PROJECT-LED EDUCATION IN ENGINEERING: MONITORING AND ASSESSING THE LEARNING PROCESS.

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Abstract
This paper presents findings from a case study carried out at the University of Minho, Portugal, with first year Industrial Management and Engineering students, who participated in a Project-Led Education (PLE) experience. It emphasizes the importance of formative assessment and the process of providing regular feedback on students' work as key features to guarantee quality in student learning. Monitoring and assessing the learning process has become an important concern when designing PLE experiences. To meet this goal, a set of milestones are established throughout the project (oral presentations, midterm reports, tutorial meetings, etc.), as well as *peer* and *self-assessment* processes, in order to support students in the process of monitoring and regulating their own learning.

Keywords: Engineering Education, Project-Led Education, Formative Assessment, Learning Process, Self-Assessment.

1. INTRODUCTION

According to the demands of the Bologna Process, new educational methods and strategies are needed in order to motivate and engage students in the learning process and guarantee higher quality at undergraduate programs.

Project-Led Education (PLE), in contrast to traditional methods, provides an environment in which students become actively engaged in the learning process, as they work together in teams to solve large-scale open-ended projects. Project-Led Education, defined by Powell and Weenk (2003:28), focuses on:

> «…team-based student activity related to learning and to solving large-scale open-ended projects. (…) A team of students tackles the project, provides a solution, and delivers a ´team product´, such as a prototype or a team report at an agreed delivery time (a deadline). Students show what they have learnt by discussing the 'team product' with each other and reflecting on how they have achieved it».

The key features of the project based approach aim at fostering student-centeredness, teamwork, interdisciplinarity, development of critical thinking and competencies related to interpersonal communication and project management. By learning through projects and teamwork, students move from merely listening and reading about abstract concepts to

working with their teammates in applying those concepts in order to solve real-world problems (Michaelsen *et al*., 2004). If we look at engineering students' future professional contexts, most of the work done by engineers today is also organized in projects and very often as teamwork. So it is very important that students develop skills in areas such as project management, leadership, collaboration and teamwork in order to be prepared to face the professional world (Hansen, 2004).

In this type of teaching and learning philosophy, formative assessment assumes an important role in the monitoring and assessment of the students' learning process. Formative assessment, according to Bloom's initial conception (Bloom *et. al.,* 1971), was used mainly to define appropriate corrective measures for students who had not yet mastered the instructional objectives. In this approach, although many corrective forms of assessment are used, the aim would always be the remediation of learning difficulties. The teacher attempts to assure that all the students will master the objectives of the unit, taking control of all phases of teaching, testing and remediation.

However, french researchers (Allal, 1979; Perrenoud, 1998) have enlarged this initial conception of formative assessment in several directions. An enlarged conception suggests the integration of formative assessment in each instructional activity rather than being just a specific event that occurs after a phase of teaching, as proposed by Bloom. According to Allal and Lopez (2005:245):

> «in addition to paper-pencil tests, quizzes or worksheets designed to verify whether students understood the content of a lesson, assessment is carried out informally by direct teacher observation, by exchanges among students (reciprocal assessment) at various points during an instructional activity, and by whole class discussions that allow students to present different ways of understanding a task or of carrying out an activity».

As shown in the table below (*Table 1*), in the enlarged perspective of formative assessment, a broader concept of *regulation* of learning (feedback + adaptation) substitutes the initial idea of *remediation* of learning difficulties (feedback + correction). The central idea of this formative assessment conception is the regulation of teaching and learning through informal, interactive assessment and through the use of instruments that are adapted to classroom practice.

Bloom´s Initial Conception	An Enlarged Conception
- Insertion of FA after a phase of teaching - Use of formative tests - Feedback + correction → remediation - Management of FA by the teacher - Mastery of objectives by all students - Remediation benefits the students who were assessed	- Integration of FA in all learning situations - Use of varied means of data collection - Feedback + adaptation of instruction → regulation - Active student involvement in FA - Differentiation of instruction and, to some extent, of objectives - Regulation at 2 levels: for the students assessed, for future students (continuing instructional improvement)

Table 1. Conceptions of Formative Assessment (FA) (Allal & Lopez, 2005: 245)

