

## Working with students' diversity toward high-level skills by means of PBL

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## INTRODUCTION

Nowadays, universities offer its services to a greater diversity of students. During 20th century, universities have passed from an elite university, to a mass university with a larger proportion of cohorts. In the mass universities there is a greater variety of students with different learning approaches. Nevertheless, society is asking for students with high-level skills. Those skills go beyond understanding basic knowledge and acquiring basic skills. It is well known that Problem and Project Based Learning (PBL) methodology is adapted to acquire such skills. In this work, we wish to understand the impact of the student's learning approach and their supervisions sessions on high level skills in a PBL context. To carry out this study, Design Based Research method has been used. Several information sources have been used: At the beginning and at the end of the process students' learning approach has been measured. In addition, two different non structured focus group discussions have been organized: the first one with supervisors and the second one with students. In this paper, preliminary results will be shown and discussed.

## 1 PROBLEM STATEMENT

Martin Trow's defines elite university as a university with 15% proportion of cohorts, and mass university with a larger proportion (16%-50%) [1]. In the last decades (Fig. 1) the percentage of the population that has attained the tertiary education has increased in most of the OCDE countries [2].

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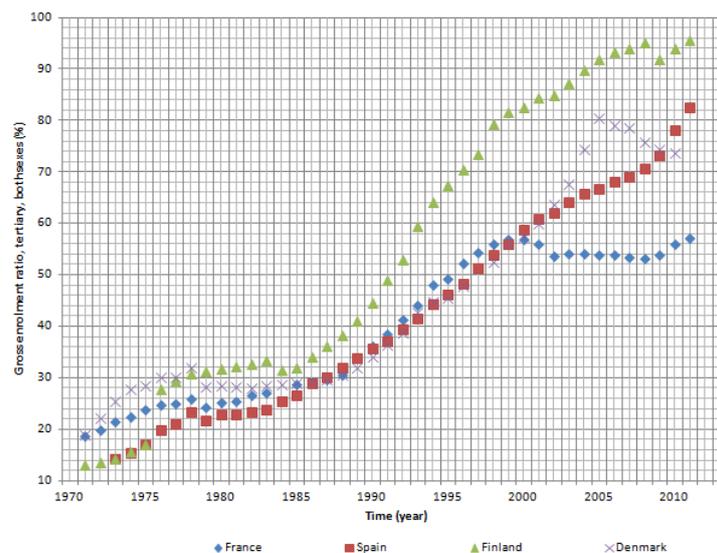
Tertiary education comprises university education as well as vocational training education (VTE) and other equivalent education.

Gross Enrolment Ratio (GER) in tertiary education is defined by UNESCO as

*The total enrolment in a specific level of education, regardless of age, expressed as a percentage of the eligible official school-age population corresponding to the same level of education in a given school year [3]*

As we can observe in Fig. 1, in Spain the number has increased from 8.6% of the population in 1971 to 82.6% in 2011; in Denmark from 18.5% in 1971 to 73.5% in 2010; in Finland from 13.1% in 1971 to 95.5% in 2011; in France from 18.7% in 1971 to 57% in 2011. From Trow's perspective, those countries have moved from elite universities to mass universities.

There could be several factors that can affect the change from elite university to mass university. In this paper, we consider two of them: On the one hand, in modern society taxpayers ask for a return for the taxes they pay. They would like a prosperous life for their children based on the university studies. This would help to continue increasing the number of students in higher education. On the other hand, the knowledge economy asks for people with higher education. In modern societies, the physical power was substituted by machines, and knowledge has become more valuable because it gives flexibility to adapt to new needs [1].



**Fig. 1. Gross Enrolment Ratio in tertiary education some European Countries (UNESCO Institut for Statistics)**

In this context, we can find a variety of students with different learning approaches. John Biggs describe them as academic and non-academic students [4]. Academic students are those that reach understanding, reflect on the consequences and applications of what they are learning. We cannot prevent them from learning; they tend to use high level cognitive process. On the other hand, non-academic's students' goal is to obtain a degree and have a job. They are not interested really in learning.

The European Qualification Framework (EQF) for lifelong learning demands high-level skills for undergraduate level [5] and tertiary education in general. In the recent OCDE rapport titled "Higher Education in Regional and City Development: Basque Country" they write this recommendation.

