

**ACTIVE LEARNING: A FRAMEWORK FOR STUDENT MOTIVATION THROUGH THE ACQUISITION OF COMPETENCIES**

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**ABSTRACT**

Student motivation is the main concern in the current undergraduate studies. Learning is an experience and as such the student needs to be an active player to be attracted by it. In this work the importance of using good active learning strategies is justified; also an experience that combines flipped learning, problem-based learning and project-based learning methodologies is described. This experience was developed in the framework of the Algorithmics subject of undergraduate studies in computer science. The good results show that students not only become more motivated, also their reasoning ability is enhanced, increasing the level of their learning.

**KEYWORDS:** Educational innovation, motivation of university students, learning methodologies, active learning.

**1. INTRODUCTION**

The introduction of the European Higher Education Space (EHES) should necessarily focus on the development of values and attitudes of students that lead inexorably to the acquisition of competencies (media, skills and behaviours) required for their formation.

Three essential attitudes should be internalized by students in their teaching-learning process [Villa and Poblete]: autonomy, personal predisposition and collaboration.

Autonomy is the capacity to act for oneself in order to perform a task independently. As shown in [Buron], as students are gaining autonomy, they do not need the detailed and repeated explanations of the teacher and may study by themselves. So, they will be capable to learn the essential notions, use and expose what they know and find meaning in what they are studying.

Personal predisposition of the students on their learning process requires the acquisition of competencies such as scheduling, time management, the acceptance of individual and team norms, compliance with deadlines of work, the periods of study and quality demands of work, etc. The learning environment should insist on the progressive strengthening of the responsibilities that students should be assuming.

The willingness to collaborate with peers is fundamental to the working groups and the learning environment in general.

Few university teachers doubt about the motivation of students, understood as the assumption of reasons for their stay at the university. However many students do not justify their motives, or at least that's what it appears. The lack of will to participate in certain activities inevitably leads to academic failure. What is happening? Why in certain learning activities students respond positively and yet they just strive in others?

Achieving the learning objectives requires personal responsibility to students, understood as the capacity for reflection and commitment or personal discipline. The lack of responsibility leads to apathy, lack of interest, little or no participation, etc ... which translates into a passive student behavior.

## 2. Why active learning?

Learning is an experience and as such the subject must be an active protagonist to be attracted by it. But this is not enough, this experience should also be worth, that is, the subject trusts the value of it and also on its expectations of achieving success -expectation of the probability of success. The following equation is based on the expectations theory of Vroom, adapted to university education by John Biggs, as described in [Prieto, 2014]. However, it has been slightly modified to indicate the need for active participation of students as a substantial condition for learning.

Learning = active role c and (value  $\square$  expectations of success)

The term c and is known as conditional and, which means:

A and B = if A THEN B else null.

Therefore, the active role constitutes a fundamental variable in the above equation. It makes students to be the protagonists of their learning experience, encouraging their personal commitment to the development of the activities and leading them to internalize the three essential attitudes. Clearly, not all students are equal, even some of them do not require the active role factor to be excellent students.

My own teaching experience based on active learning strategies supports the previously said. I have verified that the results of different learning activities of a subject are substantially different depending on the degree of active involvement required to students. In some cases it is frustrating to see, year after year, failure in the overall performance of an activity, despite my commitment to it, as the careful organization, the creation of good teaching materials, strict planning, the establishment of incentives and bonuses, etc.

The strategies and methodologies that I am putting into practice with remarkable results in recent years are: project-based learning and problem-based learning. Recently, due to the passivity of many students despite my efforts to organize, plan and especially developing teaching materials, I decided to apply inverse learning strategies in place of master classes and other traditional activities, such as the typical classes of problems or seminars aimed at resolving doubts and questions.

### **3. Active learning methodologies: inverse learning, project-based learning and problem-based learning**

#### **3.1 Inverse learning**

Also known as flipped classroom model. It is a form of blended learning where the direct instruction of students takes place outside the classroom. The classroom time is used to develop meaningful and personalized learning activities. In [OIETM] an interesting and detailed description of this new methodological trend is performed. The basics of this methodology are outlined below.

In the traditional model the teacher is the main protagonist of the learning process. The methodology is based on direct instruction of students, who take notes on the content and tasks assigned by the teacher. The teacher will also take time to answer questions about the previous class, or develop some problems, but cannot dig deep enough, since the goal is to complete the full syllabus and the time is usually not enough. It is impossible to have a personalized attention for each student who needs it. Thus, the teacher refers students to tutorials.