Recently, Fernandes (2006) has presented a new conception of formative assessment, an interactive type, centered in students' cognitive processes and in processes of feedback, regulation, self-regulation and self-assessment of learning. It is an Alternative Formative Assessment (AFA), as he designates it, distinguishing it from any other type of assessment with formative intention, since it is more interested in improving learning rather than classifying it, more integrated and contextualized in the teaching and learning process, and where the students have a leading role in the learning process. It is different from any other kind of assessment which gives more emphasis to the processes of classification and to the summative results of the students. Its main purpose is to regulate

and to improve students' learning, focusing its attention on the processes, but without ignoring the products, based on transparency, participation and clear integration of assessment in the teaching and learning process (Fernandes, 2006). Cognitive and metacognitive processes also gain relevance in this approach, helping students develop internal processes, such as self-control, self-assessment and self-regulation of learning. In this context, students acquire a more central role, as active student involvement in formative assessment is increasingly encouraged.

2. CASE STUDY CONTEXT

This paper reports on data from a longitudinal case study that is being carried out as part of a PhD research project at the University of Minho, aimed at assessing the impact of Project-Led Education on students' learning and its contribution to the improvement of teaching and learning in higher education. Findings are based on the supervision of PLE experiences which have been implemented with first year Industrial Management and Engineering (MIEGI) students since 2004/2005. The perceptions of students and teachers with regard to their participation in these experiences are, in general, positive, as they clearly recognize the advantages of PLE compared to more traditional approaches to teaching and learning (Lima *et al*., 2005; Fernandes *et al*., 2007).

The experience that we report in this article refers to the third edition of PLE, implemented for the first time in the 1º semester with first year students of MIEGI. In this semester, four curricular units (UC) of direct support project (PSC - Project Support Courses) participated in the PLE experience: *Introduction to Industrial Management and Engineering, Computer Programming, Calculation* C *and General Chemistry*. The coordination team of the project included eight teachers, three of them lecturers and team tutors, two only lecturers and three only team tutors. In the PLE process, the tutors' function is mainly related with students´ project management and team work guidance. In addition to these teachers, the coordination team still relied on three educational specialists, including the researcher responsible for the present study, as well as a recently graduated assistant developing research in Project Management. This experience involved the participation of 39 students, divided in three groups of seven elements and three groups of six elements. These six groups were formed on the first lesson of the semester, after the presentation of the PLE project. The group composition was the students' responsibility, with the need to respect two criteria: each group must have at least two students with Chemistry knowledge and there must be an equal number of boys and girls in each team. It was also told that group sizes should be below six/seven elements. The students who had entered the course in the second phase of candidature were integrated in the existing groups, with the support of the tutors. The project theme chosen for this semester was "Fuel Cells Production System", an appealing and challenging theme for the students and teachers, which required the major learning outcomes of the UC's involved in the project. Student assessment was divided into continuous assessment of the four PSC and a process for final product assessment. Both of these processes usually had the same 50% impact on the final grade. However, in this experience in particular, the final product had a 60% impact on students' final grade and continuous assessment only 40%. Each PSC defined its own way of assessment based on written tests and/or work assignments. The final project result was assessed based on a final report (35%), its revision after feedback from teachers (25%), developed prototypes (20%) and a final public presentation and discussion (20%). This group grade had an individual correction factor that depended on a written test at the end of the project and on peer assessment processes.

3. MONITORING AND ASSESSING THE LEARNING PROCESS

When organizing an interdisciplinary project, the monitoring and assessment of the students' learning process should occur in a systematic and continuous form, supplying useful and contextualized information on groups' performance. The use of varied means of data collection, at different moments of the project, is of crucial importance in order to support the monitoring and assessment of the students' learning process, guaranteeing a permanent follow up.

In the PLE experiences carried out, the monitoring and assessment of the learning process have been guaranteed by the articulation and integration of two types of strategies in the learning process: on the one hand, a set of *Milestones* aimed at viewing the state of progress of the students' projects at specific moments, and on the other hand, a set of instruments centred in processes of *co-assessment of group dynamics*, *self-assessment* and *peer assessment*. The following table (*Table 2*) shows the moments and instruments that contribute to the monitoring and assessment of the learning process in PLE. The first column indicates the projects' *Milestones* and the second column details the instruments recently included in order to support the assessment of the learning process. A brief description of these instruments, including their main purpose and some examples of the questions contained in the questionnaires, are also clear in this table. However, further information concerning each of these issues will be explored throughout this paper.