*The economic crisis, long term demographic change and competition from emerging economies require a new economic transformation in the Basque Country with greater emphasis on knowledge and continuous access to higher level skills. [2]*

From our point of view this means that knowledge and skills used to produce technological goods in a production line are not enough; we need something more. We need to be able to be critical with what we are doing. Take into consideration a wide range of solutions, even those that sound strange. E.g., Steve Jobs didn't consider the known solution for their smart devices. In the old days, when only academic students were present in the university, students obtained high-level skills without any special help [4]. However, that is not the case for non-academic students.

It is well known that Problem and Project Based Learning (PBL) methodology is adapted to acquire such high-level skills [6]. PBL has been introduced in various universities around the globe. The most well known are McMaster University (Canada) in 1966, Maastricht University (Netherlands) in 1969, Roskilde University (Denmark) in 1972 and Aalborg University (Denmark) in 1974. In our particular university, we started using PBL since 2002. This has involved mainly changes in the assessment, teaching and learning activities, supervision, etc. but there is still a room for improvement.

Assessment has been naturally understood as summative assessment. There was an attempt to adopt other type of assessments, like a continuous one. This type of assessment is close to summative. Instead of doing one final exam, there are several smaller exams during the process. All those exams' marks are taken into account for the final mark. Within this approach, students are not focused in the learning process but in the marks they receive, promoting surface learning. Other types of assessments, i.e. formative assessments, can be more advantageous to support learning process.

In our experience, we have also observed that a supervisor that made students reflect is supporting high-level skills among students. This means that, even though PBL support learning process, depending on how supervisor carried out formative assessment and reflection different learning approach can be promoted.

Those observations prompted the research question:

- In which extent can group formative assessment and reflection be used as a tool to help non-academic students to enhance high-level skills in a PBL context?

## 2 REVIEW OF THE LITERATURE

In this literature review we are going to focus in three of the main concepts of the research question: First, what we understand by high-level skills. And second, what are formative assessment and reflection, and what relation there is with high-level skills.

### 2.1 High-level skills

QAA define high-level skills as

*those which go beyond acquiring basic knowledge and understanding and being able to apply that understanding to straightforward situations. They include analysis and synthesis of a range of knowledge, which may be acquired by using research skills; critical reflection on different and potentially conflicting sources of knowledge; problem-solving by identifying a range of possible solutions, evaluating these and choosing the solution most appropriate to the situation; developing complex arguments, reaching sound judgements and communicating these effectively. [7].*

The European Qualification Framework [5] defines what is expected from each undergraduate student in Europe in term of knowledge, skill and competences:

- Knowledge level is defined as advanced knowledge of a field of work or study, involving a critical understanding of theories and principles;
- Skill level is defined as advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study;
- Finally, competence level is defined as being able to manage complex technical or professional activities or projects, taking responsibility for decision making in unpredictable

work or study contexts. And, take responsibility for managing professional development of individuals and groups.

Again, this framework emphasize on high-level skills.

In terms of Bloom or SOLO taxonomies, high-level skills like problem solving, analysis, synthesis, evaluate ... are placed in the higher levels of both taxonomies (see Fig. 2).

Bloom	SOLO	
Evaluation	Extended-abstract	High level skills
Synthesis	Relational	
Analysis		
Application	Multi-structural	
Comprehension	Uni-structural	
Knowledge	Pre-structural	

**Fig. 2. Bloom, SOLO and high-level skills**

## 2.2 Formative assessment

Assessment can be used with different purposes. On the one hand, assessment can be formative, when there is potential for improvement. On the other hand, assessment can be summative, when there is a final judgement. There is also diagnostic assessment, this is used at the beginning of the process to assess students' initial level, but we are not going to consider the diagnostic assessment in this project work.

Hassan suggests that

*Assessment tools should... be designed to be based on tacit or explicit assumptions about how students learn [8].*

For example, on the one hand, traditional assessment is grounded in the belief that knowledge is universal and that students can take in knowledge as it is disseminated. From this perspective, assessment is objective and neutral and the supervisor is the authority and expert. On the other hand, authentic or alternative assessment

*... it is rooted in the premise that knowledge has multiple meanings that cannot be objectively measured; rather, knowledge must be understood through the subjective impressions of those who possess it.*

This means that assessment takes into account not only the final product, but also how students carry out the learning process. In this case, supervisor shares learning environment control with students [9].

