ACTIVE LEARNING IN LARGE INTRODUCTORY CLASSES IN MATHEMATIC

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ABSTRACT

The teaching-learning process has been a constant target of studies, particularly in Higher Education, in consequence of the annual increase of new students. The concern with the maintenance of a certain quality level in the training of these students, conjugated with the will to widen the access to all of those who finish Secondary School Education, has triggered a greater intervention from the education specialists, in partnership with the teachers of all Higher Education areas, in the problem analysis.
Considering the particular case of Sciences and Engineering, it is witnessed a rising concern with the active learning strategies and forms of assessment.
Research has demonstrated that students learn more if they are actively engaged with the material they are studying. In this presentation we describe and present the results of an active learning strategy in an Algebra course of the Informatics' Engineering Bach., with nearly 430 students and a team of 5 teachers.
The students start to study a subject with some help from the teachers, and they have to prepare a presentation on the studied subject. They make the presentation to their colleagues and after that they are evaluated. During this year we notice that students have shown a deeper interest in Algebra classes and also improving overall results.
This paper helps us answer the following questions: Who evaluates the presentations? How is this done? What other forms of assessment are there in this subject? What was used to assess that students showed deeper interest?

KEYWORDS

Teaching-learning process, learning strategies, assessment.

INTRODUCTION

The acquisition of experimental competences is fundamental for the students of sciences and engineering [1].

The article is structured in the following manner: section 2 presents a brief reflection about the present theoretical currents of the teaching-learning process; section 3 deepens the teaching components of sciences and engineering, particularly the experimental component; the following section describes the experimental learning; section 5 describes the assessment in the cognitive domain and finally, section 6 concludes the document.

PRESENT THEORETICAL CURRENTS OF THE TEACHING-LEARNING PROCESS

We initiated this reflection assuming that the teacher must know the tendencies that influenced the teaching-learning process, to be able to understand the present context and reflect on the pedagogical performance with the goal to optimize it. The pedagogical reflections that have been produced over the last few years are convergent in the analysis of the systemic character of the components in the teaching-learning process.

It can also be said that there is no effective pedagogy without having a precise idea of what the students are required to learn in the end. If we know where we are heading, the right path to get there will be taken [2], [3], [4], [5]. The previous definition of the pedagogical goals or expected learning outcomes, as well as the analysis of the pedagogical methods and means, which makes clear what is required to achieve with the pedagogical actions that are projected and undertaken, and in the end analyze the whole process. Through the definition of the goals, it becomes possible to eliminate the ambiguity that so many times surrounds a pedagogical moment defined in terms of content or acquisition of generic and diffuse knowledge [5].

The pedagogical goals offer the teacher a line of action for the learning activities planning, the conducting of a class and evaluation of the outcome. Knowing what are the goals to achieve, the way to achieve them will be easily known. With well defined goals, the teacher has of a point of reference which allows and guarantees more rigour in the selection and structuralization of the information to be provided, activities to be developed and the most suitable methods to apply. Thus, the goals will make the teacher care more about what the student should learn, rather than what it is supposed to be taught, assuring a higher adjustment and pertinence to the assignments that need to be executed. Finally, through the attainment, or not, of the scheduled goals it will be possible for the teacher to determine the degree of success of strategies and pedagogical behaviors, therefore obtaining an important mean of evaluation and action control. The student's knowledge of the goals is perhaps one of the most effective means for the attainment of learning. According to Mager (1976) [6], "... if you tell a student the goals of his or her learning, maybe you don't have to do anything else". In fact, the knowledge of the goals allows the student to:

- know where to stand concerning the purpose to be obtained;
- take conscience of what it is going to be demanded;
- distinguish the essential from the accessory;
- have a point of reference to evaluate and control the progresses.

SCIENCES AND ENGINEERING TEACHING COMPONENTS

Concerning experimentation, the integration between theory and practice assumes special relevance.

> "Activity by itself is not enough. It is the sense that is made of it that matters."
> Driver (1983)

About experimentation in an educational context, Lopes (2004) [7], highlights the following aspects:

- The experimental work cannot be isolated from the theoretical approach;
- The experimental work is a theoretical and empirical effort in the sense of answering to a problem of the physical knowledge, relevant to the student;

- The planning of experimental work is a task that is in need of an explicit model of physical situations, concerning experimental systems;
- The theories and empirical information can be enriched with experimental work. The theoretical approach, disregarding how rich and profound it may be, does not run out by itself. Every theoretical project can only be complete if it is prepared to face the experiment and be completed by it. In the same way, the empirical information has only true meaning if it is gathered and/or produced in the context of a theoretical approach.