Inverted learning is a student-centered model which consists of transferring a portion of the direct instruction outside the classroom. This allows maximizing the interactions between teacher and students during the class time. The inverted learning is a student-centered model which consists of transferring a portion of the direct instruction outside the classroom. This allows maximizing the direct interactions between the teacher and students during class time. Direct instruction is effective when done individually or in small, homogenous groups. But universities do not have the necessary resources, since it requires a much larger teaching team, which is not possible in most cases [Bergman and Sams, 2014].

Thus, inverted learning allows improving the classroom experience [Fulton] from the traditional model, providing direct instruction outside the class time -usually through notes, problems, questions and videos. This frees up time for meaningful learning activities such as discussions, exercises, go into detail about the content, projects, etc., and also to encourage collaboration among students [PPFL]. The speed with which students receive feedback when their ideas are still fresh in their minds is one of the biggest benefits of the model and other active learning approaches.

The teacher assumes a new role as a guide during the whole process of student learning. Now he is not only the source of knowledge. He also facilitates student learning through a more personalized attention, as well as activities and challenging experiences that require the development of critical

thinking of students to solve problems individually and collaboratively. Thus the class is redefined as a student-centered environment [Bergman and Sams, 2013].

### 3.2 Project-based learning (PBL)

PBL consists of proposing a task to a group of students, whose solution requires collaborative and individual work following the guidelines set by the teacher, which will monitor the state of development. Some benefits and advantages of PBL are described below, as shown in [Martí et al.].

PBL is an active learning methodology, some of whose virtues are:

1. It is focused on students and promotes intrinsic motivation.
2. It stimulates collaborative learning.
3. It allows students to perform continuous and incremental improvements of tasks.
4. It is designed for students to actively participate in solving the task.
5. It is challenging and encourages self-improvement.

Some benefits associated with project-based learning supported by information technologies are:

- Development of competences. The level of knowledge and skills in a discipline or in a specific area is increased.
- Development of research skills. The project significantly improves the skills of students for research.
- The capacity of analysis and synthesis increases.
- It outlines and undertakes a challenging task that requires a sustained effort for some time.
- Students increase their knowledge and skills in information technology.
- Learning how to evaluate and co-evaluate. Students increase this ability and are responsible to their own work and performance; they also evaluate the work and performance of their peers.
- Commitment to a Project. Students commit actively and adequately with performing of the project work, which motivates them internally.

### 3.3 Problem-based learning (PBBL)

The following summarizes the main features and characteristics of PBBL from the clear and precise description given in [SIEUPM].

The PBBL is a learning method based on the principle of using problems as a starting point for the acquisition and integration of new knowledge [Barrows]. The protagonists of the learning process are the students who take the responsibility to be actively involved in the process. It represents an effective strategy that improves the quality of learning in several respects. The competences enhanced by the PBBL include [Prieto et al., 2006]:

- Problem solving.
- Decision making.
- Teamwork.

- Communication skills (argumentation and presentation of information).
- Development of attitudes and values: precision, review, tolerance, etc.

In addition to the already mentioned competences, the PBBL favors the development of effective reasoning and creativity, as outlined in [Benito and Cruz]. As complementary aspects, we can say that the PBBL also promotes the development of search and information management skills. It also develops research skills as students must, from a sentence, find and understand what's going on and achieve an appropriate solution.

The PBBL involves an active, cooperative and student-centered learning, associated with a highly motivated independent learning. Some of its main features are:

- It is based on a methodology focused on the student learning. Through independent and team work students must achieve the objectives in the expected time.
- Students work in small groups which favors the management of potential conflicts between them. In addition, all of them are responsible for achieving the objectives. This responsibility helps the motivation to perform the task and to take a real commitment to their learning and that of their peers.
- This methodology favors the possibility of linking different subjects or academic disciplines. This helps students to integrate their learning into a coherent whole.

#### **4. Acquisition of competences and learning activities of the subject Algorithmics**

This section presents an educational experience in which the three types of active learning methodologies discussed in the previous section are implemented. The increase in student performance has been remarkably successful in relation to traditional methodologies. Algorithmics has been the chosen subject. It is taught in the first half of the second course of the degree in computer science. It is part of the framework of subjects directly related to computer programming. Transversal competences assigned to the algorithmics subject according to the curriculum are: capacity for analysis and synthesis, organization, planning and decision-making, critical analysis and proposal and application of new solutions, and ability to communicate concepts of computing orally and in writing in different policy areas.

To achieve the competences acquisition goal students must internalize the three essential attitudes in the teaching-learning process, remember: autonomy, personal predisposition and collaboration. Such attitudes are the core of the competence acquisition and must be continually reinforced.

