Action Research:

A Way to Generate New Approaches to Teaching Mathematics in Bioengineering

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Abstract— **Bioengineering, a relatively recent engineering branch, was launched 24 years ago in Argentina at our university (Universidad Nacional de Entre Ríos). The undergraduate program aims at providing solutions to health problems through the application of advanced technology. Consequently, a highly skillful professional is required. However, learning deficiencies and difficulties have been observed among first year students. Action Research was chosen as a research tool to generate new approaches to teaching mathematics in Bioengineering.**

Keywords: Biomedical Engineering Education – Action Research – Teaching/Learning Mathematics for Bioengineering Introduction.

I. INTRODUCTION

This paper accounts for the origins, objectives, methods and first results of an Action Research project concerning the teaching of mathematics to future bioengineers. The project is being carried out within the bioengineering undergraduate curriculum at the Faculty of Engineering (Universidad Nacional de Entre Ríos). Biomedical Engineering or Bioengineering is a recently developed Engineering branch. In our country it was launched 24 years ago at our University in order to provide solutions to health problems through the application of advanced technology. Consequently, a highly skillful professional is required with solid mathematical background, for example in the field of technology applied to imaging diagnostic systems such as computerized axial tomography (CAT) which relies on the inverse Radon transform. Mathematics also interacts with Computing and Biology in the modeling and simulation of human organs, computer assisted surgery, tumor growth and the immune system modeling, prostheses design and other health related areas. On the other hand, technological changes in all areas related to the engineering field occur at a great speed. In Latin American countries, both established and modern techniques are in use, so universities must offer courses of study designed to develop creative engineers capable not only of understanding the new technologies but also of adapting them to the true needs of society. Bioengineers should also be prepared to develop innovative systems and techniques while interacting with specialists from other disciplines without losing sight of the economic, social and environmental impact of their developments. There is general consensus, thus, that Engineering undergraduate teaching courses, especially Bioengineering ones, should provide the students not only with solid background knowledge, but also facilitate the development of cognitive, metacognitive, affective and social learning strategies to foster learner autonomy and critical thinking which will serve to evaluate information and lead to continuous learning. From this analysis, it is clear that the Mathematics courses in the Bioengineering curriculum (See Table I) must be planned in such a way not only to foster the acquisition of the necessary mathematical concepts, procedures and methods to cope with the subjects in senior years, but also to contribute towards the development of abstraction, and of critical and reflective thinking.

TABLE I.

Year	First Semester	Second Semester
First	Calculus	Linear Algebra and Analytic Geometry
Second	Vector Calculus	Differential Equations Statistics
Third	Functions of a Complex Variable	

a. Mathematics Courses in the Bioengineering Curriculum

As a result, a strong emphasis should be placed on learning to learn Mathematics This means that the student should be involved in a process of discovery about learning the general mathematical abilities so as to be sufficiently equipped to face the study of new areas of this discipline according to his/her needs and interests in the future. In furtherance of this, it is necessary to adopt a learner-centered approach to stimulate the development of such abilities. Far from being a passive subject, the student will have an active role in the teaching-learning process. Although the members of this research team agree with this point of view, designing and implementing new teaching and assessment tools is far from being an easy task for the Mathematics teacher in charge of the course corresponding to the first years of the Bioengineering curriculum. Generally, the groups are numerous and students come from different parts of the Entre Ríos province and from other provinces of our country. Consequently, the mathematics background after high school is diverse. However, this may be taken on as a challenging situation by the teachers.

II. MOTIVATION

Two opposing issues triggered this research project: on the one hand the demanding professional requirements imposed on bioengineers and the goals of the mathematics courses in the curriculum mentioned above and, on the other, the complex issues concerning students who enter our university program.

The difficulties that bioengineering students face during the first years of the course of study have been a cause for constant worry at our college. An analysis of withdrawals shows that different factors interact to influence this complex phenomenon: homesickness, vocation conflicts, socioeconomic problems, insufficient schemata, poor or bad study habits, among others. In the mathematics class, there is evidence of problem-solving, reading comprehension and academic writing problems that are then reflected in low marks. During the past five years, more than 55% of the students were bound to retake the course. This situation raised a series of questions that encouraged this research project: In our role as teachers in the Bioengineering curriculum, do we foster critical reflection on our students' learning strategies? Can we design and use didactic strategies in our classroom to enhance reflective reading and writing and to generate motivation, draw students' attention to the comprehension of concepts and encourage their active, reflective and critical participation during the mathematics teaching-learning process?