Lopes (2004) widens the definition of experimental work presented previously, mentioning four important aspects:

- Questioning is part of the experimental work, as to unchain it, as well as to (re)-orientate it or even to consider it finished (it is necessary to look in the right direction, know how to look and be prepared to make the correct interpretation);
- The use/construction of a model is a fundamental characteristic of experimental work, because it is through it that it is possible to make decisions, go forward with knowledge, and make sure the relevant variables are being considered and even change the model itself or reformulate it. On the one hand, experimental work connects the theoretical models with reality and on the other, the theoretical models can only be used on models of physical situations and not on the physical situation;
- The activity concerning the empirical relation is a constant and it can belong to several types: assembly, observation, measurement, use of equipment, use of techniques, manipulation, perfecting the experimental system, etc. This activity can, in several circumstances, bear the use of computer systems for data acquisition, allowing the students to focus on the interpretation of data and less on the attainment and process of that same data;
- The interaction with the community (peers, teacher and accepted scientific knowledge) has the role of confronting ideas, clear up reasoning; communicate results and conclusions, as well as the way how it has come to them.

The conditions for the experimental work to promote the conceptual development are:

- The experimental activity has to be well thought of by the teacher and the subjacent conceptual aspects must be explained;
- The conceptual exploring must be focused on the experimental activity itself and not on its relationship with the previously mentioned subjects;
- It is necessary to invest time in experimental activities in order to deepen the conceptual aspects of the experimental activity, discuss and interpret the experimental results in light of the used models.

In this context, Lopes (2004) considers that the activities of the experimental work type are as follows:

- Activities of the predict-observe-explain type (FOE);
- Experimental verification (EV);
- Computational simulation/model (CS);
- Oriented experimental activity (OEA);
- Experimental problem (EP).

On the following table, the educational characteristics and functions of each activity are included (Lopes, 2004).

Table 1
Characteristics and educational functions of experimental work activities

Type of activity	Characteristics	Educational Functions
Predict-observe-explain	In presence of a problem and/or physical situation, it is requested to make a written prediction by presenting a justification. The teacher executes the experiment and, at the same time the students register what they observe. After that, they compare what they registered with what they predicted and explain the agreements and disagreements. The table can be used to register the synopsis of the predictions and observations. The mediation of interpretation and the conclusions must be very careful to the manifested disagreements.	Relate the theoretical approach with the experiment, based on questions. Use theoretical models and experimental systems to predict and explain discrepancies on what it is observed. Perform a scientific observation. Identify and control relevant variables. Initiate the students in competences of experimental work.Reformulate/structure/enrich a conceptual field.Widen/develop/precise sensitive experiment of physical phenomena.
Experimental verification	It is about verifying a law experimentally, or a theoretical model with an experimental system that is close to the ideal. Generally, it is guided by an experimental protocol. Considering that it has a strict protocol and the experimental system is close to the ideal (and conceived by the teacher), the experimental execution can be made by the students without the teacher's supervision. The interpretation needs to be mediated by the teacher. It will only have characteristics of experimental work if the question dimension is kept intact.	Illustrate theory (and/or study the conditions of the theory use). Study a law (and/or its limits of validity). Observe and describe a produced phenomenon in the frame of a scientific theory. Develop the competences of the data treatment. Develop competences of the experimental work. Reformulate/structure/enrich a conceptual field. Widen/develop/precise sensitive experiment of physical phenomena.
Computational Model Simulation	It is about using software to produce models or perform simulations by using previous computational models. In the sense that the perform dimension in a empiric relation is not present, it may not be considered as an experimental work. Even still, there is a manipulation component that consists in interacting with the software and see what happens. If the remaining dimensions are present, particularly the questioning dimension, there is a good proximity with advantages and flaws concerning the traditional experimental work. In any dimension of experimental work, the teacher must mediate.	Study in depth a theoretical model: its limits of validity, pertinent variables, relevant parameters, temporal evolution of the physical systems that can represent the change of physical systems with the alteration of initial conditions and parameters, the consequences of the alteration of parameters, functional relations and its visualization, etc. Test all mentioned aspects referred in a theoretical model more quickly. Reformulate/structure/enrich a conceptual field.
Oriented experimental activity	This emphasis is placed in a question (which can be a problem) and in its theoretical framing. The question must be relevant for the students, adjusted by them (obstacle identification and reformulation of its wording without changing the meaning) and properly framed by the teacher. The experimental planning and its execution is the students' responsibility. However, they're discussed and supervised by the teacher, in order to be	Study the functional relations between variables. Deepen the relations between theory-experience by deepening the conditions of the use of a theoretical model, or studying the questions that arose by the experimental results. Develop competences of experimental work, in students, involving all the

