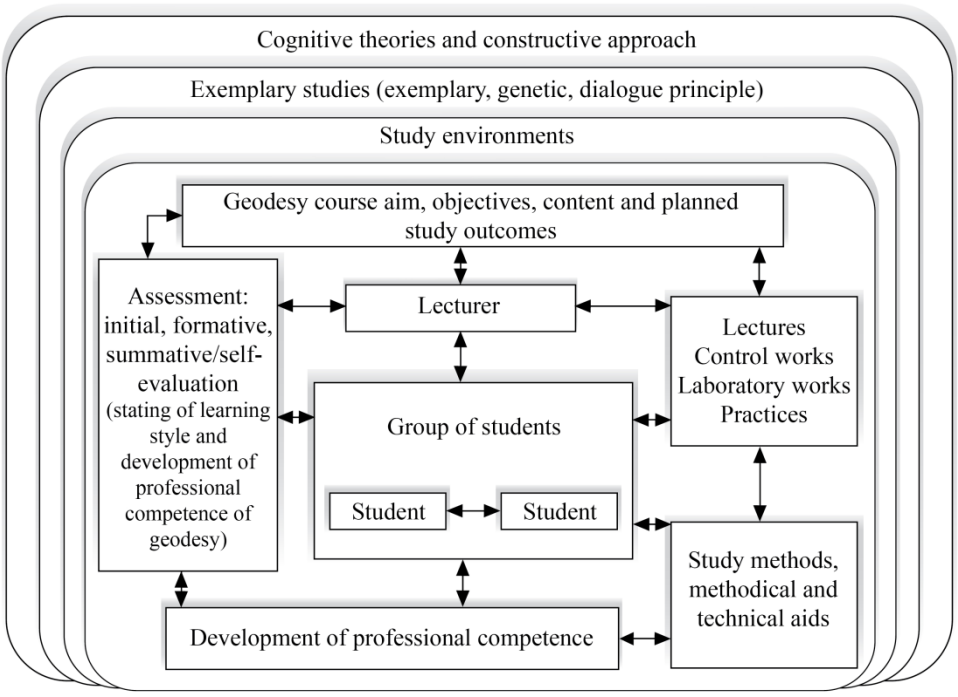

Figure 1. **Didactical model of geodesy studies**

The course of geodesy is delivered only for the first year students and many other courses and practices are linked with it. The amount of the course of geodesy is 128 academic hours (25% of time is lectures and 75% - laboratory works). Students also have an independent work at home and library for carrying out practical home assignments, preparing for control works, tests and exams. The length of the study practices related to the course of geodesy during the first year is two weeks, second year – three weeks, third year – two weeks. The length of the professional (field) practice during the second year is three weeks.

Exemplary studies are implemented in the course of geodesy for the first year students, and its principles are used in senior courses as well. The geodesy course programme for the land survey speciality first year students starts in the first semester according to the syllabus. They are distributed into laboratory work groups. Contact hours are arranged as follows: lectures for all groups together are delivered by one lecturer but each laboratory work group work under the guidance of three individual lecturers.

Laboratory works

The principle of exemplary in geodesy course studies became topical mainly because of the discrepancies in time limit and quantity of material which should be taught. The time limit created serious problems of the quality of the programme completion, and it is the first problem in the study process. Students do a lot of independent work in theory using various sources. As regards laboratory works they have to do them in laboratories and they are planned parallel lectures.

The second problem in relation to the curriculum planning is the following: successful carrying out of laboratory works is based on theory which should be delivered and comprehended during lectures. The lectures are delivered for all the target student groups simultaneously but laboratory works are organised in different times and it makes the sequence theory-practice more complicated.

Considering the author's I. Bīmane long years' experience in geodesy course delivering it is possible to assert that one of the best problem solutions is the usage of exemplary studies arranging the themes according to the principle of exemplary. It means focussing on particular exemplars versus traditional themes sequence in a text-book in laboratory works planning (Fig. 2).