Milestones	Instruments that Support the Assessment of the Learning Process		
Mini-Project (Week 1) **Group Meeting with the Tutor** (Every week)	**Assessment of the Students Initial Expectations** (Week 1)	It assesses students' expectations and motivation about PLE, at the beginning of the experience.	- *What motivated me the most about PLE?* - *Which aspects do I consider more/less positive about the experience?* - *What do I think of the assessment method?* - *What difficulties will I find? How will I overcome them?* - *Comments and suggestions.*
Formal Presentation (Week 5) **Tutorial Meeting** (Week 7)	**Self-Assessment of Performance** (Week 5, 10, 15, 20)	It assesses students' individual performance throughout the development of the project.	- *How well am I doing?* - *What are my major strengths and weaknesses?* - *What have I learned with the group?* - *What has the group learned with me?*
Formal presentation Intermediate Report (Week 10)	**Co-Assessment of Group Dynamics** (Week 5, 10, 15, 20)	It assesses group functioning during the project, through a collective reflection.	- *What is going well in the group?* - *What is not going well in the group?* - *How can the group improve?*
Tutorial Meeting (Week 13) **Preliminary Final report** (Week 15)	**Peer Assessment** (Week 5, 10, 15, 20)	It assesses the performance of each member of the group, on the basis of a set of criteria previously defined.	*Criteria of Peer Assessment: (1-10 scale)* - *Presence in group meetings* - *Level of effort in the work* - *Suggestion of solutions* - *Original contributions* - *Interpersonal relationship* - *Fulfillment of stated deadlines*
Final report (Week 18) **Written test Prototype Final Presentation and Discussion** (Week 20)	**Final Assessment of the Students** (Week 20)	It assesses students' perceptions about the PLE experience, at the end of the semester.	- *Impact on learning - what I learned.* - *Global assessment of the experience – more/less positive aspects.* - *Major difficulties and its overcoming.* - *Adequacy of the projects' theme.* - *What I would do different if initiated the project today.* - *Suggestions for improvement.*

Table 2. Monitoring and Assessing the Learning Process in PLE

The project *Milestones* intend to supply the coordination team with information on the state of the progress of each group's project, in order to support the groups that are facing problems and include the necessary adjustments (Carvalho & Lima, 2006). Since students

are free to decide what they want to make out of the projects' theme, it is possible that a project may reach a point where it could be considered unsustainable. To prevent this situation from happening, due to students little experience in managing projects with this dimension, the coordination team decided to include a set of milestones, where the groups make presentations on the state of the project and where the teachers and members of the other groups give feedback and suggestions on the work. As assessment situations to a certain extent, the *Milestones* are also a unique opportunity for students to demonstrate the soft skills they are developing throughout the project, making it possible for these competencies to become explicit and many times even observable. The fulfillment of the *Mini-Project*, the oral presentations, the tutorial meetings, the production of a concrete artefact - prototype in *Lego Mindstorms*, are some of the key-moments where it is possible for students to show their skills in communication, organization, leadership, initiative, creativity, etc.

It is commonly known that the success of a project does not only depend on individual performance but also on the groups' capacity to work as a team, undertaking a true cooperative work. Taking this aspect in account, students' assessment in PLE includes two components: an individual component and a group component. It is frequent to verify that the groups, during the twenty weeks of the semester, experience situations that oscillate between phases of high motivation, productivity, enthusiasm and self-confidence, but also less positive situations, like the lack of motivation, interpersonal conflicts in the group, the saturation of the projects' theme, the accumulation of work, the failing of stated deadlines etc. Being aware of these problems and promoting the discussion around the reasons that lead to this state of things is essential to guarantee group functioning and to keep the communication channels between students and teachers open. However, we notice that it is extremely difficult to get students to develop these types of reflections in an autonomous form. Most of the groups still lack some psychological maturity in creating a favorable environment to constructive criticism and an open dialogue between group members. In this way, *self-assessment* processes and *co-assessment of the group dynamics*, using instruments such as questionnaires or observation grids, are necessary in order to monitor students' learning process and lead to the improvement of individual performance. It is also important that the students are aware of their own capacities, strengths and weaknesses, which is only possible through processes of self-assessment and self-reflection. According to Boterf (2005), a qualified student is not only the one who knows how to act with competence; he is also capable of describing why he acts in a certain way to obtain success. In this process, the intervention of the tutor is considered extremely opportune, in order to stimulate student reflection. According to Powell (2004), the tutors' role should not be to supply answers but instead to give clues for the group itself to find the most adequate solution to the problems it faces. However, besides giving technical support on the project, the tutor will also have to play a double function by guiding students in the process of self-reflection, providing inputs and ideas for the development of project skills. *Peer Assessment* processes, centered in criteria previously defined and negotiated with the students, are equally an instrument which shows the perception that each teammate has of their own performance and the performance of others. This allows a better crossing of data from the results obtained in a more quantitative assessment (peer assessment) with the information acquired in the processes of self-assessment and co-assessment of group functioning, eminently qualitative.