The contents of the course are organized into four topics:

1. Fundamentals of object-oriented programming (OOP).
2. Logic of programs.
3. Cost analysis of algorithms.
4. Designing recursive algorithms: concepts, techniques and approaches.

Each of the topics is developed by combining the best suited active learning methodologies. Inverted learning is applied in each of the topics. Meanwhile, problem-based learning can be combined effectively with inverted learning in order to reinforce the acquisition, integration and reasoning about new knowledge and skills.

An exhaustive description of learning activities implemented in each topic is not possible due to its length, so in order to go into detail, chapters 1 and 2 of the topic Fundamentals of object-oriented programming (OOP) have been selected.

## 5. Fundamentals of object-oriented programming: learning activities design

This topic aims on the one hand; guide the student in the context of data-driven programming, particularly OOP and its connection with the main data-driven methodologies -such as abstract data types and modular programming- and structured programming. On the other hand, students are instructed to be able to make use of the main virtues of OOP in the software design process.

In addition to the set of competences of the subject, this topic covers the following: problem solving, teamwork, development of attitudes and values -autonomy, personal predisposition, accuracy, review, tolerance ...- and awareness of the own learning.

This topic contains four chapters of training knowledge:

1. Data-driven programming.
2. Workshop 1: dynamic memory management.
3. Workshop 2: development of object-oriented software.
4. Workshop 3: inheritance.

Tables 1 and 2 show an outline of the learning context of chapters 1 and 2 respectively. This includes: the learning activities, the used methodology, the context in which learning activities are carried out, monitoring of the learning process, evaluation, the trained competences and the main teaching resources used.

**Table 1. Learning context of chapter 1.**

Learning activities	Methodologies	Context	Monitoring	Student assessment	Generic competences	Teaching resources
Reading, understanding and synthesis of personal class notes	Inverted learning	Individually, no-face learning	Progress feedback, conceptual reinforcement	Yes: extra points	Synthesis, organization, development of attitudes and values	Class notes, web information, literature
Conceptual	Inverted	classroom	Progress	No	Analysis,	Slides, notes,

reinforcement learning	teaching, tutorials	feedback, objective activity, self-assessment of the progress.	development of attitudes and values, awareness of the learning	results of the reading comprehension	
Objective activity	Inverted learning	Individually, classroom activity	Objective assessment, self-assessment of the progress	Yes: activity assessment.	awareness of the learning Paper and pen.

Chapter 1. *Data-driven programming*. The knowledge aim of this chapter is to guide students in the paradigm of data-driven programming, be aware of the main methodologies and their connection, and focus on OOP as a tool and main practical objective of the chapter.

This is a conceptual chapter whose methodology is based on inverted learning. On the one hand, students must read, understand and try to summarize the notes of the teacher, available on the Moodle platform. The summary is sent to the teacher via the platform. On the other hand, they will send the teacher a list of questions, issues that do not understand and aspects that they want to go in depth. This list serves as a feedback to the teacher to prepare the necessary discussion in the next class, without repeating all the things that are clear and clarifying and deepening what students have applied, which constitutes a feedback for student learning. Finally an objective activity on chapter is done.

Chapter 2. *Workshop 1: dynamic memory management*. Through this chapter the student will achieve the competence to manage dynamic memory in OOP.

Although the conceptual content of the chapter is reduced and some concepts have been seen in previous programming courses, acquiring adequate abilities requires the acquisition of new skills and a capacity of deeper reasoning about them.

In this chapter, the inverted learning methodology –adequate to acquire the basic concepts- and the PBBL methodology –that will facilitate deepening, integration and relationship between the concepts- are combined. This will allow students to strengthen their ability to reason about the concepts.

It is necessary to overcome this chapter to continue with full guarantees learning Chapters 3 and 4. Table 2 shows the learning context of the chapter. The first three learning activities correspond to the conceptual acquisition and are performed, as in the case of chapter 1, by inverted learning. The rest

of learning activities are implemented through problem-based learning and are supervised by the teacher. A brief summary of such activities is synthesized below.

*Reading and analysis of the problems.* The teacher provides one or more problems to students to solve them. The first step is to carefully read the formulation of the problem, analyze the terms and concepts and write a list of ideas in order to determine what is known, unknown and required to solve the problem. Monitoring this activity is done through the following activity (SIP).

*Seminar on the interpretation of problems (SIP).* This is a classroom activity. It serves as feedback to the teacher to identify issues and concerns of the students in the previous activity. Also serves as feedback to students in the previous activity, allowing self-assess their progress and clarify ideas for the next activity (DP).

