A Peer Tutoring project in a situation of learning difficulty: Mathematics in Vocational School

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The Italian secondary school system is subdivided into several categories (Bernardi & Arzarello [2]). Together with the traditional Lyceums (Classics, Scientific, Artistic and Psycho-Pedagogical) which provide a broad education, there are a series of Technical and Professional Schools. This second group of schools was conceived as Vocational Schools, with the function of preparing future workers for qualified professions. The official curriculum currently set for these vocational schools is “Progetto 92”, (similar to the BEP curriculum, that is the Brevet d’Etudes Professionelles, in France); it contains a heavy mathematical content, which is quite similar to what is taught in every other type of secondary school, but with very little in common with what is used in the work place. The underlying idea is that all students should master a common core of mathematics (this sounds quite similar to the NCTM Standards situation in the USA[1]). Unfortunately, this idea doesn’t seem to work, also because our vocational curricula too often “offer the least education to students who have the greatest need” (Forman & Steen [6], talking about the situation in the U.S.A.).
The recent surveys carried out by the Ministry of Education on the school natural wastage confirm that the students who officially dropped out of school in 2001/2002 were 2.93% of those registered (compared to the 2.77% of the previous year); another 1.77% regarding the students who didn’t get any evaluation for other reasons (health, absences, non attendance), also has to be added up to this figure. A 11.30% natural wastage is recorded just at the first year of vocational schools on a national scale, reaching peaks of 13.68% down south and 16.20% in the islands: a student out of 6!
As a matter of fact, Vocational Schools are chosen by the potential “lost candidates”, or students who can't or don't want to “study” much for different reasons, yet hope to find a “practical” school that can also offer them concrete mathematics, built on advanced applications of elementary mathematics rather than elementary applications of advanced mathematics [5].
Thus, any proposal to provide mathematical education in a vocational school must take into account the necessity of promoting the competences necessary to be able to transfer learning at different levels [4]: from one classroom situation to another, from the mathematics taught in the classroom to that used in the workplace, but also from work situations to more general mathematical questions, which could give solutions to new problems arising in the work place.

For this reason, it is fundamental to have the “mathematical” requirements of the working environment clear in our minds, even if many experts in the sector currently note that mathematics is becoming always less “visible” in the professions (see [7], [10] for striking examples).

In the last time many authors (see many of the chapters of [3]) highlight the great differences between the mathematical techniques used in the workplace and the theoretical ones. From the “mathematician’s” viewpoint, the application of mathematics involves situations where specific mathematics tools can be recognized and applied: problems are merely contexts for applying learned mathematics. From the vocational viewpoint, the application of mathematics makes sense if it intervenes where it is needed, allowing improvement; on the contrary, many “pure mathematics

[1] http://www.nctm.org/standards/

attentions" are even considered misleading (e.g. any worker has a tolerance towards measures which are not tolerated by the teaching of mathematics …).

Significant differences appear when comparing the mathematical abilities required in the workplace with those present in the syllabi (even more when it comes to those provided using current teaching methods); yet, valid indications can be also found as to how to "do mathematics" in a way strictly embedded in the teaching of vocational materials.

According to all that has been said, an integration project for a disabled person was conceived and carried out [1].

An interdisciplinary project dealing with the main activities of the vocational modelling laboratory was created with the aid of a team of curricular and support teachers, aiming at the development of the vocational competences as well as the individual and social autonomy of a person with an average mental disability.

Moreover a specific logical-mathematical learning path was placed within this network of cross-wise interventions, aiming at the acquisition of a kind of mathematics which, far from being trivial, turns out to be necessary for the creation of a vocational object, like a straight curled skirt; this includes size, proportions, plane and spatial geometrical figures, geometrical transformations, etc.

It was then easy to realize that this experience could be transferred in a learning path addressing, this time, the whole class by means of an additional teaching strategy, that is the peer tutoring.

According to the Italian school tradition and our experience in the field, a possible ability to integrate knowledge and competences does not only derive from the study of the subject at school, yet also from the confrontation between people who see different aspects and links of the subject depending on their school and after school experience. Besides, the ability to implement a learning "in collaboration with one's more skilful peers" [12] is not always a common habit in school practice, which often rejects "the proximal development zone", considering what students can do by themselves as the only indicator of their skills.

