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E-learning as a tool for the recovery and promotion of meta-cognitive and affective aspects in university teaching

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Abstract. Questo lavoro descrive i risultati di una sperimentazione didattica condotta su un gruppo di studenti dei corsi di ingegneria dell'Università Parthenope di Napoli. Tali studenti non avevano sostenuto l'esame obbligatorio di "Algebra e Geometria" previsto al primo anno dell'ordinamento didattico.
Le principali ragioni di tale fallimento sono state identificate in fattori affettivi e metacognitivi, nel metodo di studio basato sulla memorizzazione piuttosto che sulla comprensione e nell'approccio procedurale nella risoluzione degli esercizi. Al fine di supportare tali studenti nello studio della disciplina e di condurli al superamento dell'esame è stato progettato e realizzato un corso di recupero. In tale contesto al fine di valorizzare gli aspetti emotivi e metacognitivi dell'apprendimento, sono state progettate lezioni ad hoc, e ideate singole attività che prevedevano la valutazione tra pari, fatte avvalendosi dello strumento workshop della piattaforma moodle.
La valutazione tra pari, infatti, migliora l'apprendimento degli studenti sviluppando metacognizione e pensiero critico. Inoltre, l'uso del computer avvicina gli studenti alla materia perché grazie alla loro giovane età, lo riconoscono come strumento famigliare. L'uso delle piattaforme di e-learning ha anche un aspetto sociale: grazie all'uso delle comunità di apprendimento, la comprensione di un argomento diventa anche il risultato di un processo comunitario.
I risultati dell'intervento sono stati mediamente positivi. Molti studenti sono riusciti a superare l'esame ed hanno mostrato più piacere nello studio nonché una conoscenza più profonda degli argomenti. Le criticità osservate sono state legate a problemi tecnici e alla mancanza di impegno e di costanza di alcuni studenti non sempre in grado di gestire bene i loro tempi.

1. Introduction

The idea of this research was born in the context of a remedial class of "Algebra and Geometry" for bachelor's degree in Engineering at the University of Naples Parthenope.

The course of Algebra and Geometry of 6 CFU (ECTS) was set in the first semester of the first year of bachelor's degree. Since the academic year 2019/20 a review of the curricula has established a single annual course of 15 CFU, named Mathematics I, that includes the topics of Algebra and Geometry and Mathematical Analysis I. In this situation, students enrolled in the second and subsequent years of the bachelor's degrees, who hadn't passed Algebra and Geometry yet, were not able to attend the courses. In fact, it is common practice for students to schedule this exam after Calculus I and General Physics I.

This choice depends on the familiarity that the students have with the course topics, in fact the topics of Algebra and Geometry are more theoretical and more distant to the topic studied at school than the topics of Calculus I and General Physics I. The necessity of knowledge of theoretical aspect to do exercises makes metacognitive aspects more important, particularly the connection between the various subjects.

Many exercises have many solutions; this circumstance confuses the students. Often, even one solution exercises can be solved in several ways and the possibility to choose one or the other concerns metacognitive aspects too.

It is precisely for this target of students that a remedial course has been set. The remedial course was followed by 40 students that have already developed negative attitudes towards the subject due to past failures. Because of the different backgrounds of the students, a further difficulty encountered was the definition of a timetable compatible with the needs of all participants. For this reason, a good part of the students attended the course discontinuously.

The remedial course was designed, taking into account the main difficulties observed over the years by the teacher and the answers given by the students in an initial informative questionnaire. This questionnaire investigated the students' motivations, their perception of the subject, the reasons for failure (understood also as not having taken the exam at the right time) and their feeling of self-efficacy.

As described also in the literature, among the typical difficulties observed by the teacher there are certainly those of a metacognitive nature: students often know the topics but are not able to connect them to each other and to have a full understanding of them. Therefore, they do not handle them well, even when carrying out the exercises. Often students solve the exercises mechanically by following recurring procedures and this leads to wrong as soon as the exercise deviates from the standard type, or for example in exercises with the parameter that are not easily standardised. This has affective repercussions as it generates frustration because an intense study does not correspond to the ability to perform the exercises.

Frequently, we find a great difficulty in the use of the typical language of mathematics: many students have problem in understanding it and above all in expressing themselves in a formally correct way. For example, they have difficulty in defining sets through their properties if they are described in mathematical terms and therefore often talk about objects of which they are not fully aware. Among the causes of failure detected over the years there are: the discontinuity in the study, the insufficiency of time dedicated to study, the presence of large basic gaps (for example with respect to the resolution and the concept of equations), the inability to self-evaluate and to decide when they are ready for the examination and a poor argumentative ability. In particular, an important cause of failure, identified in our research, is the ineffectiveness of the method of study, which prefers memorization than understanding and does not favour the connection between the various knowledge.