*Definition of the problem (DP).* Now is the time to plan the actions that students have to perform as a team, such as obtaining the necessary information to study and understand, ask for help if needed, etc., allowing them to properly define the problem to be solved. This activity monitoring is performed through the following activity (SSP).

*Seminar of suggestions about the problem (SSP).* This is a classroom activity allowing the student feedback in the previous activity. Suggestions are made to the teacher about possible definitions of the problem and different ways of resolution. The activity allows developing, among others, the competences of critical analysis and the development of attitudes and values about the student learning.

*Presentation and correction of results (PCR).* Each student group presents the results of the problem, some of which are computer programs. Presentations can be done in class, using slides, which requires them to exercise in oral and written communication. Along with the oral presentation, each group must submit a written report where the different stages of the development of the problem are reflected.

The highlights of chapters 3 and 4 summarized below, since a detailed description is not possible for reasons of extension. This will serve as a motivating idea about the importance of active learning. Chapters 3 and 4. Workshop 2: development of object-oriented software; Workshop 3: inheritance. A software project of reasonable length using OOP is put into practice. The project is carried out in groups of three students, and the results are expressed through a computer program together with a project report detailing each of its stages.



**Table 2. Learning context of chapter 2.**

Learning activities	Methodologies	Context	Monitoring	Student assessment	Generic competences	Teaching resources
Reading, understanding and synthesis of personal class notes.	Inverted learning.	Individually, no-face learning.	Progress feedback, conceptual reinforcement.	Yes: extra points.	Synthesis, organization, development of attitudes and values.	Class notes, web information, literature
Conceptual reinforcement.	Inverted learning.	classroom teaching, tutorials.	Progress feedback, objective activity, self-assessment of the progress.	No	Analysis, development of attitudes and values, awareness of the learning.	Slides, notes, results of the reading comprehension
Objective activity.	Inverted learning	Individually, classroom activity.	Objective assessment, self-assessment of the progress.	Yes: activity assessment	awareness of the learning, critical analysis	Paper and pen.
Reading and analysis of the problems.	PBBL	Individually and teamwork, no-face learning.	Progress feedback SIP	Yes: extra points.	Analysis, organization, critical analysis, development of attitudes and values, awareness of the learning, teamwork, problem solving.	Problem statement, class notes.
Seminar on the interpretation of problems (SIP)	PBBL	face learning.	self-assessment of the progress.	No	Awareness of the learning, Analysis, development of attitudes and values.	Slides, notes, blackboard.

Definition of the problem (DP)	PBBL	Individually and teamwork, no-face learning.	Progress feedback SSP	Yes: extra points.	Analysis, organization, critical analysis, development of attitudes and values, awareness of the learning, teamwork, problem solving, decision making.	Class notes.
Seminar of suggestions about the problem (SSP)	PBBL	Face learning.	self-assessment of the progress	No	Awareness of the learning, critical analysis, development of attitudes and values.	Slides, notes, blackboard.
Presentation and correction of results (PCR)	PBBL	Teamwork, face learning.	teacher assessment, self-assessment of the progress.	Yes: activity assessment .	Oral and written communication , teamwork, synthesis ability.	Computer, written report.

The core of the project focuses on the identification of the data and the design of efficient data structures. Four issues are fundamental: the identification of classes and their relationships, the organization of the elements –objects- of each class and between classes, the hierarchy of classes through the inheritance property and design of the program modules.

Each of the above issues constitutes a stage of the project development, in the specified order, with the addition of an extra stage or stage 0, in which each group should proceed with the reading and analysis of the formulation of the task the teacher provides.

The development of the project is mainly based on combining the problem-based learning and the project-based learning methodologies. At each stage the central problem is considered, which will be discussed and monitored by the teacher in the corresponding face seminar. Seminars to monitor issues of planning, organization and commitment of the project members are also implanted.

The final correction of the results is face. The quality and the participation and involvement of each member of the group are particularly evaluated. Thus, a so important task in which many competences are exercised is evaluated as objectively as possible.