A didactics based on exchange, mutual help and communication of one's own processes has developed starting from these considerations; it provides the chance to get away from the fixed and standardized roles within the classroom, which implicitly influence personal successes and failures.

In particular, the *tutoring* teaching strategy which has developed within the *cooperative learning*, rules the educational action concerning the *tutor-tutee* relationship: such an organization gives the opportunity to foster an "active and individual learning" [11].

As for the metacognitive sphere, this strategy tends to increase "a sense of pride and self-regulation and…of confidence and responsibility" [9]; on the other hand, as regards the cognitive sphere, both the tutor and the tutee get considerable, yet different advantages. Even if *tutors* are in charge of conveying previously acquired knowledge, they get cognitive advantages because they "revise and consolidate it, bridge the gaps, single out other meanings and reformulate it in other contexts; but they are most of all likely to better assimilate their knowledge, when it is addressed to a specific purpose" [9]. On the contrary, *tutees* receive "a regular feedback sharing in the correctness of their efforts, and are carefully monitored in order to make the most of the time devoted to the activity".

As far as the selection and arrangement of mathematical knowledge are concerned, the *peer tutoring* offers the opportunity to implicitly "take advantage of" the "more skilled" student, who is not considered as the "holder" of knowledge; he is an odd "strategist" who clarifies his mental processes, thus allowing the "less skilled" to identify a new way, admit their mistakes and internalise these kinds of "suggestions" by means of discussion. On the contrary, the relationship between the "average" skilled with a minimal skill difference, provides a mutual enhancement and spontaneous discussions, which can be directed towards knowledge integration by the careful role of the teacher.

As regards the recovery and understanding of well-defined mathematical concepts, the *peer tutoring* gives the chance to clarify false concepts, perplexities, and any sort of misunderstanding (concerning reading the texts of the problems, choosing the proper solution strategy, etc.) within a relationship between "peers", in which the words of the classmate-*tutor* are always seen as an "advice", not a "judgement". The tutor's correction, notes and suggestions provide the chance for a constructive debate, in which any objection is argued out and at the same time internalised in its deepest meaning: "[…] the clash of our thoughts with those of other people who arouse our doubts and need to demonstrate" [8].
Therefore, the *peer tutoring* redefines the student as a knowledge holder who has the tutor's role and takes up his responsibilities, making the learning process easier. It is an added value which allows students to overtake the fear of evaluation and mistake, since the educational relationship between peers is not considered as a place of assessment but as a chance of growth.
The project we devised is currently developing and concerns the third class of a Vocational Institute for Chemical and Biological Workers. It was the result of a survey carried out upstream on the mathematics failures of the people attending the institute. The collection and analysis of the data relating to the 2003-2004 academic year, showed a failure in mathematics which was twice the number of failures in the other subjects, both in the two-year period and in the one-year period for qualification, as well as in the two-year period following qualification. This analysis was then followed by the evaluation of the results of "standard" remedial lessons; a general 55% improvement in all subjects was recorded, except mathematics which showed a variable improvement between 0 and 20%.
The group of teachers analysed the possible connection between the two kinds of failure; they actually wondered whether failures in vocational subjects are partly due to failures in mathematics. As a first activity, they tried to single out which mathematical competences are necessary to acquire vocational competences, particularly those provided for by the project '92 as the competences to acquire at the end of the three-year period.
The following chart summarizes the activity:

Competences related to the Vocational Profile	***Related mathematical competences***
He correctly performs the sampling. He goes on with the activities leading to the analysis.	1. Costants, variables, formulas. 2. Simple and quadratic equations. 3. Problem solving and problem posing 4. Ratios and proportions. 5. Algorithms and their representation. 6. Measure.
He consciously uses current equipments and instruments to perform analytical, chemical, biological and/or microbiological evaluations.	1. Algorithms and their representation. 2. Cartesian coordinates. Reading and describing graphs of the main analytical and trigonometrical functions on the cartesian plane. 3. Costants, variables, formulas. 4. Basic computer science and related software.
He records chemical and/or chemical-physical parameters on systems, correlates the data to the processes management instructions and performs the expected operations.	1. Elements of descriptive statistics: gathering of data, synthesis values, variation indices. Statistical graphics. 2. Cartesian coordinates. Reading and describing graphs of the main analytical and trigonometrical functions on the cartesian plane.

