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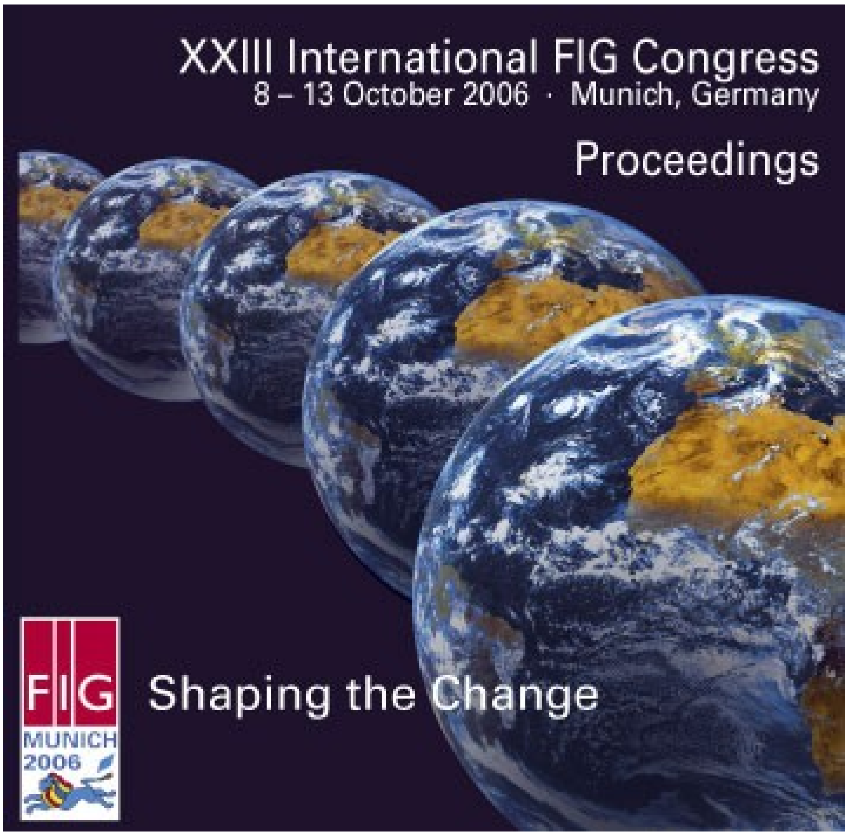

Thursday October 12, 2006

Thursday 16:00-17:30 Room 04a	**TS 84 - e-Learning** Commission: 2 Chair: Prof. **Stig Enemark**, Denmark Rapporteur: Dr. **Jaeik Liou**, Republic of Korea

TS84.5 Dr. M. **Flor Alvarez**, Dr. **José Ramón Rodriguez-Pérez**, Mr. **Enoc Sanz Ablanedo** and Ms. **Marta Fernández Martinez** (Spain):
Problem Based Learning (PBL) and e-Learning in Geodetic Engineering, Cartography and Surveying Education in the European Higher Education Area (EHEA) Frame – A Case Study in the University of León (Spain): Experiences and Results (0463)
[paper]

Problem Based Learning (PBL) and E-learning in Geodetic Engineering, Cartography and Surveying Education in the European Higher Education Area (EHEA) Frame. A Case Study in the University of León (Spain): Experiences and Results

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Key words: European Higher Education Area (EHEA), Problem Based Learning (PBL), e-learning, GIS education, cartographic education.

SUMMARY

The concepts and strategies defined in the Bologna Process to develop a European Higher Education Area (EHEA), involve a change in the educative programs, which have to be adapted to innovative teaching and learning processes based on *(i)* achieving specific knowledge according to the degree, and *(ii)* developing abilities and skills to adapt that knowledge to the professional field of work. Thus, the method has to be focused in the learning process (the student and his capability to learn) and not in the teaching process (the teacher). Problem Based Learning (PBL) emphasises learning activities which are student-centred, interdisciplinary, authentic, collaborative and foster higher order thinking. Students construct knowledge and develop skills in problem solving, communication, cooperation, negotiation, and decision making. Moreover, e-learning allows each participant in a course to be a teacher as well as a learner, so that the teacher changes to being an influencer and role model of class culture, connecting with students in a personal way that addresses their own learning needs, and moderating discussions and activities in a way that collectively leads students towards the learning goals. Both of them encourage the active participation of students in the learning process, as recommended by the Communiqué of the meeting of European Ministers in charge of Higher Education in Prague (2001) and in Bergen (2005).

The aim of this paper is to describe and discuss the applicability of PBL and e-learning in Geodetic Engineering, Cartography and Surveying education in the Faculty of Surveying Engineering (University of León, Spain). Some preliminary experiences of implementing them in the Geographic Information Systems (GIS) (2nd semester, 45 hours) course and Cartography course (4th semester, 60 hours) are described and discussed. The result of implementing PBL in an e-learning environment was evaluated using a methodological tool based on surveys, filled by the students at the end of the courses. The results were compared to the other courses based on more passive-learning methods, and on this background some future initiatives to be taken were proposed.