These worries were the starting point for the formation of an interdisciplinary group whose members study the above stated problems in a group of second-year students who are taking the subject Vector Calculus and Differential Equations.

III. METODOLOGY

Action Research was chosen as a research tool to carry out our project. The term "Action – Research" was first coined by Kurt Lewin, a social psychologist, in about 1947 [1]. Lewin's research method was not aimed specifically at education but at social practices in general. During the '70s, researchers from Great Britain and Australia put forward an alternative education research paradigm based on Lewin's model. Both John Elliot and Lawrence Stenhouse in Great Britain and Stephen Kemmis in Australia sought new ways of producing knowledge not only about the teaching-learning process but also about curriculum development and implementation [2], [3], [4]. In Latin America, the lines of enquiry developed by Paulo Freire, Orlando Fals Borda and Joao Bosco Pinto emphasize popular and informal environmental education [5], [6]. Currently, Action Research as a movement has gained strength in many countries such as Great Britain, Australia, the United States, Canada, Spain, Germany, Austria, Brazil, Colombia, El Salvador and Argentina, among others.

These lines of enquiry focus on different aspects. According to Elliott, Action Research explores situations in which teachers are involved, a sort of teacher initiated form of classroom based research aimed at improving practice. Wilfred Carr and Stephen Kemmis believe that the aim of Action Research is far from finding general pedagogic formula. Thus, it does not make any claims for universal relevance. Instead, its essential impetus is to change the system. And, as it is primarily situational, it is concerned with the solution to problems in a specific context. Action Research conforms to what is generally called active research related to the need of education quality enhancement in a specific context [7].

This is why active participation is a key element in Action Research as it offers a valuable opportunity for teachers to be involved in research which is felt to be relevant. Furthermore, as it is grounded in the social context of the classroom and the institution, it may focus directly on issues and concerns which are significant. From this point of view, every teacher is a researcher because this method is not so much something that can be done in addition to teaching but something that can be integrated into it. As a result, during the research process, teachers become involved in thinking about their own teaching which ensures continued professional development and enhances competence.

Action Research can be defined as the study of a situation in order to enhance action in the community. In this particular case, our community is formed by:

- Students in the second year of the Bioengineering curriculum who are taking Vector Calculus and Differential Equations.
- Teachers with different graduate and postgraduate professional formation (engineers from different fields: electronics, electricity, chemistry, bioengineering, with postgraduate studies in diverse areas including informatics, and mathematics teachers with postgraduate studies in education).
- Teachers who carry out Vocational Orientation and Pedagogic Counseling, a service that was created in 2004 as part of the Academic Department, and teachers from the Languages and Social Sciences Department. These members of the group are specialists in Education and Languages. They are or have been in contact with the second year students on occasion of the counseling workshops for freshers, the English as a Foreign Language courses, and other courses to develop Reading and Writing skills.
- Advanced students who cooperate with the mathematics teachers.

The first step the research group took was to discuss and establish the goals of the project:

- To reflect on our teaching practice aiming at introducing principled change to the teaching-learning process in our mathematics course as part of the Bioengineering curriculum.
- To identify needs concerning our professional formation, thus ensuring continued professional development and enhancing competence in topics related to mathematics and their specific application to Bioengineering.
- To plan our continued professional development in pedagogical aspects that will offer tools to analyze and interpret the professional situations in which we act and make informed decisions accordingly.

- To foster interdisciplinary work among scholars belonging to the Mathematics, the Social Sciences and Languages Departments and the Vocational Orientation and Pedagogic Counseling Service of our faculty.
- To encourage the active participation of the students in Vector Calculus and Differential Equations classes in order to stimulate the development of a responsible attitude towards the learning process which will, eventually, generate an atmosphere for meaningful learning.
- To plan and implement activities that contribute towards the development of learning strategies the student will use in a conscious, reflective and effective manner.

IV. DESIGN AND IMPLEMENTATION

Action Research is structured in spiral cycles which are divided into four classic developmental phases: the initial exploration phase, the planning phase, the action phase and the reflection phase which generates a new research cycle [2].