Graham Gibbs point out that assessment can support students learning behaviour and learning outcomes [10]. Some of those conditions are linked with the quality of learning promoted by assessments activities. The other conditions are linked with how well feedback support student learning. Other authors go deeper and they stress that assessment not only supports the learning process but it is part of the learning process. E.g. Torrance and Pryor [11] highlight

*Vygotsky's theory of 'the proximal zone' as follows: the teacher must not only see and assess what the student has achieved, but what the student can achieve. The interaction between teacher and student is seen as part of the assessment process, which means that the assessment should have an integral role in learning [8].*

This idea helps teacher to develop a co-construction process with the students.

## 2.3 Reflection

In section 2.1 has been stressed that high-level skills are beyond basic knowledge and understanding. In order to achieve this level, human beings need go through a complex learning process. In this section, we are going to describe two relevant theories that can support this process from a social constructivism perspective: Kolb's and Dixon's learning cycles.

Kolb [12] defines a cycle with four steps:

1. Each student generates concrete experiences.
2. Student carries out a reflective observation of his/her previous experiences.
3. Student generates an abstract conceptualization based on the reflections.
4. Student actively experiment in the project with new concepts.

Dixon [13] proposes an organizational learning cycle based on Kolb cycle. But each of the four steps is defined in a slightly different way:

1. Widespread generation of information.
2. Integration of new/local information into the organizational context.
3. Collective interpretation of information.
4. Having authority to take responsible action based on the interpreted meaning.

PBL team work can be seen as a small organisation, where each team member generates each own information (from books, internet, experiences ...). Those information need to be integrated in the team and be interpreted collectively, during team discussion or supervision sessions. In this context, each student has his/her own source of knowledge, solution, arguments ... and they need to reflect, evaluate and select the most appropriate solution.

The supervisor assessing students learning process can facilitate both individual and group reflection during supervision sessions using Kolb's and Dixon's learning cycles. This process can help students to construct more complex and rich mental schemes. The more mental schemes are restructured, the more relations are made between the concepts and, in consequence, deeper learning or higher-level skills is acquired.

## 3 METHODOLOGY AND IMPLEMENTATION

In this research work, we will use the Design Based Research (DBR) approach [14]. The literature will be used to define our application's theoretical framework. We will design something like a corridor that will guide our real practice. We would like to understand the phenomena, first from the theoretical point of view, but also as a teacher involved in a real process.

This research will be carried out in the 3rd semester of Computer Science and Telecommunication engineering degrees of Mondragon University (autumn term 2013-2014). This semester PBL has the next characteristics:

- The number of student was 18.
- The project teams were between 3-4 students. That means there were 5 project teams.
- The students were allowed to create their own teams.

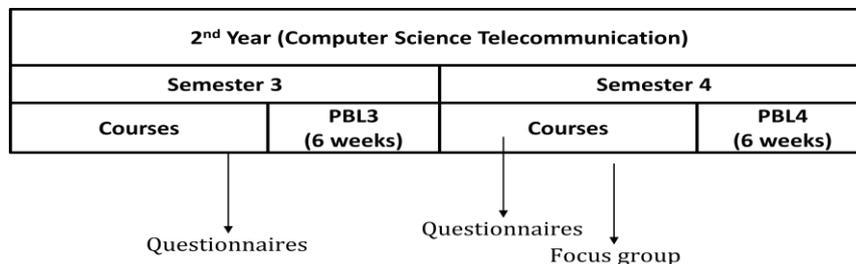
- There were various problems available for students. The students' teams were requested to select one of them.
- All students' teams were gathered in two groups (2-3 project teams per group). In one of the groups the supervision has carried out formative assessment and reflection and on the other one not.
- The supervisors that have carried out formative assessment and reflection were assigned to students' teams that had the lowest deep learning average score before the PBL; Teams number 4 and 5 (see Tab. 2).
- The other supervisors were assigned randomly.