Problem Based Learning (PBL) and E-learning in Geodetic Engineering, Cartography and Surveying Education in the European Higher Education Area (EHEA) Frame. A Case Study in the University of León (Spain): Experiences and Results

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1. INTRODUCTION AND OBJECTIVES

On one hand, the European Higher Education Area (EHEA) is the objective of the Bologna process, to create more comparable, compatible and coherent systems of higher education in Europe. Moreover the Communiqué of the meeting of European Ministers in charge of Higher Education in Prague (2001) pointed out the need of lifelong learning, in order to face the challenges of competitiveness and the use of new technologies and to provide people of all ages with equal and open access to high-quality learning opportunities. It implies raising investment in people and knowledge; promoting the acquisition of basic skills, including digital literacy; and broadening opportunities for innovative, more flexible forms of learning. The Communication stresses the need for Member States to transform formal education and training systems in order to break down barriers between different forms of learning. In the same direction, the Communiqué of Bergen (2005) encourages the active participation of students in the learning process. Thus, according to the *Frame-Document to Integrate the Spanish Universitary System into EHEA* (MEC, 2003), the differential features of this new model are: *(i)* the European Credict Transfer System (ECTS) as unit of student work, *(ii)* the design of study programs based on academic and professional profiles, *(iii)* formative objectives professionally-oriented and integrating generic, transversal and specific abilities and skills, *(iv)* knowledge organization based on learning, which will be the learning-teaching process' core, and *(v)* active teaching methods, to emphasize student's main role in the learning process.

On the other hand, society is characterized by an infinite, dynamic and changing amount of information, an extensive use of Internet and new technologies, and rapidly changing labor market, which asks professionals for not only a specific and basic knowledge, but also the skills to apply it and solve incoming problems in a creative way, involving therefore lifelong learning and working in groups (Dochy *et al.*, 2003).

In this framework, universities become the main facilitator within the process of forming and promoting the current/future identity of the surveying profession (Enemark, 2002). This educational profile was developed through a seminar held jointly by the International Federation of Surveyors (FIG) and the European Council of Geodetic Surveyors (CLGE) (2005), and should cover the areas of measurement science and land administration, as well as be supported by and set in a broad interdisciplinary paradigm in geographic information management. Enemark (2002) reviewed international trends in surveying education, finding out that: *(i)* management skills (i.e. interpretation and management of the data, to meet the needs of customers, institutions and communities) are/will be a key demand, as opposite to specialist skills, *(ii)* traditional subject-based approach should be modified by stressing the process of problem solving on a scientific basis (project-organized education and *learning by doing*), *(iii)* the concept of *virtual academy vs* classroom lecture courses represents new opportunities, with special importance in lifelong learning programs, and *(iv)* university graduation is only the first step in a lifelong educational process. It is therefore necessary to lead Geodetic Engineering, Cartography and Surveying education to a more managerial and interdisciplinary approach which addresses problems in their real-life context.

The working document to define the study program for Degree in Geomatics and Surveying in Spain (*Libro blanco de la Titulacion de Grado de Geomatica y Topografia* (ANECA, 2004)) consider these aspects, and emphasizes the use of new learning techniques and the importance of achieving skills for *learning to learn* and for theoretical problem solving, which can only be achieved through academic training at universities (Enemark, 2002). In this frame, Geographic Information Systems (GIS) courses are proposed to be equivalent to 7 ECTS (175-210 hours of work per student), while Cartography courses will mean 18 ECTS (450-540 hours of work per student) (ANECA, 2004). Nevertheless, the current situation of surveying education in Spain is based on classroom lecture courses and focused more in teaching than in learning, so that the credit system reflects just the lecturing hours, not the actual hours of work per student. It is therefore necessary to migrate to the new paradigms, emphasizing self-directed lifelong learning instead of teaching (Knowles, 2002). The applicability of Problem Based Learning (PBL) and e-learning to reach this challenge is discussed in this paper throughout two study cases (GIS and Cartography courses) in the Faculty of Surveying Engineering (University of León, Spain).

Problem-based learning (PBL) is a learning environment which has been defined by several authors and in a wide sense form of PBL that have been used include research, case studies, guided design, and engineering design projects (Woods, 1996). According to Barrows and Kelson (2006) PBL is both a curriculum and a process. The curriculum consists of carefully selected and designed problems that demand from the learner acquisition of critical knowledge, problem solving proficiency, self-directed learning strategies, and team participation skills. The process replicates the commonly used systemic approach to resolving problems or meeting challenges that are encountered in life and career. It does provide the ability for students to be immersed into pseudo-real world scenarios, thus encouraging them to take more responsibility for their own learning and apply their knowledge at successively higher levels (Denayer *et al.*, 2003). In short, PBL is a cyclic process which comprises 3 phases (Perrenet, 2000): *(i)* cooperative thinking about the initial problem and identification of learning needs, *(ii)* individual self-guided study about the learning tasks, and *(iii)* application of new acquired knowledge to the problem in a cooperative way and synthesis of their learning. As a result, the traditional teacher and student roles change. The students assume increasing responsibility for their learning, giving them more motivation and more feelings of accomplishment, setting the pattern for them to become successful life-long learners. The faculty in turn becomes resources, tutors, and evaluators, guiding the students in their problem solving efforts.

