Learning Activities according to affective profile in mathematics e-learning

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Abstract. This paper is concerned with the connection between the affective experience of the student learning mathematics and its failure in mathematics. In particular we present some learning activities regarding the vision of the mathematics, aimed to move the student's vision from an instrumental one to a relational one. The learning activities have been experimented at the University of Piemonte Orientale and at the University of Salerno (Italy).

Introduction and theoretical background

A key challenge of e-learning is the chance of personalisation of the learning process (Albano & Ascione, 2008a,b, Calvani 2002, Trentin 1998). Adaptive and intelligent Web-based educational systems makes in act such chance. Such platform infact are able to create, manage and update *in itinere* a personalised Unit of Learning for each student starting from a student model and a knowledge model. Example of such a platforms can be found in (Albano *et al*., 2007) and in (Brusilovsky & Peylo, 2003).

Actually the student model only take care about cognitive factors and do not consider at all *affective factors*, of which the research in math education has widely demonstrated the importance for the learning process.

Mc Leod is the first researcher in mathematic education who has catalogued affective factors in : emotions, beliefs and attitude (Mc Leod, 1992). Attitude is considered the more stable affective factor among the others and for this reason more complete of the "affective information" about the learner (Lester 2002).

In Albano&Ascione (2008b), a model for the student affective profile has been presented which take in account the attitude towards mathematics construct. The model has been created, starting from the definition of attitude towards mathematics introduced by Di Martino&Zan (2007), take into consideration three correlated factors:
-    the learner emotional disposal, revealed by the expression "I like/I don't like";
-    the learner's view of the mathematics, reflected by his/her beliefs "The mathematics is…";
-    the view which the learner has of his/her relationship with the mathematics (sense of self-efficacy), revealed by the expression, "I'm successful/I'm not successful".

With respect to the emotional disposal, the model in particular investigate also on the feelings associated to do mathematics. This is because, as pointed out by Zan, they are sensors useful to understand the interpretation of the learner mathematics experience, as they are generated exactly by the latter, and then they are useful to choose the right didactical action.

With respect to the sense of self-efficacy, the model in particular investigates the causal attributions, that are the beliefs constructing and elaborated by a person trying to interpret his failure. They often refers to the three agent of the educational process that are the subject, the teacher, him/herself.

With respect to the vision of the mathematics, the model distinguishes different levels, moving from the pure instrumental vision to the relational vision (Skemp, 1976), which is the one of the "mathematician", that is the view shared by the scientific community of mathematicians as positive.

In this way the model created contain just the information both to monitor the affective profile and to choose the right personalized intervention.

In particular in (Albano & Ascione, 2008b) also a model to monitor the learning process has been introduced, named *mathematical affective space*. It's a tri-dimensional space whose axes are the *view of the mathematics*, the *emotional disposal*, the *sense of self- efficiency* (fig 1).
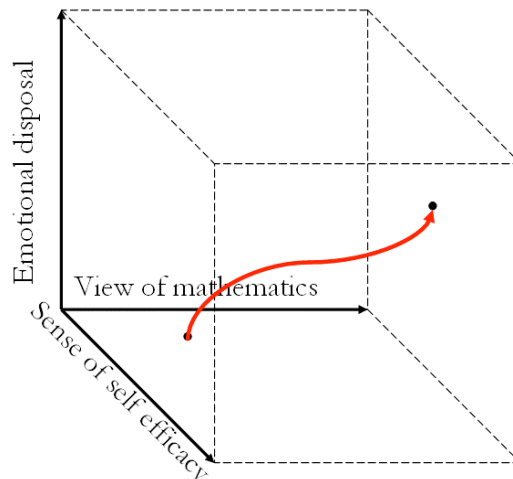
It will be used on one hand to individuate the interpretation of the mathematical experience in order to have some indications to be used in the tailored learning activities, and on the other hand to have a picture of the learner's attitude towards mathematics that can be used during the learning process to evaluate the effectiveness of the intervention on the affective aspects, and so to monitor the learning process.