	completed by the students without problems or delays. The interpretation is made by the students and with the teacher's mediation. Finally, it is necessary to evaluate what was learned and what mistakes were made.	dimensions (problem, variable identification/control, experimental planning and execution, registration of observations, data attainment, production of results, physical situation model and experimental system, use of theoretical models to relate predictions with results, obtain conclusions, communicate the results). Reformulate/structure/enrich a conceptual field. Widen/develop/precise sensitive experiment of physical phenomena.
Experimental resolution of the Problem	The experimental task that is initiated with an experimental problem, which is explicit within a certain context. The problem must be relevant for the students, adjusted by them (obstacle identification and reformulation of its wording without altering the meaning) and properly framed by the teacher. It is a small investigation conducted by the students and oriented by the teacher with a greater control of the timing and means by the students. It culminates with the presentation of a product and/or results. It may be used in a curricular manner in 3 ways: i) Task connected to classes but not using classes for the execution. Classes are used to discuss the development of the problem solution and communication of results; ii) Task independent from classes, integrating extra-curricular activities, allowing the interested students to indulge their intellectual pleasure; iii) Project.	Develop competences of experimental work, in students, involving all the dimensions (problem, variable identification/control, experimental planning and execution, registration of observations, data attainment, production of results, physical situation model and experimental system, use of theoretical models to relate predictions with results, obtain conclusions, communicate the results). Build/study/use theoretical models. Build/study/use experimental systems. Subject a theoretical model to a wider empiric relation.. Investigate under the teacher's guidance. Develop communication and argumentation competences. Reformulate/structure/enrich a conceptual field. Widen/develop/precise sensitive experiment of physical phenomena.

The analysis of table 1 allows us to conclude that the questioning and the right mediation coming from the teacher are still two essential and indispensable elements, which will bind the possibility of development of the competences in the psychomotor domain.

EXPERIENTIAL LEARNING

In the book of Experiential Learning (1984), David Kolb [8] presents a theoretical and practical study of learning, in which he defends that, in an adult, learning represents a focus on the relation between the environment and the individual, in the dimensions of: acquisition, specialization and integration. According to Kolb (1984) experimental learning is the product that proves that the adult experiences the world and changes through means of man-mean interaction, in his work, education and personal development relationships.

Kolb took to himself the contributions of Vygotski, non-explicitly, to consolidate the idea of learning as a process of interaction between the internal and external characteristics, the personal and social knowledge. According to Kolb (1984), there is an acquisition of feeling or experience. This stimulus and repertory interact and direct the specialization of knowledge.

The information is adapted according to the needs, to finally occur formulation or reformulation of the experiment. Each person, by means of interpretation of their own experience, structures the building process of knowledge. Learning travels through these axes: capturing and transforming. Capturing is "apprehension", it occurs through an opening to experience, through the right path or through the comprehension of concepts. Transforming is "grasping", decoding the perceptions or the concepts and getting them closer to reality, using the repertory or the application of experience. Information gains meaning through reflection, in a path of intention or through the new exposure to experience, in the extension path.

According to Kolb (1984), learning is the alteration of behavior as the result of an experiment. Experimental learning values the interaction of the students' way of living and the environment (concepts, experiences of masters and colleagues). First of all there is an acquisition of information, skill or experience. This external stimulus and internal repertory of the individual interact and direct learning to another moment, when there is a specialization of knowledge. The information is adapted in accordance to the needs and interests of the students, to finally occur the moment of interaction, when learning is finalized. It is the intersection between theory and practice, individual and social needs. Life experience learning, as a process, travels between two axes: capturing and transforming. Capturing or grasping something intellectually in the act of learning, is to "learn". Transforming is to internalize what was learned, "understanding". Capturing is exercising perception, decoding external information and coming closer to life experiences, along with the stored repertory. In the process of transformation, information, that was once isolated, gains now significance through reflection and critical analysis. Capturing and transforming are permanent actions of the human mind. But all the theorists, in the Educational area, somehow unfolded them and compose these two dimensions in other dimensions in order to explain the construction of the apprenticeship.