The PBL model has been applied in different educational environments, for different degrees and areas (Garcia, 2002). Fernandez *et al.* (2004) made a revision concerning PBL evaluation and comparison to traditional approaches, considering the effects on the emotional component, the practical realization, the effects on learning and generalization. This study concludes that PBL is positive in most cases and satisfies most of the previous assumptions, and indicates that other approaches can complement and improve it, as for instance *e-learning*.

Ally (2004) defines *e-learning* (or *on line learning*) as the use of the Internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience. The European Commission has adopted the *eLearning initiative* to adapt the EU's education and training systems to the knowledge economy and digital culture (EC, 2003). It seeks to mobilize the educational and cultural communities in order to speed up changes in the education and training systems for Europe's move to a knowledge-based society. The *eLearning program for the effective integration of Information and Communication Technologies (ICT) in education and training systems in Europe* (2004 – 2006) is a further step towards realizing the vision of technology serving lifelong learning.

Draxler (2003) summarized the 4 elements one can examine to observe the differences between e-learning and face to face learning: (1) *information acquisition*: e-learning transforms the process of information acquisition into something more directly under the control and responsibility of the learner, where the mediator is either non-existent or in a role of counselor, (2) *transformation of information into knowledge*, so that e-learning liberates the learner into a world of almost infinite sources of information, where the learner has a great deal of responsibility in choosing, sorting and evaluating that information, which makes it more subject to individual choice and judgment, and therefore both promising and dangerous, (3) *mediation process* can to some extent be freed of human intervention and constraints, and (4) *validation*, although the difference is small because most of the same techniques and issues prevail.

Four main pedagogical perspectives that are often used when developing e-learning are: *(i) cognitive perspective*, which focuses on the cognitive processes involved in learning as well as how the brain works, *(ii) emotional perspective*, which focuses on the emotional aspects of learning (e.g. motivation, engagement), *(iii) behavioural perspective*, which focuses on the skills and behavioural outcomes of the learning process, role-playing and application to on-the-job settings, and *(iv) social perspective*, which focuses on the social aspects which can stimulate learning (e.g. interaction with other people, collaborative discovery and the importance of peer support as well as pressure). Therefore, online instruction occurs when learners use the Web to go through the sequence of instruction, to complete the learning activities, and to achieve learning outcomes and objectives (Ally, 2002).

In the area of Geodetic Engineering, Cartography and Surveying education, eight European Geographic Information (GI) institutes use existing courses and adapt them to the requirements of the e-learning course exchange (EDUGI, 2006). The project idea is to (re)use existing resources by the exchange of e-learning courses via the internet. They foresee the development and exchange of 8 e-learning courses, so that some of the expected results are to establish an e-learning platform and an organizational framework for exchange.
In this framework defined by the EHEA, society requirements, and teachers' and learners' challenges, the goals of this paper are: *(i)* describing PBL implementation in an e-learning environment in Geodetic Engineering, Cartography and Surveying education, *(ii)* evaluating the method and comparing it to the other courses based on more passive-learning methods.

2. MATERIAL

2.1 Course Description

Two compulsory courses to obtain the Degree in Surveying Engineering (3-year degree) in the University of Leon (ULE) (Campus de Ponferrada) were selected as study cases: GIS and Cartography. The main features for both courses for the academic year 2005/06 are showed in Table 1, as well as the objectives, educational methods (lecturing, PBL, e-learning) and evaluation criteria. ULE credits correspond to the actual study program, which is not yet adapted to the EHEA, and each credit is equivalent to 10 teaching hours (theoretical or practical).

Table 1. GIS and Cartography course characteristics.

	GIS	Cartography
Semester	2nd	4th
Hours (total)	45	60
Theoretical	15	30
Practical	30	30
Students	57	21
Lecturers	1	1
Objectives	(i) Learning GIS concepts, techniques and methods (raster/vector, object/layer oriented). (ii) Acquiring technical skills in GIS software use and management. (iii) Acquiring data processing general strategies necessary to improve students' intellectual work, to help them to understand and join the current information society.	(i) Understanding the general workflow for mapping. (ii) Learning different map types and peculiarities of cartographic techniques, emphasizing data processing and cartographic generalization. (iii) Map element analysis and layout. (iv) Application of theoretical contents to mapping.
Lecturing	Yes	Yes
PBL	Yes	Yes
e-learning	Yes	Yes
Evaluation criteria (% final mark)	Test (30%) Computer's laboratory exam (60%) Assigned tasks (10%)	Test (10%) Maps presentation (70%) Assigned tasks (20%)

2.2 Problem Based Learning (PBL): Materials and Methods

The following paragraphs describe the implementation of PBL in each course, by describing the study case (problem, project, research task) proposed through its objectives, materials, group organization and evaluation criteria.