In order to individuate the defined student's affective profile in mathematics, a questionnaire has been build up (Albano & Ascione, 2008a), which is composed of three sections, one for each item of the affective model. For each item both closed and open questions have been formulated: the answers of close questions, can be easily foreseen and classified wile open questions avoid the risk of forcing the answer (Di Martino et Al., 2007). Also same question to evaluate the efficiency of the questionnaire has been introduced (Albano & Ascione, 2008b). The questionnaire so composed has been tested on more than 600 students of the first year of engineering and first results of this experimentation can be found in (Albano & Ascione, 2008a).

In order to implement the questionnaire in platform an algorithm has been created (Albano & Ascione, 2008b) which assign to each answer a number that will contribute to create for each student a numerical array $v=(v_1, v_2, v_3)$, that with the matrix of the causes of the failure, will represent his/her affective profile.

How to intervene on the vision of the mathematics: some Learning Activities

According to the model, for each student we can individuate a point in the affective space, which represents at the moment his/her vision of the mathematics, how much he/she feels successful in mathematics (with respect to his/her vision of the mathematics) and likes mathematics. Moreover the model for each student will contain two lists: one related to the feelings associated to doing mathematics, and one related to the causes felt for his/her failure in mathematics. How to use such information to improve learning in mathematics?

We recall that the cognitive, meta-cognitive and peri-cognitive levels are intrinsically linked. Thus the affective space gives also information to be used in choosing and presenting the students suitable cognitive and meta-cognitive activities to improve his/her success in mathematics.

More precisely the ordering on the axes can be associated to various teaching methodologies and contents' types.

The student's point in the affective space individuates a rectangular which represents the zone where the student is ok from the peri-cognitive level and then the zone where he/she feels and is successful in mathematics from the cognitive and meta-cognitive point of view too. The idea is to propose the students activities which are coherent with the zone near their affective rectangular, moving along one of the two directions given by the vision of the mathematics and on the sense of self efficacy. Experience shows that improving those two factors positively impacts on the emotional disposal.

Between the remaining two dimensions, we choose to start the intervention taking into consideration the dimension corresponding to the minimum value (as coordinate of the point in the affective space).

Considering the view of the mathematics, according to the value obtained, the recovering activities will be aimed to pass from an instrumental view to a relational one, which means to pass from pure applications of rules and algorithms to the comprehension of the reasons of those applications and so on until the student becomes aware of what he/she is doing in mathematics and makes experience that he can "create" mathematics.

In the following we present some activities aimed to modify the experience made by the student with the mathematics with respect his/her vision. The activities are devoted to move the vision of the mathematics from the

instrumental one to the relational one, allowing the students to make experience of critical processes, connections among various topics, different representations of mathematical concepts.

Activity 1

The following activity is based on the "focus markers" (Guidoni, 1985) on the basic factors of the proof process. At first the markers are useful in order to foster the student to a meaningful reading of the proof, forcing him/her to stop and think about where he/she spontaneously did not. Then the activity foresees the identification of the focus markers as invariant for the understanding of a proof, so to lead the student to use them in an autonomous way and so to activate his/her own meta-cognitive resources.

To reach this aim, the study of theorems has been guided by means of forms, containing questions devoted to understanding which have been grouped into three sections, as described in the following:

1. *guide to the analysis of the statement*: in this section the focus markers are posed on the identification of hypothesis and thesis within the statement. In this respect various questions to be completed are posed, formulated in terms of necessary and/or sufficient condition, so to bring the need both to distinguish hypothesis and thesis and to not bind to a single formulation of a theorem;
2. *guide to the proof*: here the focus markers on the proof process and on the explanation and justification of each step of such process. In particular the focus markers are moved on the recognition of the need of the hypothesis in the proof context, on the applicability of some theorems previously analyzed, on the used proof method;
3. *a global view*: in the last section the focus markers are moved from the microscopic viewpoint, where the previous sections have posed the attention, to the macroscopic viewpoint defined by the "logical thread" of the proof. In particular the student is required to "give some sense" to the theorem in the context of his/her studies and, in case of conditions only sufficient, some counter-examples for the necessary condition are required.