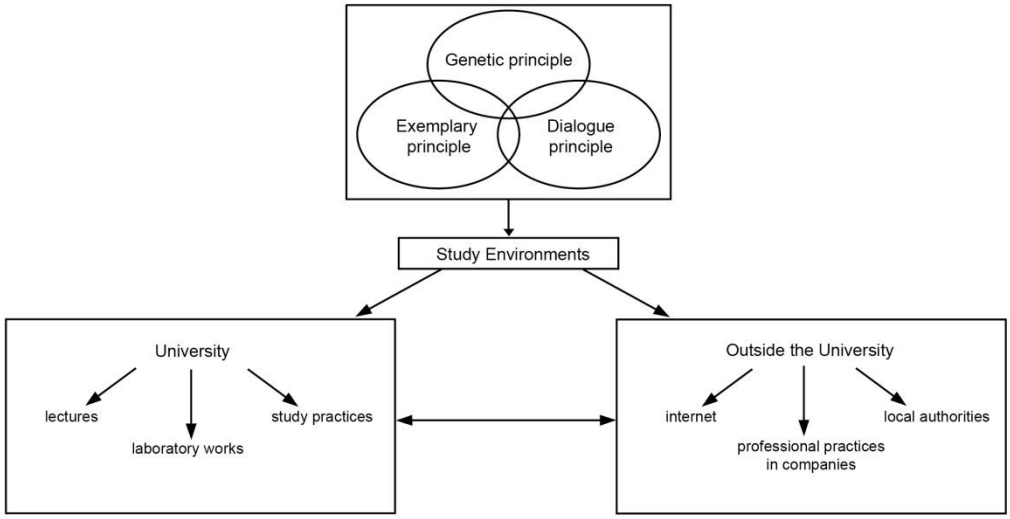

Figure 2. **Exemplary studies principles in various study environments**

Depending on an assignment, students carry out laboratory works in small groups or individually. Students accomplish analytically graphical tasks individually, hereto each students has a distinctive version. Needed theory and the process of the assignment accomplishing is talked and repeated before a running work, hereto the students are motivated to engage in a dialogue with a lecturer. It is very important to be a skilled assessor of the result, e.g. exactness of measuring or completion of necessary controls of analytical tasks. That is a way for students to develop their logical and critical thinking.

Works where geodesy instruments are used students accomplish in groups of three or four. The participants of the groups can be changed by the students' choice next time. Every student writes a report on the works accomplished and submits to a lecturer a completed calculation or graphic work which is also a basis of the work acceptance.

As regards lecturers they help students and have the role of advisers and promoters in the process of doing laboratory works and particularly with instruments. Results are recorded in special journals and the lecturer confirms them with a signature.

The sequence of laboratory work themes were arranged according to the principle of exemplary choosing exemplars (focal themes). They were chosen considering the features of totality, historical and scientific coherencies, and interdisciplinary. Other themes are grouped around the exemplars.

It is very important to understand the entirety of the course of geodesy in the process of its acquiring because the geodesy works is the whole complexity. Its peculiarity is in actions sequence and the actions are not possible apart by themselves at the same time. Measuring is possible only by means of geodesic instruments therefore students learn their construction, testing, history of instruments production and get to know about nowadays advanced instruments and technologies. Here arise the rest features of genetic learning: acquiring of the course getting knowledge also about the development of humanity and culture, holism and humanistic values. Students comprehend that their knowledge will be a means for meeting both an individual and society needs. The students are motivated to think critically in the course of geodesy, to participate in a dialogue actively and find out solutions in the case of problems appearance.

Study practice

The study practice is planned at the end of the first study year after completion of the course of geodesy.

Students organize groups of five or six participants in each by their choice at the beginning of a practice. The students do not change the groups during the practice. A leader of each group is responsible for all the work organization and discipline during the practice. The accomplishment of the practice tasks is a shared work therefore the practice documentation is only one copy per group. The entire group defends the practice results which are evaluated both by the students and a practice

leader (a lecturer). Actually the practice mark is got considering both the practice leader and the students' assessment.

The following criteria and their features are realised during the practice: genetics (problem based learning, interdisciplinary of mathematics and optics), exemplary (exemplars of classical measuring and the most common situations topographic measuring), dialogical (the students develop critical thinking; expose and substantiate ideas and come to solutions; respect and keep personal autonomy and clarity of each participant's individual contribution; listen attentively with the purpose to understand others; find out new possibilities and alternatives in the process of assignments accomplishment; recognise their shortcomings of knowledge and skills).

Professional (field) practice in companies

Students are required to complete three weeks in summer after the second year of studies in land surveying companies.

The aim of the practice experience is to promote the professional development of students by providing opportunities to apply theoretical knowledge and skills get in laboratory works in land surveying fields.