2.2.1 GIS course

The task *"Can you read spatial information?"* is described in Table 2. This task was included in the program due to the lack of cartographic knowledge of 2nd semester students, who cannot attend any course on Cartography until 3rd semester. However, some concepts (map measurements and scales) should have been learnt in the Graphic Expression course (1st semester), son that this task brings students to the same knowledge level. Its completion was not compulsory but students had to complete the same task in the exam using a given map. The degree of PBL involved in this task is not too high, because discussions are critical decisions are limited, and results have to be presented individually. Nevertheless, it is a helpful example to introduce 2nd semester students in a PBL environment, where answers do not come from the teacher, but from the student and after discussing the alternatives in the in-progress meeting, and where come across self-directed learning strategies. In the same way, six practical tasks regarding the use of GIS software were also proposed to the students; each task was introduced in the beginning of the practical class and a similar example was done following teacher's directions (1 hour); the practical task had to be completed afterwards by the student (1 hour).

Table 2. *"Can you read spatial information?"* task description for the GIS course

Task	**Can you read spatial information?**
Objectives	Differencing cartographic elements in a map, interpreting marginal information, measuring distance and slope, determining UTM and geographic coordinates.
Materials	1: 25.000 Topographic map. Task objectives (available at the e-learning platform). References (e-learning platform).
Output	Digital text document, uploaded through the e-learning platform.
Group	Individual.
Dates	Start: 8th March. Deadline: 29th March.
Meetings	Goals meeting: 8th March. In-progress meeting: 20th March. Evaluation results: 7th June. Feedback Meeting: 8th June.
Evaluation criteria	Answers completeness.

One of the main objectives of the GIS course was learning what GIS is and which are the main applications. In order to stress students' active role, a task regarding these topics was settled: *"Introduction to GIS: definition and applications"*. Students had to find out (1) a definition for GIS in a book (so that they will visit the library and be aware of the available bibliography) and (2) a GIS development in a journal and/or the Web. A table had to be filled with that information, so that they worked with digital formats and learnt how to cite references, achieving therefore transversal skills. The task was available at the e-learning platform, and the output had to be uploaded there. Eight days were given to complete it, and the results were discussed in the classroom through a brainstorm for GIS definitions and applications, in order to settle a new definition in a cooperative way, as an application of new acquired knowledge. All these aspects suggest that the PBL approach was taken into account in this task design.

In brief, 70% of the course was based on active learning methods (the 8 previously described tasks), while 30% relied upon lecturing and a more traditional approach.

2.2.2 Cartograhpy

The task *"Mapping: reference and thematic maps"* was designed in a PBL environment, and the case (*problem/project*) is summarized in Table 3. Its completion was compulsory and involved 70% of the final mark of this course. Students were organized in groups of two, and they had 3 hours each week to work on the project. It was optional to stay at the computers' lab, but during the lab sessions questions were posed by the students and replied by their classmates, as informal meetings. The scheduled review meetings (I, II) involved that each group had uploaded a table with the difficulties they had found to complete the task in review, as well as the solution they had found. During the meeting each group shared this information and tried to solve those unaddressed questions by asking other students. Therefore, after each scheduled review meeting, each group had to upload the updated table with each difficulty/problem and the proposed solution by the group itself, other groups, or the teacher (if applicable and as the last resort). A virtual forum was also used to pose/solve questions. The final output (maps and report) were presented in a CD/DVD, because they were too large to be uploaded to the e-learning platform. 18 evaluation criteria were considered to mark this task. Each group had to present their maps and justify its decisions regarding legends, reference systems, layout, scale, format, etc. The other groups could make questions and discuss the presented work, as well as the teacher.

Table 3. *"Mapping: reference and thematic maps"* task description.

Task	**Mapping: reference and thematic maps**
Objectives	Leaning thematic and reference mapping concepts and applying them. Focus on: available data management, metadata creation and reference system definition, cartographic design principles application, and legend suitable definition.
Materials	1:10.000 vector topographic file (dxf), 1:10.000 orthophotograph (same area) Hydrologic features (3 shp), administrative boundaries (shp), 1:50.000 provincial land use map (shp) Text files with information regarding mapping All materials were up-loaded to e-learning platform
Outputs	1:10.000 reference map for the area assigned to each group Digital Terrain Model (A3 format) for the area assigned to each group Slope thematic map (A3 format) for the area assigned to each group Land use map with hydrologic information (A3 format) for a subset area (common to all groups) Report including decision justifications
Group	2 students/group (9 groups)
Dates	Start: 13th March. Deadline: 30th May.
Meetings	Goals meeting: 13th March. Review meeting (I): data management, database and metadata creation. Reference map questions: 21st April (Posted 3rd May). Review meeting (II): reference map layout and thematic map questions: 22nd May (Posted 9th May). Preliminary evaluation (map presentation) and feedback meeting: 7th June. Definitive evaluation (final maps) and feedback meeting: 9th June.
Evaluation criteria	Map layouts (four) and report Multimedia map presentation to the class and discussion of results

Some of the theoretical contents of the course were met through the task *"History of cartography"*, consisting on researching, summarizing and presenting in 9 minutes the part of the history of cartography assigned. Students worked in groups of 3, and had 2 hours/week during 3 weeks to prepare it. There was a review meeting to delimit each group's topics more, in order to avoid overlapped presentations (penalized in the evaluation). Evaluation criteria were: contents (50%), presentation (20%), multimedia use (15%), and time adjustment (15%). This compulsory task was designed to stimulate active learning, and meant 20% of the total mark of the course.