	3. Costants, variables, formulas. 4. Basic computer science and related software.

The solution to application problems such as the quality and quantity research on specific substances with specific methods, requires the execution of complex paths, above all theoretical, logical-deductive and finally practical; these require a real internalization of mathematical and vocational cross competences.

Starting from this initial discussion, the attention was moved to what happens in the chemistry laboratory, assessing the single experiments going over the underlying mathematical competences and later providing their recovery.

The analysis of the experiences connected with the calculation of the concentrations mainly required one of the fundamental competences of the specific vocational profile: "correctly perform the sampling. He goes on with the activities leading to the analysis".

The analysis carried out together with the teachers on this vocational competence pointed out "which kind" of mathematics to introduce. It has a complex and well-structured content requiring specific competences of the chemical, theoretical and practical field, such as the knowledge of moles and molarity, number of equivalents and normality, equivalent weight, pH, neutrality and neutralization, etc.; it also requires mathematical knowledge and competences, such as the meaning and use of constants and variables, reading and interpreting formulas, creating and solving simple equations, as well as the concepts of ratio, proportion and measure. The fundamental ability to identify mathematical aspects in chemical contexts is also necessary; yet, this is often an activity which requires reading and decoding the specific language of chemistry.

The collaboration among teachers has been crucial to the achievement of the experimentation; the aim was to develop the ability to go over a particular vocational situation according to one's teaching viewpoint, besides realizing the individual and group responsibility for the acquisition of "necessary" mathematical competences and solve a vocational situation like "the calculation of the wine acidity" (common vocational procedure to sell wine)!

The initial phase of the project dealt with the analysis of mathematics and chemistry deficiencies; this activity was performed both by going over the maths and chemistry works of the students and by cross- interviewing the maths and chemistry teachers.

The research phase was useful to identify the clear mistakes in the manipulation of inverse formulas, the little ability to perform simple operations, the wrong meaning given to the exponential writing of a number, the common mistakes when solving simple and quadratic equations; this was a clear confirmation of what we had expected, and it also pointed out the need to give importance to the laboratory phase as the right occasion to recover and develop mathematical abilities, aiming at the creation of a specific professionalism.

The project was conceived starting from this analysis, particularly an acid-base indicator. At the beginning the laboratory experience to propose to the students was identified, with the teaching activity unreeling by means of the identification of a possible "vocational" algorithm to follow in order to repeat the same experiment, proving its validity in the laboratory by a similar experiment with different numerical values.

Cooperation methods had never been used before, so students were arranged in pairs in the early stages and it was given them a series of questions to stimulate gradual problem posing and problem solving activities, where necessary.

Going through the vocational activity once again and having to recreate the whole experience in its intermediate stages, with the same observed results, stimulates a discussion aiming at singling out the contents of theoretical chemistry at stake and the mathematical competences they require.

The identification of the necessary mathematical concepts will motivate a phase of close examination, reference and explanation of the same concepts by means of alternative more mathematical strategies and exercises of consolidation. Then, in the last phase students leave the classroom of mathematics and repeat the initial experiment in the laboratory using different data; this activity led us to an overall evaluation, crossing between vocational competences and acquired mathematical competences.
The project is still developing and news on its monitoring and overall results will be provided at the Conference; yet, it is worth mentioning that the continuous monitoring of the experiences points out a considerable increase in the number of students who consider equations as a tool to use in different contexts; it also records the acquisition of the concept of unknown and its crosswise nature, as well as the ability of students to identify equation in different contexts and choose the most appropriate solution strategy among the alternatives; moreover, about 90% of the students seem to have acquired the competences necessary to indication. However, these considerations belong to the perception level and refer to what was crosswise observed by the teachers.
As a result, strictly mathematical and vocational competences and knowledge become part of an integrated and vocationally-addressed view.
The first considerations of the teachers concerning the experience and their ability to teach can be summarized as follows (yet this is not the only way to do it!):

- customize activities according to specific difficulties;
- start the learning path from where it stopped;
- properly and carefully adapt the teaching activity;
- aim at the creation of a global knowledge.

The idea of starting from vocational experiences relies on the strong positive influence exerted on the motivational level; yet, the modest attempt will be trying to note how far this helps building mathematical experiences as well as vocational ones.

Selected readings

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