Our research question was whether the use of e-learning platforms can support the learning of students who have had a first negative approach to the subject. Above all, whether it can help the student to arrive at a more meaningful learning that privileges comprehension over memorization and in which the student herself is able to recognize his degree of preparation and, if necessary, autonomously design a recovery path. We therefore wonder if through e-learning platforms we can somehow teach learning and self-evaluation and we can support teaching from the point of view of the emotional aspects that influence its success.

The paper is organized as follows. The next section presents theoretical background. Section 3 illustrates the experimental setting. Section 4 discusses the results of the experiment analysed based on a final questionnaire, interviews with students and examination results. Conclusions and future developments end the paper.

2. Theoretical background

The starting point of this research is a similar experience carried out by Rosetta Zan (2000) in the academic year 1993/94 at the Faculty of Biology in a course of Mathematics Institution. The two experiences have in common the target of students with an experience of failure and the identification of the causes of failure in metacognitive and affective aspects. However, there are some differences, which will be discussed in this paper, related to the context, the topics of the remedial course and, above all, the choice to use e-learning as a tool to support traditional face to face teaching. Lester (1987) and Schoenfeld (1987) observed, also at university level, the failure in Mathematics of students who probably possessed the necessary knowledge but

seem not able to use it. Indeed, their research suggested that metacognitive and affective factors could inhibit the correct utilization of knowledge in students.

The metacognitive factors relate to knowledge management are:

- awareness of one's cognitive resources and thought processes;
- ability to self-regulate, that is to activate control processes and to regulate one's own behaviour according to available resources.

The distinction between these aspects is very subtle. Metacognitive factors also include beliefs, that is the subjective (therefore not necessarily true) knowledge of a subject about herself and about the disciplines, she is learning. They influence the decisions to use certain strategies and testify the deep link between cognitive and affective aspects, as they also regulate attitudes and emotions (Lester, 1987). They can also concern particular aspects of a discipline, but also aspects of the student who learns, and of the relationship between the student and his way of learning. They involve cognitive aspects (having a misunderstanding), metacognitive aspects (thinking that one subject is more complex than another) and affective aspects (being convinced that you are not good at a subject). Beliefs on the one hand can be "powerful guides" but also "affective barrier" to educational success.

In the field of learning and school performance, the "causal attributions" (Weiner,1974) are particularly significant: these are the beliefs that a subject builds and elaborates to interpret the causes of some real situations of failure or success.

These causes can be considered:

- internal and external to the subject who learns, depending on whether they are identified in his potentiality (ability and knowledge) or in an external element (help of others);
- stable over time or not stable;
- controllable (the commitment) or uncontrollable (difficulties of the task).

According to Brown at al. (1983) metacognitive skills naturally improve as the students get older but sometimes the development of these skills appears to be inadequate. However, instructional interventions aimed to develop metacognitive abilities are very rare, especially at university level. Some experiences in this regard have been made at school by problem solving, (Lester, 1987 and Garofalo at al., 1987).

Literature shows the limits of an intervention based only on metacognitive aspects uncontextualised in specific knowledge. Since there is a link between the development of metacognitive abilities and the reasons pushing the subject towards learning, it is necessary to consider also affective aspects (emotions and attitudes), in particular related to motivation, such as a sense of self-efficacy and the enjoyment of learning, which are closely related to the selection of strategies and the processes of control. (Mc Leod and Adams,1989). Borkowsky, at al. (1990) highlight the link between metacognitive skills and the reasons which drive a student to learn. Emotions are subjective reactions to specific situations: typical examples are joy, fear, anxiety and frustration. They can act as a driving force for actions in a stimulating or debilitating way, but they can also be a consequence of action.

Attitudes are characterized by a greater persistence in time with respect to emotions but from a lower intensity and therefore are characteristic traits of a student, even if eventually transitory. The attitudes most related to performance are motivation, interest, confidence in yourself and fatalism. There's a close relationship between emotions and attitudes: a repeated emotional reaction in the same situation tends to lose intensity and consolidate in an attitude towards that situation. It becomes less intense but more persistent.

For example, if a student has continuous negative experiences with demonstrations, the emotional impact with respect to such tasks will lose with time intensity, and the emotional reaction to demonstrations will become more stable (McLeod, 1989).