Thus, only 10% of the course involved traditional lecturing, while 90% combined active learning approaches (e.g. PBL, learning based on researching).

2.3 E-learning Platform

2.3.1 Description

GIS and Cartography courses were implemented in a common e-learning platform at the beginning of the second semester of the Academic Year 2006/07. Previously, materials for these courses were available on a personal website. Therefore students could access to the class material, but feedback and questions could only be sent to the lecturer and by e-mail. To improve its limitations, both courses were redesigned and migrated to Moodle. Moodle (Modular Object-Oriented Dynamic Learning Environment), is an open source e-learning platform, with a user base with more than 12.000 registered sites in 155 countries with more than 4 million users in 376.565 courses (as of May 30, 2006). Moodle is modular in construction and can be extended to create activity modules. Moreover it is user friendly and easy to install and upgrade. Its social constructionist philosophy implies that the four pedagogical perspectives described before are considered (MOODLE, 2006). The platform can be accessed at http://www.ingecart.unileon.es/recursos/, where 4 more courses of the Geodetic Engineering, Cartography and Surveying area are available. Access was restricted to University of Leon professors/students by allowing only users with the e-mail domain *unileon.es*.

The GIS and the Cartography courses were organized in weeks, so that lectures and practical materials for the tasks were available. Moreover a forum was created for each course, as well as a calendar which reflected the main activities. Task outputs had to be uploaded using the platform. Teacher could mark and comment the output, and that information was confidentially available for each student. Summaries regarding access time and contents, marks, or student profiles, were available to the teacher. The Cartography course included also a "Wiki", in order that each group included two questions/answers regarding the history of cartography task. Two of those questions would be in the theoretical exam, and the Wiki allowed them to complete other group's questions/answers.

2.4 Evaluation Tools

2.4.1 Problem Based Learning (PBL)

Three scalar surveys were used to Evaluate Educational Methodology (EEM) (EEME1, EEME2, and EEME3), and also a semantic differential one (EEMSD). They were adapted from the EPU (*Evaluacion de Practicas Universitarias* – Universitary Practical lesson Evaluation) developed by the Education Sciences Research Group of the University of Leon (2002-2004). Thus, PBL was evaluated using four different surveys, which were individually filled by the students before the final evaluation of each course. Surveys gathered students' opinion about PBL regarding the following issues: (i) Generalization (GE) (future applicability, other areas connection, continuing with the method, possible generalization to other courses, effects on the institution, environment..); (ii) Learning Effects (LE) (acquired skills -e.g. written/oral expression, group work, decision making, critical thinking, self-confidence, learning to learn, management, languages…-, characteristics of acquired knowledge…); (iii) Actual Implementation (AI) (information about time, effort, dedication, work, required by this approach, and characteristics and criteria for implementation/evaluation); and (iv) Emotional Component (EC) (satisfaction, expectations, attitudes, motivation, environment). The main characteristics of each survey are showed at Table 4.

Table 4. Characteristics of the PBL evaluation surveys used in this study.

Survey	Issue	Items	Introductory question	Type
EEME1	AI	16	Thinking about the methodology applied in this course, rank the importance which has been given to the following aspects (1: min. to 5: max)	Scalar
EEME2	GE, LE, AI, EC	48	Thinking about this course and method, rank your agreement to the following statements (1: min. to 5: max)	
EEME3	LE	18 (36)	Several transversal skills are listed. Evaluate (i) the IMPROVEMENT achieved for each one *in this course with this methodology*, and (ii) the UTILITY of these skills in your *future career* (1: min. to 5: max)	
EEMSD	GE, LE, AI, EC	32	*The methodology applied was…* (indicate how close you are to each adjective) (1 to 5; low rates in this test indicate positive attitudes and feelings).	Semantic differentials

On the one hand, GIS students filled twice each survey, regarding: (i) the 8 tasks most PBL oriented, and (ii) traditional lectures in the GIS course. On the other hand, Cartography students could not compare both learning approaches for this course, because traditional lecturing was hardly ever used, so that they completed the survey regarding: (i) PBL cartography tasks, and (ii) traditional lectures in the Geophysics' course (4th year semester course). 19 students per course completed the surveys, which means 33.3% and 90.5% of the students of the GIS and Cartography course, respectively.