**6. RESULTS**

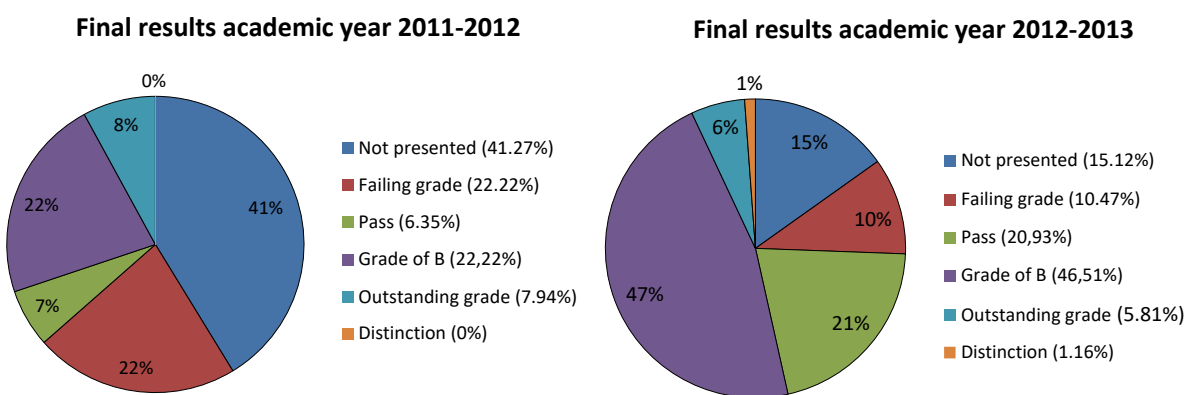
Figure 1 illustrates the evolution of the results of the subject published by the university from the academic year 2011-2012 to 2013-2014.

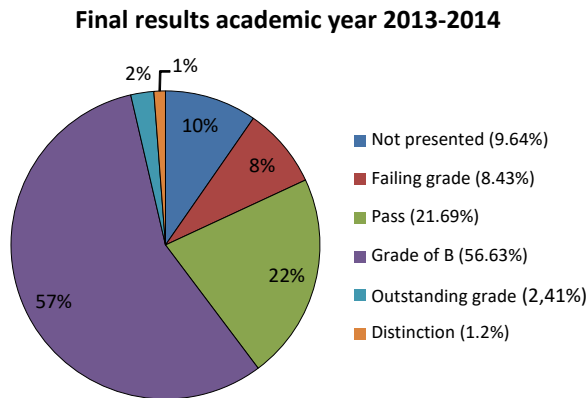
During the 2011-2012 academic year traditional learning methodologies based on lectures, classroom problems and laboratory practices were applied. A lack of motivation is reflected in the number of not presented students (41.2%). Among the students who took the course, a little more than a third of them failed, while among those who passed, most obtained a grade of B.

In the 2012-2013 academic year, active learning methodologies based on PBL and PBBL were applied to practical aspects. For theoretical concepts we continued applying traditional lectures. The success increased significantly in all grades, except in the percentage of outstanding and distinction grades, which remained similar. It is noteworthy the degree of activation showed by the students, given that the percentage of not presented decreased by 63.3% of the total, while the percentage of failures did so in 52.9%. Also, the number of students who actually was involved in the studies increased significantly -the percentage of pass students increased by 229.6% and 109.3% the grade of B.

During 2013-2014 academic year took place the full implementation of active learning methodologies, replacing traditional lectures by inverted learning strategies. Regarding the previous year, it is remarkable the 36.24% decrease in not presented students and the 19.48% decrease in failing grade students. Additionally, the amount of student that got a grade of B increased by 21.76%.

**Figure 1. Results of the three last courses.**





These results show that the introduction of active learning methodologies is very suitable not only in the activation of students, also in their involvement, which is translated in effort.

## 7. CONCLUSIONS

The involvement of students in their own learning process is the key to successful methodologies and strategies. To this end students should be activated by granting them a full role in their learning experience.

Active learning consists of giving the lead role to the learner, promoting the three essential attitudes that students should internalize: autonomy, personal predisposition and collaboration. The responsibility is a commitment, and a function of the teacher is to activate students in this regard, stimulating habits that encourage the sacrifice capacity.

They have been introduced active learning methodologies in all learning activities of the subject Algorithmics. The characteristics of each chapter and the designed learning activities will decide the most appropriate methodologies to be applied.

Replacing traditional lectures by active learning activities is the most innovative and important step we have taken lately. However, the first year of implementation is not easy, since the change is quite deep and supposes an increase in the workload of the students and the teacher. Currently there are some tools that facilitate the task of the teacher. Our intention is to use them in the immediate future. There are institutional obstacles that do not facilitate the development of these active methodologies, among which we include the shortage of human resources, the rigid distribution of classroom teaching in some universities, the current distribution of courses in semesters at some universities, and the number of teaching hours assigned to teachers (in some cases, the real number of teaching hours is twice the number of assigned hours).

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