In several articles, (Albano, 2009), (Albano, 2017) and (Albano at al., 2007) the author show how e-learning can contribute to improve cognitive, metacognitive and affective aspects of learning by improving students'

attitudes towards mathematics. In the experiences described in these articles e-learning is always used in blended mode, i.e. with the integration of face-to-face teaching with on-line learning activities through moodle platform. This mode, from an affective point of view, improves the relationship with mathematics, with the teacher. It increases the motivation to learn from a meta-cognitive point of view, helps to develop critical thinking, reasoning, learning strategies and self-assessment. The experiences described use 'workshop' or 'task' modules of moodle and from the point of view of mathematical education theory, they fit into the socio-cultural or 'discursive approach' (learning is seen as the result of participation in a discussion, with others or with oneself) (Kieran *et al.,*2001). Such activities are based on limited time role-playing games, which actively involve students and induce them to address learning topics in a more critical way in order to promote a deeper level of understanding and higher order thinking. Respecting a collaborative approach, peer learning is much used (Boud et al., 1999), where students learn from each other without the immediate intervention of a teacher. In particular, self-evaluation and peer evaluation are used where students actively develop the evaluation criteria provided by the teacher. The interactivity of e-learning platforms lends itself very well to this type of activity.

From an affective point of view, being connected to a network is now such a typical part of our life and it has changed the way we are socially and also the way we learn. Virtual groups of students are born spontaneously where the same group is born in real life. In the network, we exchange experiences, knowledge, information from which everyone can benefit. For example, materials and requests for help are exchanged, but each person then uses these materials in an autonomous and therefore possibly incorrect way. For this reason, such spontaneous communities are not able to support the student towards a higher level of mathematical thinking and the acquisition of self-control, self-regulation and self-evaluation skills. To achieve these goals, learning communities inspired by scientific research communities are needed (Brown and Campione, 1994). In them, it is assumed that everyone has some kind of competence, which is made available to all members. Here, therefore, the concept of "multiple zones of proximal development" is introduced: each member of the community is placed in the proximal development zone for other members, i.e. in the distance between the current and potential level of competence, already present in the embryonic state and which can be reached through the activation of appropriate interactions (Vygotskij, 1978). In this perspective, learning communities adhere to the metaphor of participation: learning a subject is the result of a process of belonging to a community (Sfard, 1998).

Moreover, the teacher engaged in a blended activity is considered as a teacher who takes care of his students' learning by increasing their motivation to study and reducing their anxiety about the exam, (Albano,2006).

3. Description of the experimentation

At the beginning of the course a motivational and informative questionnaire was proposed in order to plan the activity.

3.1 Analysis of the initial questionnaire and projecting of the experimentation

The initial questionnaire showed a heterogeneity of the target. Most of the students, but not all, had already followed the course of Algebra and Geometry, at the Parthenope University or in other universities. Only a part of them had failed the written exam and some had passed it, failing to pass the oral one. This circumstance, different from the students of Zan experimentation, where all students failed the exam, conditioned our choice to design the course in its entirety and not focusing only on some topics considered more significant.

The answer about the perception of the causes of the failure were quite homogeneous, in fact most of students attributed it to personal causes, in particular to lack of study or disorganization (internal to the subject who learns). Few students attributed the failure to the complexity of mathematical language (external to the subject who learns). No one attributed failure to bad luck and few to emotional factors. Few students declared that they do not like mathematics and that they do not have sufficient basic preparation, showing a poor capacity for self-assessment and inconsistency with their situation. Few of them, in fact, declared to have had more difficult than before in Math after the transition to university. The emotions associated with mathematics were generally positive. Many students declared they preferred exercises to theory (which is

typical of engineers) and expected the remedial course to give them a better understanding of the subjects in order to pass the exam. They study first for written exam and then, once admitted, for oral one. For this reason, different from (Zan, 2000), the theory and exercises were presented together, in order to emphasize the close connection between them. Everyone agreed that it was useful to study on a day-to-day basis, but some said that it was not always possible because of personal problems or problems related to the organization of other courses and exams. All students appreciated the collaboration between colleagues. Compared to the use of e-learning platforms almost all students claimed to appreciate the video lectures already on the net, but almost none of them have had experience of blended courses to be associated with frontal teaching. While some said they was curious about this kind of experimentation, some others were perplexed because they are afraid that a new mode might take too long.