All supervision sessions were planned once a week. The role of both type of supervisor was described in a supervisor guide, developed during this research work. On the one hand, the first type of supervisors is focus on the next tasks:

- Facilitate project organization and project planning.
- Facilitate team-work meeting.
- Facilitate rapport writing.
- Facilitate students' team in everyday work.
- Verify that the team is on the track.
- Carry out skills' summative assessment.

On the other hand, the second type of supervisor is also focus on formative assessment and reflection using Kolb's and Dixon's learning cycle.

In total, 18 students filled out the questionnaire, giving a response rate of 100%. 88.8% of the students were male. The average age of students when entering the programme was about 19 years. The study was conducted using web tools and respecting the anonymity of students' responses.



**Fig. 3. 3rd semester's implementation structure and measurement check points**

To analyse the results we have collected information from several sources (Fig. 3). At the beginning (before PBL) and at the end (after PBL) of the process we have measured students' learning approach using Biggs R-SPQ-2F [15] questionnaire translated in Basque (Garcia, 2011). At the end, we have also made a non structured group discussion with students and supervisors.

## 4 RESULTS

In this paper, we will show and discuss our preliminary results. In Tab. 2 students final marks and students learning approach are shown. The students' learning approach measured before the PBL and after the PBL. The final columns show the difference among the students learning approach in terms of Cohen's d between before and after the PBL.

$$Cohen's\ d = \frac{Mean_{after\ PBL} - Mean_{before\ PBL}}{\sqrt{\frac{(N_{after\ PBL} - 1) \cdot SD_{after\ PBL}^2 + (N_{before\ PBL} - 1) \cdot SD_{before\ PBL}^2}{(N_{after\ PBL} + N_{before\ PBL} - 2)}}$$

Final marks were taken from the PBL exam using the grading scale shown in Tab. 1. This grading scale is a modified version of Danish grading scale. This was a team exam where students need to answer to examiner's questions. Based on SOLO taxonomy, students are requested to demonstrate high-level skill like argumentation and justification of the design and work they have carried out during the PBL.

**Tab. 1- Marking or grading scale**

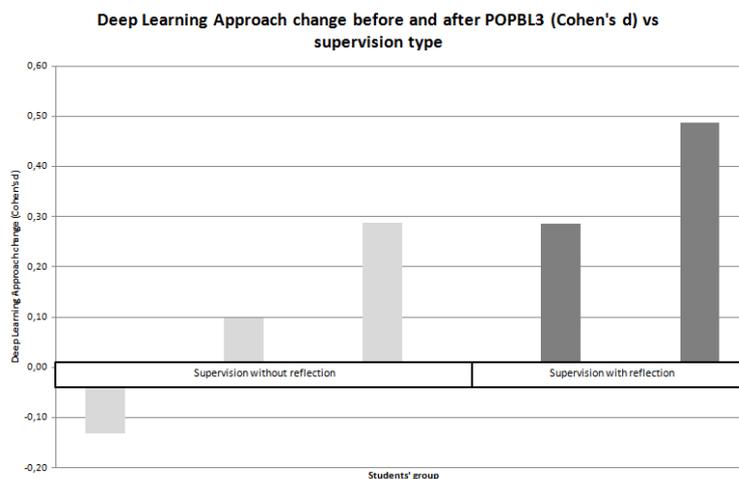
Mark	Description	
10	Excellent	High level of command of all aspects - no or only a few minor weaknesses
8	Very good	High level of command of most aspects - only minor weaknesses
7	Good	Good command - some weaknesses
6	Fair	Some command - some major weaknesses
5	Adequate	The minimum requirements for acceptance
2.5	Inadequate	Does not meet the minimum requirements for acceptance
0	Unacceptable	Unacceptable in all respects

**Tab. 2. Students Learning Approach and Final marks**

Group	Size	Final marks		Before PBL				After PBL				Difference	
		Mean	SD	Deep Learning Approach		Surface Learning Approach		Deep Learning Approach		Surface Learning Approach		Cohen's d	Cohen's d
				Mean	SD	Mean	SD	Mean	SD	Mean	SD		
1	4	7,00	0,00	3,26	0,75	2,45	0,96	3,15	0,86	2,30	0,85	-0,13	-0,17
2	3	7,33	4,62	3,60	0,99	2,00	0,97	3,70	1,03	2,10	0,91	0,10	0,11
3	4	7,00	1,41	3,13	0,76	2,23	1,00	3,35	0,80	1,98	0,92	0,29	-0,26
4	4	7,25	0,50	3,07	1,28	2,53	1,25	3,47	1,50	1,80	1,06	0,29	-0,63
5	3	7,50	0,71	3,03	1,30	2,53	1,25	3,63	1,16	1,97	0,76	0,49	-0,55