4. FINDINGS

The assessment instruments used at different moments of the project reveal important information concerning the perceptions of students according to the project, namely, expectations, motivations, difficulties and suggestions of improvement.

A diagnostic assessment, at the beginning of the learning process, offers details about students' first impressions concerning the project. In this way, at the end of the first week of the presentation of the PLE project, a questionnaire was applied to students in order to assess their perception concerning teamwork and the PLE experience, at an initial phase of the project. Some conclusions can be drawn from a content analysis of the answers to the questionnaire. We easily point out *teamwork* as the main factor of student motivation in the project. The *autonomy* granted to students and the *practical component* of the project are also aspects sufficiently valued in this methodology. However, as less positive aspects, the students point out the great amount of *time* and *workload* required. In fact, the students can easily realize that we are in the presence of a student centered type of learning, which means that they play an active role in their instruction. Some of students' answers on the questionnaire can prove this:

- *It motivated me the fact that it is <u>active learning,</u> where the students participate directly in the learning process while developing the project.*

- *What motivated me the most was the fact that learning is more practical. In my opinion, through projects, we can learn much more than with theoretical lessons.*

- *I consider that PLE occupies a great amount of students' time during the semester. However, it also helps us to learn <u>how to work in groups</u> and to <u>learn by ourselves</u>.*

- *Most positive aspect: the students are very well prepared to face future professional life; Less positive aspect: it is a type of learning that requires a lot of students <u>time and work.</u>*

Throughout the development of the project, the students filled in an individual *Questionnaire of Self-Assessment*. It included both closed and open form questions, using either a Likert scale to assess a set of dimensions related to teamwork or by answering openly to a set of questions related to student performance. The most critical aspects mentioned by students' in the self-assessment and co-assessment processes were *time management* and *lack of motivation*. In the middle phase of the project, the majority of the groups identified situations of lack of engagement from their teammates. It is in this phase that we generally start to verify conflicts at the level of *interpersonal relationship* and the non fulfillment *of tasks and deadlines*, which are some of the main reasons that lead to loss of motivation on the project. The following comments from students reveal some of the groups' problems that appear at a mid-term phase of the project:

- *In my opinion, PLE is <u>really tiring</u> but it is also a great help for our <u>individual and group development</u>. However, it is important to point out that <u>it is difficult to put everyone to work</u>... it is very complicated!*

- *I feel that my group could improve <u>if all teammates worked harder and assumed much more responsibility</u>. There are <u>teammates that reveal very little capacity to work</u>. There should be <u>more group organization</u> and <u>better time management,</u> as well as the accomplishment of individual tasks. The group should also <u>fulfill the stated deadlines better.</u>*

- *The group could improve if <u>it didn't relax so much</u> and if <u>we didn't leave everything for the last minute</u>.*

During the semester, *Peer Assessment* processes were carried out at four specific moments of the project (week 5, 10, 15 and 20). This process involved students rating their

teammates, with the use of a Likert scale, based on six assessment criteria. After students completed these assessments, the results were later shown to each group and, on the next tutorial meeting, the team tutor would discuss with the students the meaning of the presented results.

From a global analysis of students' ratings in peer assessment, we noticed that, in most of the groups, there were always one or two students who were better rated than the rest of the teammates throughout the whole semester. Curiously, if we compare the results obtained in the peer assessment processes and the ones obtained on the written test, we see that there are some similarities in terms of student ranking. The best teammate classified in peer assessment would correspond, in most cases, to the best qualified student on the project's test. Although both instruments assessed different domains (cognitive and attitudinal), in which peer assessment was over all centered in aspects related to the functioning of the group, based on criteria such as *the presence in group meetings, the level of effort in the work, original contributions, interpersonal relationship and fulfillment of stated deadlines*; the written test, in turn, intended to assess the knowledge of each student, individually, on the project handled by that group in particular. Thus, it was clear that the students with better cognitive performance had also been the ones who had presented better attitudinal performance, which allows us to conclude, to a certain extent, that these two skills (cognitive and attitudinal) are intrinsically related and had been mutually developed.