3.2. Organization of the experimental activity

At the beginning of the course, it was stressed to the students the importance of the acquisition of responsibility because of they were an active part of their knowledge process and their commitment must be constant. This became fundamental in our context for those students who, due to overlapping with other courses (it has been impossible to create a timetable that can be reconciled with all the courses that students enrolled in various academic years and courses of study had to follow), were not able to follow the lessons assiduously.

In case they lost a lesson, they were responsible for recovering and studying the topics covered before the next lesson so that they could follow it with the necessary propaedeutic tools. Throughout the course the students were invited to express any doubts during the lesson or immediately afterwards in order to arrive to an active and participated listening. Much importance was given to the theoretical aspects and proofs because only in this way you can exercise in a conscious and not mechanical way, being able to connect various topics and develop the exercises in different ways, having a control over the results obtained that also passes through theoretical knowledge.

Great importance was given to the proofs, in fact, according to Rav (1999), all the mathematical know-how is immersed in them and they are the true essence of mathematical reasoning. In order to strengthen the metacognitive and affective aspects we associated the face-to-face course with a blended activity made up of moodle workshops in which we proposed peer review activities aimed to develop argumentative and self-evaluation skills. For each topic we assigned an exercise in a moodle workshop to be returned in a given time. In each exercise it was always stressed to argue and write the theoretical reasons for any answer. It was also made explicit that the exercise needed be written clearly for anyone who read it (student) and not only for those who already knew the arguments (teacher). The delivered productions were then randomly redistributed by the system to other students (in particular each one had two elaborates) who must evaluate them according to criteria of completeness, correctness and clarity well described in the workshop description. In order to help students in this activity some guiding questions were proposed to evaluate: the substantial and formal correctness, the completeness of the answers and the clarity with respect to the explanation of each step with the appropriate theoretical references. The student evaluator was asked to give his own version of the points considered incorrect or incomplete. Please note that, contrary to what was done in another similar blended activities, we did not give any value to the grades proposed by the students for the final evaluation (summative evaluation). It would have been very complex to weigh the students' grades and it would have been beyond our scope to use peer-assessment to develop argumentative and metacognitive skills.

In order to promote the metacognitive skills, theoretical questions and proofs had also been proposed (as done in Zan, 2000) to investigate the proving ability. In these questions we asked to explain, for example, the passage in which each single hypothesis was used or we asked to make counter-examples to show the necessity of some hypotheses. The use of such a blended activity had already been experimented in the previous academic year for the Algebra and geometry course done in the first semester of the first year. Such experimentation was very complex because in the first semester students often matriculate late and therefore, they did not have access to the platform. Moreover, the newly enrolled students are very reluctant to deliver elaborates because they are not sure enough and they were afraid to show their shortcomings by showing that they did not know the educational potential of the error. Obviously, both issues were overcome in a remedial course where students are already enrolled and more mature. Moreover, this methodology, together with use of some video lessons already present on the platform, has also been used to help students to study constantly

and, especially for those who could not follow all the lessons, to make up lost lessons and keep up with the course. Differently from what Zan did, in fact, no specific activities were done to schedule the study times for the various topics, but through the blended activities, an attempt was made to give study times to students who were obliged to deliver in a given time. Participation in these activities was optional but the students were invited to participate by telling them about the results obtained in similar experiments. Workshop activities were also very useful to devote more time to exercises than it would have been possible in a 48-hour course, where the whole program had to be covered. We do not go into the details of the proposed exercises here, as we are more interested in the methodologies than in the contents, since we have typical exercises of the linear algebra course similar to those proposed in the exams.

In order to facilitate the passage of the information, at the beginning of the course we had set up an e-mail list through which students were notified when new workshops were activated with the relative deadlines. This tool was also used to encourage participation when deliveries were in late. Students were invited to report immediately any technical problems via e-mail so that it could be resolved in a timely manner. The evaluations made by the students were used only for training purposes and in no way it was used for the final evaluation. The teacher's feedback was given on-line but sometimes took place during the lesson where the exercises proposed were carried out correctly and some of the assignments and assessments made by the students were analysed. This was possible because of the small number of students participating.

4. Results and discussion

The students' participation in the activities was fluctuating: after a first phase in which they had some resistance also due to some difficulties in the use of the platform, they started to participate more actively thanks to the teacher's solicitations. The students found an advantage in participating in the activities because they were able to understand their shortcomings through the workshops and to fill them before going on and to better understand the following topics. There were times when deliveries were less assiduous and it coincided with overlaps with mid-course tests or other examinations. This is because not all students are able to reconcile the study of several subjects at once. The most delicate phase was certainly the evaluation. In fact, all the students delivered most of the work, while a fairly small part was able to evaluate the delivery of colleagues. Theoretical questions were those that created more difficulties in line with the observations made on the lack of metacognitive abilities. Given the small number of students involved, this analysis was carried out simply by collecting data from individual deliveries and related revisions.