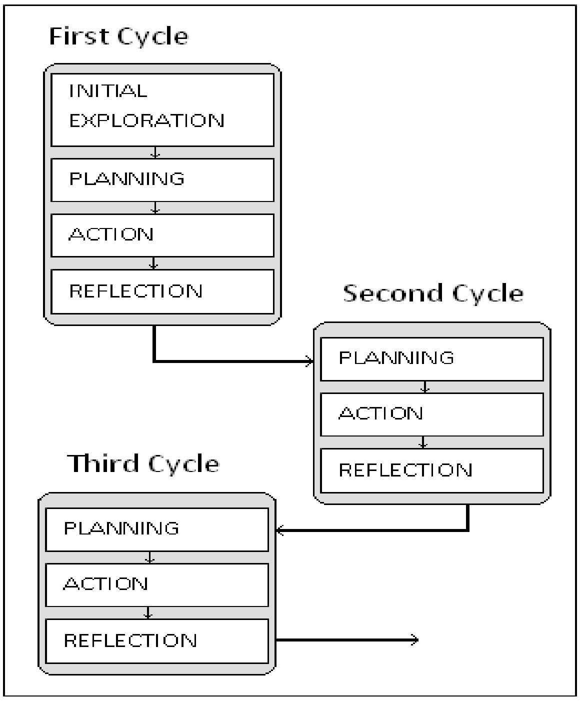

Figure 1. Action – Research Cycles

A. *Initial exploration and conceptual frame of reference development.*

The number of variables and circumstances that affect the teaching-learning process is significant. Thus, it is absolutely impossible to keep complete control over this complex whole. The first step in our project was to identify a problem and pose a specific question. We were confronted with the following dilemma: which aspects of the teaching-learning process are the most troublesome? We agreed that assessment is, doubtless, one of the burning issues in the process.

Traditionally, assessment in the Vector Calculus and Differential Equations courses has been carried out by means of term and final tests. The former have focused only on practical exercises while the latter deal with both practical and theoretical issues independently. The great number of students in our courses and Mathematics distinctive characteristics have led us to decide on administering written tests. Only on seldom occasions does the student sit an oral exam. We have noticed that students generally postpone study time to the last minute and the mistakes committed in the tests provide evidence of lack of conceptual and methodological comprehension. Furthermore, many students prepare for assessment solely through solving previous tests. This problem area led us to focus our enquiry on assessment.

Reflexion on our assessment techniques to brainstorm possible questions was the next step taken. Why do we assess this way? What do we assess? Which underlying rationale about teaching and learning Mathematics can be traced according to our assessment criteria? What other learning assessment criteria exist? Are there reports on recent research projects concerning these problems? These questions guided our research and helped to design a reference frame that served to redesign assessment.

According to Díaz Barriga an exam cannot improve the learning process by itself. The fundamental change must be carried out in the methodological strategies [8]. But those strategies cannot be designed without delving into the different principles that guide decision makers. The design of this conceptual frame was a long and complex process that brought about both agreement and disagreement among the members of the team with varied professional formation.

We finally agreed to synthesize criteria from Pedagogy, the didactics of Mathematics, and Cognitive Psychology that we have adopted as underlying principles that will inform the methodological changes and the redesign of learning assessment tools in our course:

- We adhere to a constructivist approach because it highlights the importance of understanding the knowledge construction process.
- In this particular context, our role changes from teachers to facilitators. That is, we do no longer merely transmit information to the class. Instead, the teacher must learn to act as a mediator that helps the student develop a set of cognitive skills that will enable the optimization of his / her reasoning skills (teaching to think) and favour mental strategies and processes awareness (metacogntion) in order to enhance learning (teaching about thinking) [9], [10], [11], [12]. Knowledge of metacognition was first developed in research on memory. Flavell (1971) first used the term metamemory, and later the term metacognition comprised metacognitive skills like monitoring and regulating cognitive processes [13] .
- We believe assessment is part of the teaching-learning process. It should promote learner autonomy and

responsibility. It is necessary to opt for assessment criteria that stimulate not only content learning, but also thinking processes and the development of metacognitive skills to assure students' awareness of the processes that have taken place, the mistakes committed, the learning strategies used and the difficulties encountered during the learning process [14]. In other words, our option is 'formative assessment' [15], [16], [17]. Moreover, apart from being a technical process, assessment is also a moral phenomenon and has an ideological and social component [18], [19].

B. Planning actions

From this point of view, we agree with Biggs in the sense that being a good teacher has much in common with being a good material designer. Good tasks should motivate the student and encourage him / her to reflect on his / her own learning process [20].

Once we had agreed upon our reference frame, without modifying neither the set amount of weekly face-to-face meetings for the courses (7 hours in the first semester and 8 hours in the second), nor the minimum contents for the subjects, the meetings took on a new whole meaning.