At the end of the semester, students' perceptions concerning the PLE experience were also collected. Since the coordination team also wished to continue with PLE in the 2nd semester of the first year of the MIEGI, students' opinion concerning this decision was very important. The collected data not only allowed us to identify students' perceptions concerning the experience they'd had, but also helped a better planning and organization of the next semester, in accordance with the students' needs and motivations, such as remaining or not in the same teams and the possibility of continuing or not with the theme explored in the first semester. If, on the one hand, the participation of the students in this decision process contributed to a better adjustment of the semester planning, on the other hand, it also allowed a higher implication and responsibility of students in the project, since it was the result of a decision in which they'd had an active voice. The results obtained in this questionnaire divided, in an almost equal form, the students who considered the implementation of PLE as positive and those who considered it as a less positive option. The most significant reasons pointed out by the students to continue with this approach to teaching and learning were related to the fact that PLE encourages the *development of abilities* and fosters a *more practical view of contents*, allowing a better articulation between theory and practice. The ones who were 'against' PLE evoke reasons such as the *need of a lot of students' time and work* and the fact that the *students' final grade depends on the group*. The following statements from students exemplify this:

- *I think this is a positive decision because I consider PLE a good form of learning which <u>forces the students to follow the content</u> of all the subjects throughout the whole semester instead of studying just before the exams. I also find that PLE helps the students develop <u>research</u> and <u>teamwork skills</u>, among others.*

- *I find PLE interesting, since it <u>develops important skills</u> and I do not consider that the workload that it demands is exaggerated. However, it is difficult to implement, since a significant part of the students <u>do not show interest and initiative</u>, <u>do not assume responsibilities</u> and practically <u>do not work</u>. The good students, who make an effort to accomplish the project, aren't recognized on the final grades. Students lose most of their motivation because the final grade obtained on the project <u>lowers the high grades obtained in the continuous assessment</u>. I think there must be a mechanism to correct this unfairness and force all the students to work well.*

In fact, many students regard that the *low value of the final grade* attributed to the project caused a feeling of great dissatisfaction and unfairness at the end of the project. As a student mentioned, in reply to the questionnaire of *Final Assessment of Students*, "all the effort carried out in the development of the project 'is not compensated' in the grades that we obtain". Thus, we believe this shows the sign of an academic culture still highly centered in the processes of classification and certification, where the weight of grades prevails as the main indicator of students' learning outcomes and competencies developed. Relatively to other less positive reasons pointed out, such as *requiring a lot of students' time and work,* this seems to be more of a stimulus to continue designing PLE experiences, rather than a reason to give up, as it enhances a truly student centered learning.

At the moment, PLE is already in its fourth edition, with the particularity of having been carried out, for the first time, in two consecutive semesters, fact that brought some advantages and disadvantages. The experience acquired by students with the first semesters' project is unquestionable. It gave them much more confidence on their future work, as they were clearly aware of what was expected of them at each moment. By means of taking advantage of this situation and recognizing the importance of what happens during the learning process, the students were challenged to determine, in the first week of the project, the planning of the project management for their group. We consider it was a successful activity, due to the students' motivation and involvement while doing this *Mini-Project*. Students presented innovative and creative proposals in terms of strategies to implement in the groups in order to assure the best teamwork and project management. It was a reflective process for the majority of the students, showing the groups' concerns in order to adjust the projects requirements to the characteristics of each group, its own method of work, its members' learning styles and personal objectives in the course, etc. In fact, it was easy to notice that the nature of the concerns that derived from each group was very different. For example, some groups were very worried with the peer assessment system, as for some of the other groups this was no problem at all and this process wasn't even mentioned on their planning. This also shows that students should play an important role in their own instructional development, taking responsibility for the assessment of their own learning.

5. CONCLUSIONS

Dealing with Project-Led Education demands a deep reflection on the meaning of assessment processes. In fact, one of the greatest potentials of project work is the emphasis placed in the learning process, while drawing attention to students' behaviour and attitude, their capacity to work in teams, their spirit of leadership, initiative, that is, attributes which refer to the way students relate with others. However, at the end of the semester, it is on the final product that assessment of learning is based: students' performance is measured on the basis of predetermined knowledge considered relevant by the teacher. In our experiences, the assessment system is focused over all on the product, on a final report and a public presentation, thus reducing all the dynamics of the learning process and the whole meaning that was initially announced by valuing and making explicit students' heterogeneity. Student assessment must also recognize the importance of what happens during the learning process. Focusing the assessment system exclusively on a final product may imply that what happens during the process is not relevant and students' time and effort on the project may fall to ground. The assessment method in PLE experiences must

also account for the process, in so far as it is where the invisible work of students gains its true value.