4.1 Analysis of the final questionnaires

In order to evaluate the students' perception of the activity carried out and the reasons for the low participation in the evaluation phase, a final questionnaire was prepared, to which three-quarters of the participating students replied. Almost all students consider the workshop activity useful to verify the knowledge learned during the course (formative evaluation) and to keep up with the study. They did not have great difficulty in using the platform except in the evaluation phase where it gave problems to upload files. This was the motivation that almost all students gave to justify the low participation in the evaluation phase. But some of them don't feel prepared enough to judge someone else's production. Some relevant comments were: "I think we are not able to develop an evaluation criterion, since we are not even able to do it on ourselves"," It was my first experience in this regard, so I found it very uncomfortable", "I would eliminate assessments because I don't feel able to assess someone else's assignment". This feeling also came out during the interview of the students at the exam. Some students don't find the peer-review useful to learn the exercises better and they prefer to use their time differently: "I prefer to take the time to repeat other things", "Personally I saw and tried to do all the arguments, but I gave less than half of them out of personal insecurity and because I was busy studying for the exercises of the other courses in the second year". There is still an insecurity in the ability to evaluate as well as a lack of understanding on the fact that by evaluating others one can acquire knowledge especially with regard to argumentative skills. Another critical point was the management of delivery schedule at the same time as other academic and non-academic commitments. In this regard, there was a decrease in participation in conjunction with the period of the rehearsal or other writings in which many students were involved. Most of the students found the collaboration between peers good, but there was one

student who said:" Surely the opinion of a colleague can be useful, but it is not the opinion of a teacher so it can be right or even wrong and sometimes I think it can create confusion and misunderstanding", highlighting the limit of peer evaluation of lack of authority. Obviously this is overcome if there is a teacher's correction at the end, but this is not always possible. Almost all students, while recognizing the challenging activity of participating in the workshops, especially for the request to argue everything and for the deadlines, have recognized it as a valuable help in passing the exam and especially a way to keep up with the study. Through the workshop activities it is possible to practice the topics explained and to get feedback.

5. Conclusions and future developments

In order to be able to evaluate the experimentation, interviews to students during the exam were also carried out and all the students seemed quite happy with the experimentation. Moreover, by evaluating the results of the exams, almost all students who had assiduously carried out the activities, passed the exam in the first two sessions with good grades and above all they showed a good understanding of the topics and a more conscious performance of the exercises than before the course.

As far as future developments are concerned, we certainly hope to have solved all the technical problems that in some way compromised the experimentation. Furthermore, we intend to use the workshops on the annual course of Mathematics I. In an annual course this method could be even more useful then in a shorter one in order to keep the attention step by step and to help students not to leave the whole study at the end. Moreover, it takes time to acquire technical and time organization skills and therefore these competences could be more relevant and better acquired in an annual course. Clearly the activities of the workshops will also have to be retargeted to the themes and difficulties of the Mathematical Analysis I present in the Mathematics I course. To help students to be more confident in the assessment phase, we intend to organize exercises with teacher, where peer assessment is required but under the supervision of the teacher. Taking advantage of the students' suggestions, we will try to network after the end of the workshop the correct execution of the exercise and some evaluation of some paper delivered. This is to give certain feedback to those who do not feel confident in peer review. From an affective point of view this activity can bring the student closer to the study of the matter both because it uses channels and tools very close to the new generations, and because of its social character as a learning community. Obviously, in courses with a greater number of students it can also be a tool to get the student out of the crowd and give them a little bit of the feeling of belonging that was created in the classroom in the school experience. This was not crucial in the course described in this experience, where the limited number of participants allowed to create an environment very similar to the school class regardless of the use of the platform, but it will certainly be relevant in Mathematical I course where the number of students is higher.

A mention must be made of the current emergency: the sudden mandatory transition to e-learning due to the coronavirus pandemic has shown a lot of potential in the use of new technologies for teaching. We continue to believe, however, that the success of teaching can only be achieved through blended modes with the use of e-learning platforms in support of traditional teaching and not as a substitute for it. This is because we consider that the personal relationship between student and teacher, and the social component of the learning are very important: they both have a crucial role in real classroom, and only after the real life experience they can be cultivated in the virtual groups.

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