2.4.2 E-Learning

2.4.2.1 Constructivist On-Line Learning Environment Survey (COLLES)

In order to evaluate tutor's capability to exploit the interactive capacity of Internet to integrate students in a dynamic educational environment, the Constructivist On-Line Learning Environment Survey (COLLES) was selected. The COLLES was designed to help assess key questions about the quality of an online learning environment from a social constructivist perspective (Taylor and Maor, 2000). The instrument consists of 24 questions (actual value from 1 to 5) arranged into 6 scales: *Relevance* (how relevant is online learning to students' professional practices?), *Reflection* (does on-line learning stimulate students' critical reflective thinking?), *Interactivity* (to what extent do students engage online in rich educative dialogue?), *Tutor Support* (how well do tutors enable students to participate in online learning?), *Peer Support* (do fellow students provide sensitive and encouraging support?), and *Interpretation* (do students and tutors make good sense of each other's communications?). Nine Cartography students (42.8%) and eight GIS students (10.5%) completed the survey.

3. METHODS

3.1 PBL compared to traditional approach

Survey data were included in a database including information regarding the student (anonymous ID), course, method, and vales (1 to 5) for each item. EEME2 data were processed so that items were classified as GE, LE, AI or EC, and the average value for each class was calculated, by student and method. The same procedure was applied to EEMDS data< it has so be highlighted that low rates in this test indicate positive attitudes and feelings (e.g. interesting, functional, demanding, active, flexible, motivating). EEME3 data was split in degree of (a) skill improvement and (b) future utility, so the average value was calculated for each category, by student and method, and stored in two new fields in the data base. EMME1 data did not require additional processing.

PBL and the traditional approach were compared by the results obtained in the for EEM surveys through a sample comparison analysis at 95% confidence level, in order to validate the following null hypothesis:

- EEME1 data: there were no differences between PBL and the traditional approach regarding each one of the 16 items concerning AI.
- EEME2 and EEMDS processed data: there were no differences between PBL and the traditional approach regarding (i) GE average values, (ii) LE average values, (iii) AI average values, and (iv) EC average values.

- EEM3 processed data: there were no differences between PBL and the traditional approach regarding average values obtained for improvement in the listed skills and capabilities (LE).

Statistical analysis to compare the two different samples (PBL vs traditional) had to consider the ranked nature of the variables, so that the nonparametric Mann-Whitney test of location for two independent samples was carried out to determine whether or not the values of a particular variable differ between two groups. This test does not assume normality in data and can be used regardless data distribution. Each two-tailed significance value estimates the probability of obtaining a Z statistic as or more extreme (in absolute value) as the one displayed, if there truly is the null hypothesis that the two groups come from the same population. For those groups significantly different according to U-Mann-Whitney test, the error bars with the confidence intervals at 95% for the individual variables were plotted, as an aid to interpret the tests results. Separate analyses were conducted for each course.

3.2 E-Learning Analysis

The 24 items surveyed by COLLES were summarized in the six scales described above, estimating the average value for each of them, ranging from 1 (min) to 5 (max). The average values were plotted to illustrate student's perception.

4. RESULTS AND DISCUSSION

4.1 PBL Compared to Traditional Approach

Table 5 shows the items of the EEME1 test concerning Actual Implementation (AI) for the Cartography course which were significantly different when comparing PBL and the traditional approach, according to the Mann-Whitney test results. 12 of the total 16 test items resulted to be significantly different. The error plots and confidence intervals showed that students think that know-how learning was given more importance in PBL than in the traditional method, as well as oral reports, group work, and student participation, while regular attendance to class was no so important. Student-teacher communication out of the classroom was also more important in PBL, as well as frequent evaluation of the learning process and the use of new technologies and different data sources (journals, databases, books, Internet…). It should be highlighted that these values were not only different, but also high for PBL in the 1 to 5 scale. No differences between methods were found when analyzing data from GIS students, so neither the plots nor the significance tests are displayed.

Table 5. Mann-Whitney results (left) and error plots and confidence intervals (right) for EEME1 test variables (Cartography course)

VAR	Item	U	Z	Sig.
V201	Know-how	113	-2.0	0.04
V204	Oral reports	17	-4.9	0.00
V205	Group work	12	-5.1	0.00
V206	Student participation	60	-3.6	0.00
V207	Regular class attendance	104	-2.3	0.02
V210	PBL	60	-3.5	0.00
V211	Student-teacher communication	105	-2.2	0.02
V212	Frequent evaluation	53	-3.8	0.00
V213	Resources use	39	-4.2	0.00
V214	Connection to professional future	119	-1.8	0.05
V215	Test exams	70	-3.3	0.00
V216	Use of new technologies	50	-3.9	0.00