Kolb uses the teachings of Lewin, Dewey and Piaget, valuing a sequence of stages that compose the Learning Styles. Learning, according to Kolb, is a cycle of interaction, allowing information to be experimented, observed, reflected and appraised, permitting four stages or phases in the construction of learning to be observed:

1. Concrete Experience: there is an emphasis in the relationship of two individuals, in daily situations; information is captured in the environment. The apprentice focuses more on his or her feelings, rather than on the systematic focus of problems. Learning is the result of a specific experiment and the relationship between people. The apprentice is predisposed to a new experiment.
2. Reflective Orientation: there is a commitment to ideas and situations deriving from different points of view. The apprentice trusts in objectivity and in careful judgment; in his or her own thoughts and feelings to formulate opinions. Observing and reflecting simultaneously allows the transformation of previous ideas into new ideas through internal mechanisms.
3. Abstract Conceptualization: the result of reflective orientation, with the captured experiment allows us to create schemes, theories and abstract interpretations. The apprentice uses logic more, trusts in systematic planning to develop theories and ideas to solve problems. The performance is based on the intellectual comprehension of a situation. On this stage the intellect captures what is new, exclusively by mental processes.

4. Active Experimentation: setting the created schemes, theories and abstractions. The apprentice performs with the goal of influencing and modifying. There is an interest in finding how theories and schemes work in practice, as opposed to a simple observation of a situation. The apprentice appreciates the accomplishment of tasks and results by taking risks. It is skillful to accomplish tasks and influences through actions. For Kolb (1984; 101) "life experience learning is based on a theory of dual knowledge: the Concrete Experience of the empiric grabbing reality by the direct process of learning, and the Abstract Conceptualization of the rationalist analyzing reality by mediating through the abstract conceptualization process".

This author defends an experiential approach, with the help of the interaction between concrete experience and the abstract conceptualization. Learning is seen as cyclical process, constituted by four phases: concrete experience, active experimentation, conceptual abstraction and reflective observation. The four types of aptitude are considered necessary, in order for learning to be effective, in spite of believing that the majority of people have only one or two more developed due to their former experiences, like the scholarity level and other social and cultural factors.

Kolb presupposes that all knowledge results in the interaction between theory (abstract concepts) and experience, and the LSI (Learning Style Inventory) is based on this concept of experiential education. The LSI defines the experiential learning process. To understand the learning process based on Kolb's experiential learning model, we can analyze the following situation:

> When we come across with the task of determining a procedure, first we formulate a theory about the solution for the problem (abstract conception). Taking it from there we test this theory (concrete experience); we reflect about it and possibly make some alterations on the original theory (reflection and observation) and from there we test our modified plan, based on the accumulated experience from the execution of our first plan (active experimentation). Each time this cycle is complete, we gain more knowledge, and therefore we are going through a process of experiential education.

ASSESSMENT IN THE COGNITIVE DOMAIN

In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning. This taxonomy contained three overlapping domains: the cognitive, psychomotor, and affective. Within the cognitive domain, he identified six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. These domains and levels are still useful today as you develop the critical thinking skills of your students. Verb examples that represent intellectual activity on each level are listed here.

1. **Knowledge**: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state.
2. **Comprehension**: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate,
3. **Application**: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.
4. **Analysis**: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.
5. **Synthesis**: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.
6. **Evaluation**: appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate.

The following tables present the subjects, assessment activities and results of an Algebra course at ISEP.

Table 2
Assessment Subjects

2004/05	**1º Test** – Determinants and matrices operations **2º Test –** Linear systems and geometry in space **Final Exam –** All subjects
2005/06	**1º Test** – Determinants and matrices operations **2º Test –** Linear Systems and geometry in space **Final Exam –** All subjects
2006/07	**1º Test** – Matrices operations, determinants and Linear Systems **Final Exam –** Vectorial space and geometry in space **Laboratory Project – M**atrices operations and Gauss Seidel method to solve Linear Systems.
2007/08	**Final Exam –** Operations with matrices and Gauss Seidel method to solve linear systems. **Laboratory Project -** Operations with matrices, Determinants, matrix inverse and rank matrix.
2008/09	**Group work assignments:** - Matrix operations (1 Group Work) - Matrix Rank (1 Group Work) - Matrix inverse by the method of condensation. (1 Group Work) - Vectorial space R (2 Group Works) - Geometry in space (2 Group Works) **Laboratory Project -** Geometry in space **Final Exam –** All subjects.