To the aim of fostering the student to autonomously use the focus markers, the forms are varied in the contents, even if they have conserved the structure above described. Three levels have been individuated, as said in the following: 1) *I level*: the questions on each theorem are specific, and then different from a theorem to another one; 2) *II level*: standard questions have been proposed, that are not dependent on the specific content of the theorem at stake, in order to make evident what is invariant in the study of a theorem; 3) *III level*: in this case, the students are required to formulate the questions by themselves as they are teachers who want to assess the learning of the theorem at stake, exploiting what they have done in the previous two levels.

Activity 2

As underlined by NCTM (VV.AA., 2000), when students become able to see the connections among different mathematical contents, they become able to have a global and integrated vision of the mathematics. It is important that as they build on their previous mathematical understandings while learning new concepts, students become increasingly aware of the connections among various mathematical topics. The connections so developed give the students greater mathematical power. On the other hand the development of such connections needs the coordination of different semiotic registers, which is at the basis of the comprehension in mathematics (Duval, 2006) and allows to create new knowledge.

In this framework, an activity has been designed, focused on the study of a proof, or supposed ones, which includes four typologies of practices described in the following:

1. DCD: the teacher individuates the goals need to construct the proof and the student task is to prove them;
2. DCA: the teacher individuates the fragments of the proof aimed to prove some goals useful to the proof at stake, the student has to understand which are the goals reached by each fragment and which is the aim of each goal in the global context of the proof process;
3. CE: the teacher gives a statement and a sequence of fragments which could constitute pieces useful to the proof of the given statement, the student has to use such fragments in order to prove the statement if possible, other wise he/she has to individuate where the proof fails and gives a counter-example;
4. RC: the teacher gives a text, the student has to write some parts of it in order to integrate them or make them clearer o more precise, or to explain them in verbal language or to make use of other pieces of knowledge not yet involved.

Each typology has been enriched using visual proofs.

Activity 3

It is well known that the cognitive processes induced by talking, discussing and explaining to others the concepts to be learnt promote deeper level or higher-order thinking (Johnson & Johnson, 1987). In this framework we want to put emphasis on reciprocal peer learning (Boud *et al*., 1999), which is intended as the use of teaching and learning

strategies in which students, acting as both teachers and learners, learn with and from each other without the immediate intervention of a teacher. Falchikov (2001) analysed the various peer tutoring techniques and the benefits linked to each of them. She found evidence of some improvement in comprehension, memory for lecture content, performance and facilitation in encoding and retrieval of material given by Guided Reciprocal Peer Questioning.

Our idea is to support the students by on-line, time restricted activities based on role-play, which actively engage them and induce them to face learning topics in a more critical way.

In our setting, the course programme has been split into parts and each part into as many topics as the number of students engaged. For each part a sequence of activities based on role-play has been created. Each student had to deal with three topics:

- for the first topic, the student acts as a teacher who wants to evaluate someone other's learning, so he/she has to devise some suitable questions;
- for the second topic, the student has to answer to the questions prepared by a colleague;
- for the third topic, the students again acts as a teacher, checking the correctness of the work made by other two colleagues.

At the end of each sequence, the files produces by the students were revised by the teacher-tutor of the course and the revised files were made available to the students.

Future trends

The learning activities presented in the previous section have been experimented at the University of Piemonte Orientale and at the University of Salerno (Italy). Specific analysis of the outcomes is in progress. The results of this analysis will be presented in the extended paper after the conference.

We plan to go on with research on the design and experimentation of tailored learning paths, taking information of the affective profile of the students.

Further learning activities will be designed according to various profiles some of the found causes and implemented in a specific learning context in order to experiment them.

The already started study on correspondence between the list of the causes of the failure in mathematics and some actions/activities to be done in order to overcome the student's difficulties will be deepened.

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