First three teams (rows) Tab. 2 have normal supervisors and the last two reflective supervisors. All teams have shown deep learning approach in all the process and good final marks in the end.

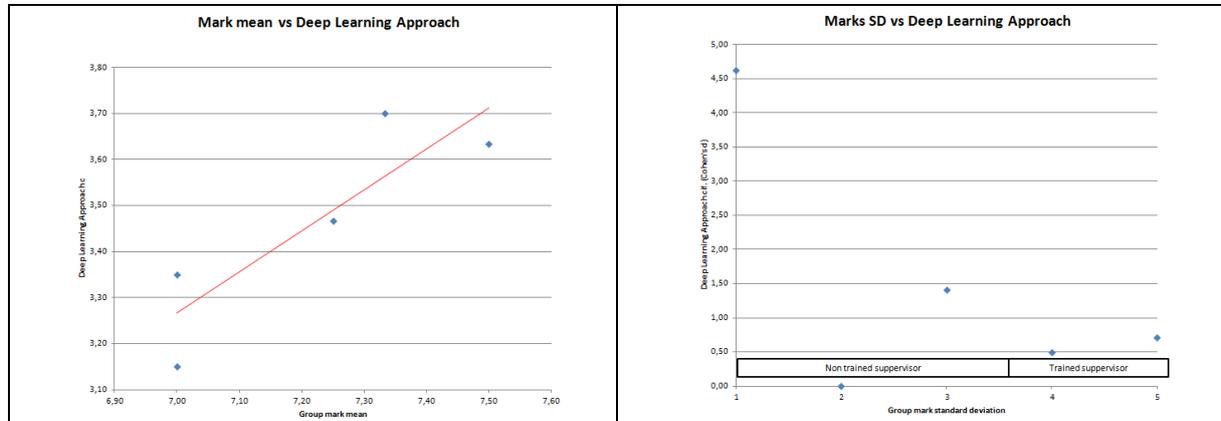
As we can see in Tab. 2 and Fig. 4, team 1 and 2 have shown small change in deep learning approach -0.13 and 0.10. Team 3 has shown medium change 0.29. Teams 4 and 5 have shown medium/high change in learning approach: 0.29 and 0.49.



**Fig. 4. Deep Learning Approach change before and after POPBL3 (Cohen's d) vs. supervision type**

There is also a correlation between teams' marks average and students learning approach. A better learning approach of the students leads to better marks.

Finally, analysing the standard deviation of the marks, we can observe that (Fig. 5) reflective teams have in general lower standard deviations. This can be due to greater discussions between students team promoted by Dixon's organizational learning cycle.



**Fig. 5. (a) Mark mean vs. Deep Learning Approach (b) Marks standard deviation vs. supervisor type**

## 5 CONCLUSION

With this study we have seen that supervision has significant impact on the students' learning approach. Those students' teams that had a significant change had more superficial learning at the beginning, in other word less academics. Their learning approach has been significantly changed, making them deeper learners in the end. The supervision has been focused mainly in team reflection, stopping students for a while and making them reflect on the work at hand.

We have found that there is a correlation between teams' deep learning approach average score and teams' average mark. During the supervision process students are requested to reflect and argue in a similar way as they are requested during the exam. This can be the reason that explains this correlation.

We have also found that the standard deviation of the team's mark is in general lower in the case of teams with supervision with reflection than in the other cases. This can be explained due by the fact that those supervisors use Dixon's organizational learning cycle, where all team members are requested to participate in the reflection.

This is a small study, which cannot be generalized. Nevertheless, it seems quite coherent with the literature. In the future, this experience needs to be checked in other similar contexts and with more participants.

## 6 SUMMARY AND ACKNOWLEDGMENTS

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