Error plots

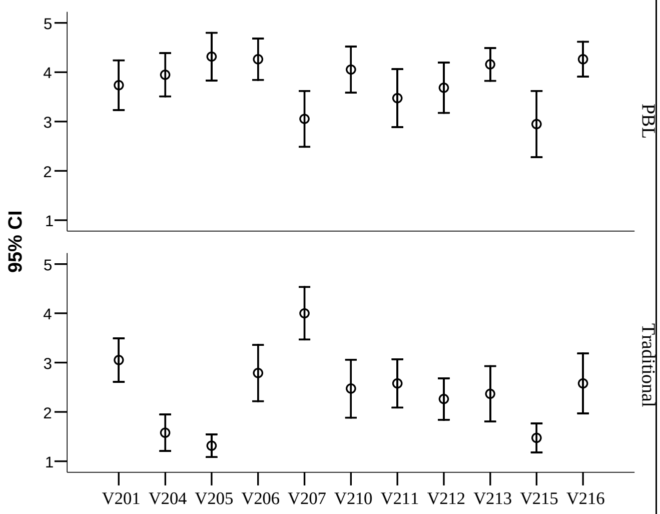


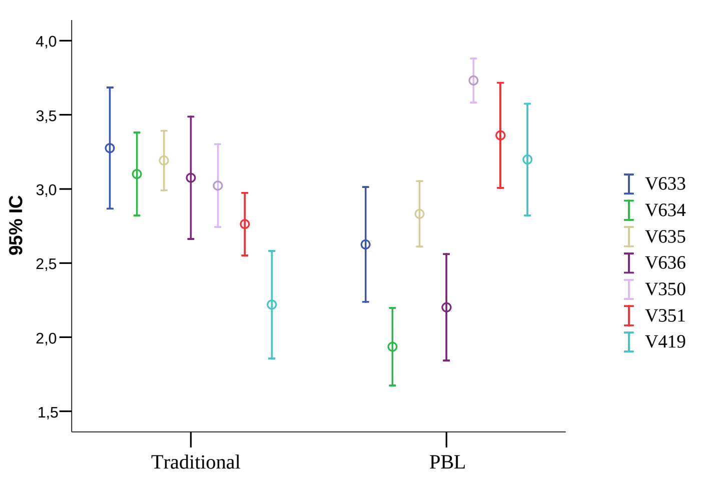
Table 6 shows that EC, AI, LE and GE were significantly different for Cartography students when comparing traditional lecturing and PBL by using the EEMDS test. Low rates in this test indicate positive attitudes and feelings (e.g. interesting, functional, demanding, active, flexible, motivating). Error plots showed greater values of EC, AI, LE and GE (V633, V634, V635, V636) for the traditional approach, therefore the lower values for PBL involved a more positive reaction of the students to this method.

Moreover, the values of variables AI (V350) and LE (V351) obtained throughout the EEME2 were significantly different for the traditional and the PBL approaches. For this test the greater the value, the more favorable the comments from the student. Therefore, the larger values displayed for PBL in the error plot pointed out the Actual Implementation and the Effects on Learning were better when using PBL than traditional methods.

PBL and traditional learning were also significantly different when comparing the average improvement achieved in the 18 skills listed by the EEME3 test. For this test the larger the value, the greater the improvement (IMP). As a result, the larger values displayed for PBL in the error plot indicated that general improvement in skills was greater by using PBL (according to students' perception). As expected, there were not differences for the variable UTI (UTILITY of these skills in their *future career*); because this variable did not depend on the educational approach and can be used to test the reliability of the survey.

There were not significant differences between methods for any of these variables when considering GIS students, so that neither the statistical results nor the error plots and confidence intervals were included in this paper.

Table 6. Mann-Whitney results (left) and error plots and confidence intervals (right) for variables derived from EEME2, EEME3 and EEMDS tests (Cartography course).

Test	Item	VAR	U	Z	Sig.	Error plots
EEMDS	EC	V633	83	-2.1	**0.04**	
	AI	V634	24	-4.1	**0.00**	
	LE	V635	86	-2.0	**0.04**	
	GE	V636	69	-2.6	**0.01**	
EEME2	EC	V349	128	-1.3	0.19	
	AI	V350	81	-2.7	**0.01**	
	LE	V351	106	-2.0	**0.04**	
	GE	V352	108	-1.9	0.05	
EEME3	IMP	V419	45	-3.4	**0.00**	
	UTI	V420	105	-1.3	0.18	

On the one hand, results above reported showed that 1st year students (GIS course students) did not find differences when comparing both methods applied in the GIS course, so that in their opinion PBL did not involve any advantage, but also any drawback. This response can be due to the degree of PBL applied in this course, which is not as high as in the Cartography course and group work was not frequent. Moreover, the sample was not as large as desirable, and less than 50% the students completed it; nevertheless they were nearly all the students who regularly attended the lectures/practices.

On the other hand, 2nd year students (Cartography students) had a positive attitude to PBL (Table 5 and Table 6). With regard to the Emotional Component (EC) students find PBL more interesting, challenging and enjoyable, as well as it allows self-directed learning and makes them be proud of their work. Other aspects considered as very positive by the student regarding PBL were: cooperative work, utilization of real problems, active participation, transversal skills integration and better self-knowledge. This outcome agrees to the results achieved by Fink (1999), Morales-Mann et al. (2001), Sluijsmans *et al.* (2001, 2002) and Denayer *et al.* (2003) for engineering and applied science students. McGrath (2002) found similar results in a review about PBL, so that students are more satisfied and are more positive regarding their learning, while students in the traditional curriculum often tend to evaluate their experience as irrelevant, passive and boring.