The objectives are: to get acquainted with work environment in the companies of land surveying, develop working skills with progressive geodesy instruments, carry out topographic, geodesic and mapping and other works under the guidance of experienced specialists and to develop ability to work in teams.

Inductive approach in the learning process is activated during the practice because students get experience on the basis of real practical assignments. The students work as surveyors assistants and they are in a new setting during the practice. It means new work assignments, time, space and interpersonal relations. There is the change of the status from a student to a new and less experienced colleague, and the students have to implement their knowledge and skills in collaboration with experienced colleagues.

The major part of students meets their future professional colleagues including also company managers for the first time just during the professional practice. They are potential employers. The practice co-ordinator from the side of the company writes a report at the end of the practice. The report comprises such items as: the student's attitude towards work, kinds of assignments, quality of the assignments' completion. Each student prepares a report of the practice and defends it in the presence of other students and two lecturers.

The following principles and their features are realised during the practice: genetics (problem based learning - students together with professionals try to find the most appropriate solution of the assignment, interdisciplinary of mathematics and optics and maintaining and testing of geodesy instruments), exemplary (the students learn to use knowledge and skills into new cases), dialogical (the students under the guidance of the practice co-ordinator develop critical thinking; expose and substantiate ideas and come to solutions; respect and keep personal autonomy and clarity of each participant's individual contribution; listen attentively with the purpose to understand others; find out new possibilities and alternatives in the process of assignments accomplishment; respect other settings; recognise their shortcomings of knowledge and skills).

Internet

Students use Internet looking for additional information both in theoretical and practical parts in the course of geodesy. They also use Internet with the purpose to find out information on changes in normative documents which regulate topographic and geodesy works.

Genetic principle dominates in Bachelor theses writing widely discovering the theme starting from history and basics and linking them together with nowadays science. The feature of interdisciplinary is apparent preparing theoretical and practical assignments.

Table 1

Students' self-evaluation on the development of their professional competence of geodesy

No.	Question	Responses*	Responses, *n*					Totally		Mode	Median
			LLU		RTU	CULS	MAU				
			1st year	3rd and 4th years				*n*	%		
1	Does the study course *geodesy* teaching promote your co-operation with other students and teachers?	4	32	29	25	5	22	113	49	4	3
		3	23	22	21	15	11	92	40		
		2	3	8	2	3	5	21	9		
		1	-	-	1	3	2	6	2		
2	Does the study course *geodesy* teaching promote your understanding on your career in the field of land survey?	4	42	35	30	-	27	134	58	4	4
		3	14	15	16	10	8	63	27		
		2	2	7	3	10	4	26	11		
		1	-	2	-	6	1	9	4		
3	Does the study course *geodesy* learning promote your understanding on duties in the field of land survey?	4	39	30	23	1	19	112	48	4	3
		3	19	22	22	14	17	94	40		
		2	-	4	4	8	2	18	8		
		1	-	3	-	3	2	8	4		
4	Does the study course *geodesy* learning promote your understanding on professional values and professional ethics?	4	19	18	14	2	19	72	31	3	3
		3	32	30	26	12	10	110	47		
		2	6	9	8	5	6	34	15		
		1	1	2	1	7	5	16	7		
5	Does the study course *geodesy* learning promote your skill to think coherently?	4	21	19	15	1	20	76	33	3	3
		3	32	37	33	9	11	122	52		
		2	5	3	1	12	4	25	11		
		1	-	-	-	4	5	9	4		
6	Does the study course *geodesy* learning promote your skill to think on your speciality?	4	43	32	25	-	26	126	54	4	4
		3	14	21	23	7	6	71	31		
		2	1	5	1	8	5	20	9		
		1	-	1	-	11	3	15			
7	Does the study course *geodesy* learning promote your understanding on creativity and innovations?	4	11	10	13	1	10	45	19	3	3
		3	33	22	24	13	17	109	47		
		2	12	22	10	8	10	62	27		
		1	2	5	2	4	3	16	7		
	Probability (p- value)		.00	.52	.00	1.00	.03	.00			
8	Does the study course *geodesy* learning promote your understanding on becoming an expert in the field of land survey?	4	20	17	11	-	17	65	28	3	3
		3	32	28	24	7	14	105	46		
		2	6	9	11	11	6	43	18		
		1	-	5	3	8	3	19	8		
9	Does the study course *geodesy* learning promote your understanding on the necessity of continuous education and necessity of extra knowledge?	4	30	23	25	-	24	102	44	4	3
		3	24	27	23	6	14	94	41		
		2	3	8	1	11	1	24	10		
		1	1	1	-	9	1	12	5		
10	Does the course of geodesy promote the formation of understanding on the professional action impact on the environment and society?	4	-	19	-	-	-	19	32	3	3
		3	-	27	-	-	-	27	46		
		2	-	11	-	-	-	11	19		
		1	-	2	-	-	-	2	3		
	Total number of students		58	59	49	26	40	232			