Traditionally, three weekly classroom activities were carried out in the following order: theoretical classes, discussion sessions, and practice sessions. The incorporation of assessment and metacognition activities was planned in the following way: The teacher presents the didactic unit in the theoretical classes by means of problematic situations to raise motivation among the students. Didactic questions are used to effectively diagnose the weak points concerning background knowledge.

When new concepts are presented, the teacher highlights the relationship between these and both prior knowledge and topics to be dealt with in future lessons or in other subjects in the curriculum. Definitions, properties and fundamental theorems are constructed collaboratively. A weekly study guide in which the goals of the unit are clearly set is presented to the students. It also includes a full bibliography and suggested readings[1], activities to be carried out during the discussion session and the weekly report to be discussed in the practice session.

During the discussion sessions some theoretical concepts presented in the theoretical class are dealt with more deeply by means of the analysis of selected demonstrations of formative value. This class aims at offering the student a space to carry out individual or group work using the suggested text and the weekly guide in order to clear up doubts and discuss mistakes while discussing demonstrations and examples. These activities also help to develop study strategies using Mathematics text books.

1 The texts used are: "Multivariable Calculus" by James Stewart, "Differential Equations with Boundary-Value Problems" by Dennis G. Zill and Michael R. Cullen.

This sequence of activities (see Table II) allows for a shift of the pendulum from a teacher-centered classroom to a more learner-centered one where students gain protagonism under the guidance of the teacher.

Classroom Activities	**Methodology**	**Assessment**
Theoretical Classes	Teacher presentation. Didactic interrogation.	Diagnostic assessment
Discussion Sessions	Group work with teacher participation. Discussion of demonstrations and examples. Integrative explanation carried out by the teacher.	Formative assessment Detection and correction of mistakes.
Practice Sessions	Students presentation of the weekly report. Integrative presentation carried out by the teacher.	Formative assessment. Self-assessment Peer-assessment

b. Activities.

The activities in the practice sessions are, thus, focused on the students. In furtherance of this, two types of activities are designed: the weekly report and the laboratory tasks.

What is the weekly report? In the theoretical class, the teacher presents the weekly guide in which the problems sections in the reference text are indicated. The sections correspond to the topics previously dealt with in the theoretical class and the discussion sessions. The selected exercises and problems are those that demand the application of different mathematical procedures and that are also related to other subject areas such as physics or biology. Between ten and fifteen problems are suggested, out of which five must be solved before each practice session using the text that was previously read in small groups and after having studied the corresponding theoretical background. A record of this activity must be kept in a weekly report in the following way: for each problem, the student must write the enunciation, the data provided, he / she must indicate its objective and explain the mathematical procedure(s) used to find the solution even if the attempt(s) failed.

At the end of each exercise, the student is asked to answer the following questionnaire: What new concepts or properties did I use? In what section and page of the textbook are they? Did I have to consult extra bibliography? What concepts from other subjects did I apply? Did I face any difficulties? Which ones? How did I try to solve them? Did I understand the concepts I used? Can I express them? What doubts do I still have?

The aim of this activity is to encourage a reflective attitude in the students, to promote the development of metacognition skills, to favour self-assessment habits and to promote learner autonomy. It enables us, teachers, to detect doubts and to act accordingly. As a result, the practice class is designed for students' full participation. They solve the problems presented in the weekly guide on the board, indicating the corresponding theoretical justification for each. If a student fails to solve any of the exercises, he / she is asked to mention the obstacles encountered. The teacher's task during this activity is to create an atmosphere of respect among students so that they can express their doubts without fear. This will favour both error correction and peer-correction, as well as making suggestions on the way the explanation was done. The teacher will do those exercises that present most difficulties to the group and will put forward others he / she considers appropriate for the students to solve in class individually or in groups in order to clarify concepts and methods.

The second activity is Computing Laboratory Tasks. Two integrative tasks are set for each semester. The teachers explain the rubrics of these tasks before presenting the corresponding topics. The students have the freedom to decide when to do them in a group of no more than three students. The only constraint is due date which coincides with the test corresponding to the same topic. In this way, carrying out the task will contribute towards learning the topics that will be assessed. These tasks also aim at taking advantage of software numeric, graphic, symbolic and calculus potentiality. To solve these, general mathematical procedures that contribute to the professional development of an engineer must be applied, i.e. modeling, graphic design, calculating, comparing, algorithmizing, solving, interpreting. Moreover, the student must apply definitions, formulate hypotheses, and refute linking theory to practice and to the applications proper to Bioengineering which are desirable in a second year student.