Table 3
Laboratory Project

2006/07
One of this year's projects was about matrices operations, in a close relation with the Algebra course. In the project the students, in groups of 2 or 3 elements, had to implement a Java application to: • add and subtract matrices • multiply two matrices and a vector by a matrix • solve linear systems by the Gauss-Seidel method
2007/08
From this year on there is only one project in this course. This year project's theme was closely related to the Algebra course. The students had to develop, in groups of 2 or 3 elements, a Java application to implement matrix operations: • matrix addition and subtraction • matrix product and vector by matrix product • matrix transpose • matrix rank • matrix inverse • calculate the determinant of a matrix
2008/09
This year project's theme was also closely related to the Algebra course, but focused on Geometry in space (3D). The students had to develop, in groups of 2 or 3 elements, a Java application to: • obtain the equations of a straight line given two points or a point and a vector

• given a straight line's equation, obtain a point and the line's vector • given the equation of a straight line, obtain the other line's equations • obtain the equations of a plane given three points, two points and a vector or two vectors • given the equation of a plane, obtain the other plane's equations • given a plane's equation, obtain a point and the plane's normal vector • calculate the distance between a point and straight line between a point and a plane • graphically represent a straight line (using two 2D graphs) • graphically represent a plane (using a 3D graph)

Table 4
Work Assessment

Project	Formal presentation of the group's work to a 3 element jury (3 teachers), logbook and project's report assessment.
Group work	Oral presentation, individual class attendance information, individual assessment exercises in some classes, logbook assessment, Annex 1.

Table 5
% of each Assessment and Successful Rate Results*

2004/05	2005/06	2006/07	2007/08	2008/09
2 Tests - 20% Final exam–80%	2 Tests - 25% Final exam–75%	1 Test – 40% Final Exam–45% Laboratory Project – 15%	Final Exam– 100% Laboratory Project on other course	7 group works – 30% Laboratory Project on other course Final Exam–70%
40% Success rate	37% Success rate	57% Success rate	57% Success rate	58% Success rate

* all students were evaluate

We found that most of the students have better results, with significant improvement of classification, when required to think only at the lowest possible level - the recall of information or recognition of facts, not having noticed improvements with the introduction of practical work in the area of geometry, a subject that requires more complex and abstract mental levels, to the highest order which is classified as evaluation.

To support the evaluation process, surveys were used to allow teachers to discipline access to the perception that each of the elements of the groups had in relation to their own performance and the performance of colleagues in pursuit of the tasks.

CONCLUSION

The study must follow the guide lines centered in the teaching-learning process, particularly in the components of sciences and engineering teaching and assessment of HOTS "higher-order thinking skills" which are concentrated on the top three levels of Bloom's Taxonomy: analysis, synthesis, and evaluation.

Based on the provided results, is our intend to provide strategies that may potentiate for technicians cover knowledge, comprehension and application, but not concern itself with analysis and above, whereas full professional training may be expected to include this and synthesis and evaluation as well.

We will seek to maintain strategies in which one cannot effectively — or ought not try to — address higher levels until those below them have been covered (it is thus effectively serial in structure). In the end it is expected the attainment of a basic sequential model for dealing with topics in the curriculum, and a way of categorising levels of learning, in terms of the expected ceiling for a given programme.

REFERENCES AND BIBLIOGRAFY

[1] Feisel, L. D. & Peterson, G. D. (2002). A Colloquy on Learning Objectives for Engineering Education Laboratories. Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition. Taken from http://www.abet.org/Linked%20Documents-UPDATE/White%20Papers/Laboratory%20Learning%20Objectives.pdf on December 26th , 2007.

[2] Jaques, P. A., Bercht, M., Bocca, E. & Viccari, R. (2003). Cognitive Reasoning to Respond Affectively to the Student. Artigo apresentado na IASTED International Conference on Computers and Advanced Technology in Education. Taken from http://www.inf.unisinos.br/~pjaques/trabalhos on January 28th, 2008.