Concerning Actual Implementation (AI), students found that PBL requires more time, resources and effort, as also reported by Fink (1999), McGrath (2002), Denayer *et al.* (2003) and Sluijsmans *et al.* (2001, 2002). It was also found that the success of PBL requires that students have specific skills to work in group, or that they have a receptive attitude to acquire them. Another important issue concerns evaluation: the evaluation during/of the complete process stimulates the student and brings positive attitudes, as reported by Willis *et al.* (2002). Nevertheless, Dolmans *et al.* (2001) found that sometimes students do not determine clearly what new knowledge they have to acquire, so that it is necessary to activate their previous knowledge as a first step, and clarify the connections to the new learning objectives.

Effects on learning (LE) were found different by both tests which analyzed them, and the results showed that PBL is more effective on developing skills at problem resolution, critic thinking development, previous knowledge activation, increase of self-learning responsibility, and improvement at social and communicative skills. The items surveyed in the EEME3 test emphasized this aspect. It agrees to Dolmans *et al.* (2001), which also found out that it favors lifelong learning and the development of desirable attitudes for future practice. Moreover, students who follow PBL are not in disadvantage compared to those in the traditional curriculum, regarding basic scientific knowledge or professional skills acquisition (Fink, (1999), Dochy *et al.*, (2003).

With regard to Generalization (GE), students had an attitude significantly more positive to PBL than to the traditional approach (EEMDS test), and recommend it implementation in other areas. However, the EEME2 test did not reported significant differences at 95% confidence level (but did at 90%). There are not many studies which analyze the generalization component in PBL, but they both suggested the hope of keep on using PBL and the recommendation to students and teachers to use it, as well as the need of developing wider and more interdisciplinary projects (Fink (1999), Morales-Mann et al. (2001), Enemark (2002), Denayer *et al.* (2003)).

4.2 E-learning

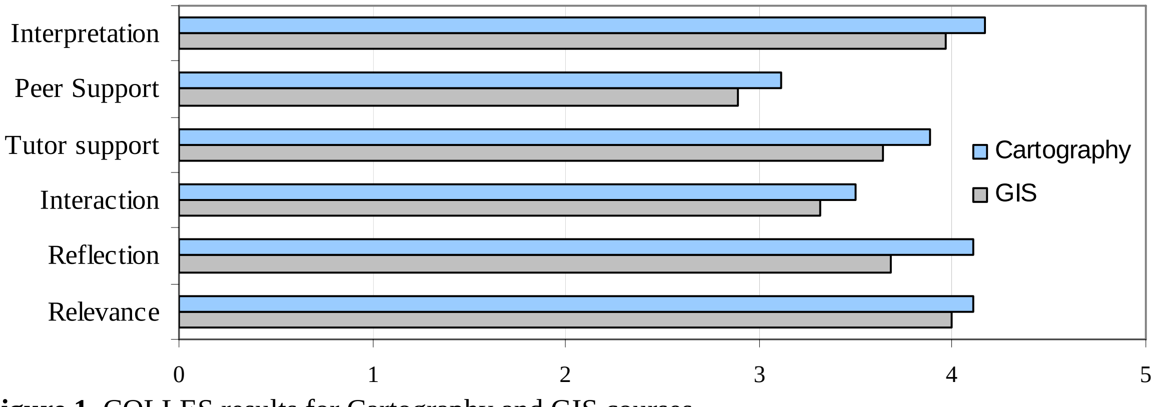


Figure 1. COLLES results for Cartography and GIS courses.

There were 7031 accesses to the GIS course and 7031 to the Cartography course, as total values for 17 weeks. It means an average of 413 accesses per week. Considering the number of students per course, a GIS course student accessed 123.4 times as average, while a student in the Cartography course accessed an average of 334.3 times, twice over GIS student's accesses. There were therefore significant differences in the use of e-learning platform regarding the course. The reason can be that 2nd year students are more used to using internet with educational uses. However students who use the e-learning platform often and who completed the COLLES, were satisfied with its use regarding Relevance, Reflection, Interactivity, Tutor Support, Peer Support, and Interpretation, as showed at Figure 1. It agrees to Marcelo (2006), who presented a study based on analysis of the messages sent to the discussion forums of ten e-learning courses, and concluded that virtual learning spaces do provide new vision and possibilities to develop more innovative learning processes that are more in consonance with the way adults learn.

5. CONCLUSION

The PBL and e-learning implementation in Geodetic Engineering, Cartography and Surveying education had reported successful results according to student's opinions. They improve significantly their analytical and transversal skills and competences, and become experienced in applying the theoretical elements from the lectures in practical problem solving. Generic, transversal and specific abilities, skills at *learning to learn*, and the basis for a *lifelong learning* are improved by this approach more than with traditional methods, emphasizing student's main role in the learning process. Those are the main goals of the EHEA, so that this approach is highly recommended to be considered when defining the new curricula for Surveying Engineering.

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