During the semester two integrative term tests that delve into theoretical and practical problems are carried out. One is administered mid-term and the other at the end of the semester. Vector Calculus and Differential Equations are courses whose accreditation is subject to the following conditions: a) presentation of 80 % of the reports carried out for the weekly practice session; b) marks corresponding to 80% (average) in the Laboratory Tasks; c) marks corresponding to 80% (average) in the term tests. Those students who fail to fulfill these requirements must sit a final exam (theory and practice).

C. Action

This planning was carried out for the first time during the development of Vector Calculus and Differential Equations courses in 2008. During the first semester, 66 students attended the course.

D. Reflection

To know the opinions of the students about the activities carried out during the course, the following survey was administered:

1) Did you become engaged with this activity? 85% of the students answered affirmatively.

2) How much time during the week did you devote to the activity? According to the answers, the average time devoted to carry out the activity was 4 hours (minimum 2 hours and maximum 10 hours).

3) Have you formed a group to carry out and discuss the problems or do you prefer to work individually? 36% of the students responded that they worked individually while 52% prefers to solve problems with a classmate.

4) Have these activities helped you regulate your study time adequately? Yes?, No?, Explain. 79% answered that the activities helped to "study the subject regularly which was positive when preparing for the term tests", "take advantage of the theoretical and practice classes", but some felt "it was an extra obligation to carry out the activities and assumed it as a burden". 21% explained that although they tried to complete the weekly activities at the beginning of the semester, they eventually could not sustain the rhythm. In some cases, they explicitly acknowledged that they needed to work at a slower pace than the one the subject syllabus imposes.

5) How do you value this experience as a means to promote effective learning? Has it helped you detect and correct mistakes (conceptual and procedural ones)? 85% of the students considered that the experience was useful and necessary because it helped them understand concepts and correct mistakes; 15% considered that is was not positive, especially because it did not respect individual rhythms as it is time consuming.

6) Mention positive and negative aspects of this activity. Some of the answers concerning positive aspects were: "I learnt how to study Mathematics better", "**we** worked more", "it helps to study day by day", "it helps to realize which are our doubts and clear them up in class", "it helped me realize that it's very advantageous to be constant", "it helps to study", "when we solved problems in previous years we were not obliged to think", "interesting and productive for the development of effective learning", "it helps me understand the topics", "it provided me with a way of studying". Students perceived the following pitfalls: "individual rhythms are not respected", "it's an extra burden", "it reduces time to study other subjects", "timetables to consult the teachers are insufficient", "there is no time to study a great variety of cases".

At the end of this first experience, the teachers in charge of the practice sessions expressed: "almost no students come to class without having tried to solve the problems", "the questions students ask are much more to the point", "gradual and continuous learning can be observed, some go deeper into the concepts studied in theoretical classes and discussion sessions". As regards the negative aspects and / or difficulties faced during the experience, some teachers said: "it is difficult to distribute time between monitoring individual work and group discussions to explain topics in which the whole group has problems", "the great amount of students per group makes personalized monitoring difficult".

Despite students' positive perception concerning the experience, we have noticed a strong resistance towards completing the questionnaire at the end of each weekly report problem. In many cases, this is due to the fact that many students believe it is "a waste of time", while others do not achieve to identify their difficulties. On occasions they say they have understood the concept, but the mistakes committed prove that it is quite the opposite. This is one of the aspects to be examined in future cycles of the project.

V. RESULTS AND CONCLUSIONS

The results of the 2008 academic year were good as only 11% of the 66 students who had enrolled in Vector Calculus had to retake the course, 30% passed the subject without sitting a final exam and 59% will sit the exam. At the end of the second semester (Differential Equations), 17% will have to retake the course, 43 % will sit a final exam, and 40% passed without having to sit it. As it was stated at the beginning of this paper, during the last five years 50% (average) of the students had to retake the course. This is why we consider that our project has brought about an opportunity for advancement. We should not forget, though, that both groups and context change year after year so it will be necessary to carry out adjustment cycle after cycle.

The analysis of the written material provided by the students and their weekly oral presentations are a source for obstacles detection. The lack of schemata to learn new topics is a constant problem. In many cases, the students themselves identify the topics that were not sufficiently dealt with in high school or during the first year of the university curriculum. Although some students offer resistance against completing the questionnaire in the weekly report, we still have the moment of the oral presentation or even a personal interview to complete that missing information.