*4 – agree, 3 – moderately agree, 2- moderately disagree, 1 – disagree.

Local authorities

As regards local authorities, students look for information in local geodesic nets and their point coordination as well as other materials necessary before the start of completion measuring assignments or during it. A peculiarity of geodesic works is that each measuring situation has specific features. Specialists help the students to generalize and compare situations of assignments with similar real life situations.

Dialogical and exemplary principles dominate in co-operation with local authorities. As regards the exemplary principle students understand that each measuring case is particular and learn to use knowledge and skills into new cases. The students learn to co-operate with specialists with a purpose

to complete the measuring assignments from dialogical aspect. Listening and argumentation skills are developed particularly (the students have to listen attentively with the purpose to understand others; find out new possibilities and alternatives in the process of assignments accomplishment; recognise their shortcomings of knowledge and skills).

Questionnaire of students' professional competence of geodesy *(Table 1)*

The didactical model of geodesy studies is used at LLU completely. RTU, MAU and CULS do not use the principles of exemplary studies. They use other elements of the model. The model implementation results at LLU were approbated in the scientific conferences for land survey specialists at RTU, MAU and CULS. The students of the four universities were questioned on the development of their professional competence.

The students of LLU, RTU and MAU evaluated the effective development of their professional competence during the course of geodesy positively - respectively 87%, 88% and 80% agreed or moderately agreed. CULS students were more critical and only 44% agreed or moderately agreed.

Examples of exemplary studies abroad nowadays

Wagenschein's ideas are supported also from Russian scientists (Васильева, 1991; Иванова, 2001), e.g. describing four main features of the principle of exemplary: thematic rather than systematic acquiring of study material considering students' interests; the usage of heuristic and problem based methods which promote the development of the students creative thinking; the study process should be creative and educational rather than focussed on getting ready and non-disputable knowledge (Васильева, 1991).

Project works in mathematics are popular in European universities and they comprise problem-based studies, interdisciplinary, participant-directed studies, the principle of exemplarity, etc. (Vithal et al, 1995).

A good example was Aalborg University and Roskilde University (Denmark) outlining a valuable experience in mathematics and natural sciences teaching/learning perspectives both for teachers and students. The students themselves decided which problems they wanted to work with at Roskilde University. The projects reflected possibilities, advantages and also weak sides of the project method and the principle of exemplary. The key notions in the project works were: exemplary and interdisciplinary.

The two year introductory study programme of natural sciences at Roskilde University is an example of a project organised, participant directed, problem oriented, and interdisciplinary science study programme (Blomhøj, Kjeldsen, 2009).

Conclusions

- The didactical model of geodesy course studies improves the quality of acquiring the course of geodesy including specific professional, varied social and cultural skills, and develops critical and analytical thinking. The principle of exemplary helps to avoid traditional thematic sequence discrepancies in laboratory works in the course of geodesy for the first year land service students at LLU. Usage of the principle of exemplary requires an extra work from a lecturer because the course has to be rearranged according to exemplars, and it means preparation for lectures and laboratory works in coherencies with the science development aspects historically, interdisciplinary, holistically and culturally.
- Exemplary studies foster students' perception of science as a cultural phenomenon and views from various angles. It helps to understand interdisciplinary of a definite theme or entire course, and to see that sciences do not function as absolutely autonomous units but they have overlapping fields.
- Exemplary studies exceed the borders of the particular study course knowledge and skills because the principles (genetic, dialogical, exemplary) promote the development of critical thinking and this attribute has an important social value. Critical thinking is one of the features of democracy and a means of multisided valuation of phenomena.

- Didactical model of geodesy studies promotes the development of LLU students' professional competence of geodesy more effectively than before its usage since the study year 2009/2010.

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