[3] Lesser, V., Ortiz Jr., C. L. & Tambe, M. (2003). Introduction to a Multiagent Perspective. In G. Weiss (Series Ed.) & V. Lesser, C. L. Ortiz Jr. & M. Tambe (Vol. Eds.), Multiagent Systems, Artificial Societies, and Simulated Organizations: Vol. 9. Distributed Sensor Networks: A Multiagent Perspective (1ª ed., pp. 13-14). United Kingdom: Kluwer Academic Publishers.

[4] Levine, T., Donitsa-Schmidt, S. (1998). Computer use, confidence, attitudes, and knowledge: A causal analysis. Computers in Human Behavior, 14(1), 125-46.

[5] Peters, O. (2001). Didática do Ensino à Distância. Experiências e estágio da discussão numa visão internacional. Rio Grande do Sul: Editora Unisinos.

[6] Mager, R. F. (1976). Atitudes favoráveis ao ensino (José Darcy C. Rodrigues, trad.). Porto Alegre: Globo. (Originally published in 1976).

[7] Lopes, J. B. (2004). Aprender e Ensinar Física. Lisboa: Fundação Calouste Gulbenkian & Fundação para a Ciência e Tecnologia

[8] Kolb, D. (1984). Experiential Learning. New Jersey: Prentice-Hall.

[9] Bencomo, S. D. (2004). Control learning: present and future. Annual Reviews in Control. 28(1), 115-136.

[10] Jinks, R. (1994). Developing experimental skills in engineering undergraduates. Engineering Science and Education Journal, 3(6), 287-290.

[11] Leite, L. (2001). Caetano, H. V. & Santos, M. G. Santos (org.). Contributos para uma utilização mais fundamentada do trabalho laboratorial no ensino das ciências. Cadernos Didácticos de Ciências, 1. Lisboa: Ministério da Educação.

[12] Ma, J. and Nickerson, J. V. (2006, Setembro). Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review. ACM Computing Surveys, 38(3), Artigo 7. Taken from http://portal.acm.org/citation.cfm?id=1132960.1132961 on December 26th, 2007

[13] Nickerson, J. V., Corterb, J. E., Esche, S. K., & Chassapis, C. (2007). A model for evaluating the effectiveness of remote engineering laboratories and simulations in education. Computers & Education, 49(3), 708-725.

[15] Wasserstein, J. (2005). Learning and teaching with new technologies - from innovation to impact. In A. Gaskell & A. Tait (Eds.), The 11th Cambridge International Conference on Open and Distance Learning (pp. 219-225). Cambridge: The Open University.

[16] Daniel Spooner, "Analyse et évaluation des cahiers de projets", Ecole Polytechnique Montreal 26 septembre 2007

[17] McAlpine, H., Hicks, B.J., Huet, G., Culley, S.J., An investigation into the use and content of the engineer's notebook, Elsevier, Design Studies, Vol. 27, No.4, Julho 2006

[18] Paul, R., Niewoehner, R., Elder, L., Engineering Reasoning, Foundation for critical thinking, 2006, 56 p., ISBN 0-944583-33-4

ANNEX 1

DEPARTAMENT: Mathematic

LOGSHEET ASSESSMENT

On some classes

Assessment subjects
Information on the project logsheet
Accuracy of language
• Identification of individual tasks and performance • Tasks assigned • Date of end of work • Progression documented • Compilation of working hours

TYPES OF CONTENT TO FIND IN THE PROJECT LOGSHEET

	Title	**Descrition**
Texto	Group Identification	Name of the elements of the group Group ID (CLASS+Number) **Exemple:** A2 –Group number 2 - Class A
	Handwritten notes	Notes made during the individual and collaborative work.
	Meeting notes	Notes taken during a meeting
	Meeting dates	
	Hand calculations	Hand calculations to evaluate a complex situation
	Tables and pictures	Hand made table and pictures

Bibliography:

Daniel Spooner, "*Analyse et évaluation des cahiers de projets*", Ecole Polytechnique Montreal 26 septembre 2007

McAlpine, H., Hicks, B.J., Huet, G., Culley, S.J., An investigation into the use and content of the engineer's notebook, Elsevier, Design Studies, Vol. 27, No.4, Julho 2006

Paul, R., Niewoehner, R., Elder, L., Engineering Reasoning, Foundation for critical thinking, 2006, 56 p., ISBN 0-944583-33-4

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