We now have documented information which was regularly and systematically obtained that serves the purpose of working on different aspects of the teaching-learning process such as the articulation between the Mathematics Department chairs. As regards the Computing Laboratory tasks, students have responded with enthusiasm to these activities and the teachers have profited from the knowledge of other specialists teaching in the senior years such as the Biomechanics teacher who helped to find suitable and motivating problems for our students.

For the Mathematics teachers in the research team, it is an enriching experience to work together both with education professionals and Bioengineering specialists because their specific use of the language and their different points of view contribute towards our professional development. But this is only the beginning of a spiral process. New hypotheses have arisen to continue the process and to overcome the system's natural opposing forces

As we have tried to show in this paper, Action Research is a means for teachers to carry out both methodological and assessment changes to classroom practice according to the reference conceptual framework we designed and through which we can evaluate such modifications. In this sense, we consider it is a valuable tool for the professionalization of university undergraduate teaching.

REFERENCES

[1] J. Willis, M. Jost and R. Nilakanta, *Foundations of qualitative research: interpretive and critical approaches.* Thousand Oaks : Sage Publications Inc., 2007.

[2] J. Elliott, *Reflecting Where the Action Is: The Selected Works of John Elliott*, London: Routledge, 2007.

[3] J. Rudduck (Ed.), *An education that empowers: A collection of lectures in memory of Lawrence Stenhouse*. Philadelphia: Multilingual Matters,1995.

[4] S. Kemmis and R. McTaggart, *The action research reader*. Geelong, Australia: Deakin University Press, Third edition, 1988.

[5] N. K. Denzin and Y. S. Linco, *The SAGE handbook of qualitative research*. Thousand Oaks, London, New Delhi: Sage Publications, 2003.

[6] G. Anderson and M. Montero-Sieburth (eds.), *Educational Qualitative Research in Latin America : The Struggle for a New Paradigm*. New York : Garland Press, 1998.

[7] O. Zuber-Skerritt, *Action Research in Higher Education: Examples and Reflections*. London: Kogan Page 1992.

[8] A. Diaz Barriga, *Docente y Programa*. Bs. As: Aique Grupo Editor, 1.995.

[9] S. G. Paris and P. Winograd, "Metacognition in academic learning and instruction", in *Dimension of thinking and cognitive instruction,* B. F. Jones (Ed.), Hillsdale, NJ: Erlbaum ,1990, pp. 15-44.

[10] P. R. Pintrich, "The role of metacognitive knowledge in learning, teaching, and assessing", in *, vol.41*(4), *Theory into Practice,*2002, pp 219-225.

[11] M. Pressley and K.R Harris, "Cognitive strategies instruction: from basic research to classroom instruction" in P.A. Alexander and P. H. Winne (Eds.), *Handbook of Educational Psychology,* 2nded.. Mahwah, NJ: Lawrence Erlbaum Associates Inc, 2006, pp. 265-286.

[12] D. J Hacker, J. Dunlosky and A. C Graesser, Eds., *Handbook of Metacognition in Educations* (The Educational Psychology Series). New York: Routledge, 2009.

[13] Flavell, J. H. , "Metacognition and cognitive monitoring: A newarea of cognitive developmental inquiry" in *American Psychology, vol.34*, 1979, pp. 907-911.

[14] B. Hoffman and A. Spatariu, "The influence of self-efficacy and metacognitive prompting on math problem-solving efficiency", in *Contemporary Educational Psychology*, vol. 33, no. 4, 2008, pp 875-893

[15] C. Rosales López, *Criterios para una evaluación formativa.* Madrid: NARCEA, SA. DE EDICIONES, 2003.

[16] V. M. Lopez Pastor (Coord.). *Evaluacion Formativa y Compartida en Educación Superior. Propuestas, técnicas, instrumentos y experiencias.* Madrid:2009.

[17] D. Boud and N. Falchikov, *Rethinking assessment in higher education: learning for the longer term.* London: Routledge, 2007.

[18] A.R.W. Camilioni, S. Celman, E.Litwin y M.C. Palou de Maté, *La evaluación de los aprendizajes en el debate didáctico contemporáneo*. Buenos Aires: Paidós Educador, sexta reimpresión, 2008.

[19] M.A. Santos Guerra, *La evaluación como aprendizaje, una flecha en la diana*.2ª.ed..Buenos Aires:Bonum, 2007.

[20] J. Biggs, Teaching for Quality Learning at University. Buckingham: Open University Press, 1999.