The use of self-assessment processes, during the PLE experience, aim at providing a formative character to the assessment process, stressing the importance of students' role as authors of the assessment of their own learning. However, we verify that the used procedures still reveal some weaknesses in terms of attaining this last goal. In fact, with the instruments used throughout the learning process, it was possible to diagnose, in a systematic way, a set of issues related to students' individual performance and group dynamics. Yet, in terms of real change in students' performance, there are some doubts concerning the impact of self-assessment and self-regulation processes for the improvement of learning. An effective awareness of the strategies needed to improve learning was not, in some cases, easily attained by the students. Therefore, we consider that an active engagement of students in the assessment process can make a positive difference in student learning. Through a criterion-referenced assessment, based on criteria and standards, known and negotiated by teachers and students, it is possible for students to take a leading role in the assessment of their own learning. To become independent learners, students need to get an idea from the start of what is to be learned. Thus, students should be conscious of the learning goals they are expected to achieve as a result of studying a course and participate in setting criteria and performance indicators which will enable them to assess their own learning process in a successful way.

Acknowledgement

References

[1]   ALLAL, L. (1979). "Stratégies d'évaluation formative: conceptions psycho-pédagogiques et modalities d'application". In L. Allal, J. Cardinet and P. Perrenoud (eds.), *L'évaluation formative dans un enseignement differencié*, Peter Lang, Bern, pp. 153-183.

[2]   ALLAL, L. & LOPEZ. L. (2005). "Formative Assessment of Learning: A Review of Publications in French".   In *Formative Assessment – Improving Learning in Secondary Classrooms*. Paris, FR: OECD Publishing. pp. 241-265.

[3]   BLOOM, B., HASTING, J., MADAUS, G., (1971). *Handbook on Formative and Summative Evaluation of Student Learning*. McGraw-Hill Book Co, New York.

[4]   BOTERF, G. (2005). *Construir as competências individuais e colectivas : resposta a 80 questões.* 1ª Ed. Porto: Asa.

[5]   CARVALHO, D. & LIMA, R. (2006). Organização de um Processo de Aprendizagem Baseado em Projects Interdisciplinares em Engenharia, In *XXXIV Congresso Brasileiro de Ensino de Engenharia (COBENGE´2006)*, Passo Fundo, Rio Grande do Sul, Brasil.

[6]   FERNANDES, D. (2006). "Para uma teoria da avaliação formativa". In *Revista Portuguesa da Educação*, 2006, 19(2). CIED – Universidade do Minho. pp. 21 – 50

[7]   FERNANDES, S., FLORES, A. & LIMA, R. (2007). "Avaliação de uma experiência de ensino-aprendizagem baseada em projects interdisciplinares". In *International*

Conference on Engineering and Computer Education (ICECE' 2007), São Paulo, Brazil, pp. 422-426.

[8] HANSEN, S. (2004). "The supervisor in the project-organized group work should participate in developing the students' project competencies", In *European Journal of Engineering Education*, September 2004. Vol. 29, No. 3, pp. 451–459.

[9] LIMA, R., CARVALHO, D., FLORES, A. & HATTUM, N. (2005). Ensino/aprendizagem por projecto: balanço de uma experiência na Universidade do Minho, In *VIII Congresso Galaico-Português de Psicopedagogia* (B. D. Silva and L. S. Almeida), Braga - Portugal, Centro de Investigação em Educação (CIEd) do Instituto Educação e Psicologia da Universidade do Minho, 1787-1798.

[10] MICHAELSEN, L., KNIGHT, A., FINK, L. (2004). *Team-Based Learning. A Transformative Use of Small Groups in College Teaching.* Stylus Publishing. February 2004.

[11] PERRENOUD, P. (1998). "From formative evaluation to a controlled regulation of Learning Processes. Towards a wider conceptual field". In *Assessment in Education*, 5(1), pp.85-102.

[12] POWELL, P. & WEENK, W. (2003). *Project-Led Engineering Education*. Utrecht: Lemma.

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