EVALUATION OF TRANSFERRING SKILLS IN A FIRST DEGREE COURSE

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Abstract

The role of skills in higher education and their corresponding accreditation are becoming increasingly important in the context of the knowledge society and lifelong learning strategies and policies. It begins with a first definition of the notion of skill, distinguishing between transversal or generic competencies and specific skills. The hypothesis held in this paper is that the transversal competences can be achieved and accredited whenever conditions of possibility are created for this. The obligation to assess is a reflection of what has been called the evaluating state and the emphasis on accountability, which emphasizes accountability and results, without paying attention to the processes. Faced with this tendency, the authors argue for the need to promote institutional measures and favorable learning environments so that the students' abilities have their best development and recognition not only formal, but substantive, in academic terms and in the labour market.

The transversal competences project launched at the Polytechnic University of Valencia (UPV) (http://www.upv.es/contenidos/COMPTRAN/) has as its main objective to accredit these competences to the students graduated in its official degree programs. The present work focuses on establishing a strategy for the evaluation of transversal competences to accredit their acquisition in three subjects in the area of mathematics in a first degree course.

The strategies used for the teaching of competences are those based on collaborative learning and through the study of cases. The above is based on teamwork, which helps to develop several transversal skills at the same time. In addition, this method forces to question, to recognize the relevant knowledge, and to reorganize these skills, which abound in the analysis and resolution of problems in general, being this another important transversal skill.

This paper describes the experience carried out in the subjects of Algebra, Calculus and Mathematical Methods, analyzing the results obtained from a qualitative and also quantitative point of view, carrying out the evaluation by means of global and analytical rubrics. It also analyzes how far the preparation of these tasks has helped to create necessary study habits in students, to promote effective cooperation between them and to obtain better academic results. We also analyze what other social and educational factors would be necessary to achieve the proposed objectives.

Keywords: Transversal Competences, Teaching-Learning Methodology, Meaningful Learning, inverted/flipped classroom, Labour Market.

1 INTRODUCTION

What could be the ultimate goal of teaching: the transmission of knowledge, to awaken interest in students to learn continuously throughout their lives, the education of autonomous beings for autonomous societies, the education of subjects with emancipatory values and critical sense, the education for growing social progress compatible with sustainable development? We cannot give a simple answer. Education is a complex and lively process, which involves different actors and requires a permanent revision and adaptation of the methodology in order to help us achieve the main objectives. At this moment society demands graduates who accredit the acquisition of certain skills or competences in their curriculum, which implies a methodological change. Indeed, the role of skills in higher education and their corresponding accreditation are becoming increasingly important in the context of the knowledge society and lifelong learning strategies and policies.

Two decades ago, in 1997, the OECD promoted the study Definition and Selection of Competencies (DeSeCo)1, in order to provide a conceptual framework in which to highlight the importance of key

1 http://www.oecd.org/edu/skills-beyond-school/definitionandselectionofcompetenciesdeseco.htm
competencies in a globalized world. A few years later, the executive summary elaborated in 2005 defines the notion of competence as "more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context. For example, the ability to communicate effectively is a competency that may draw on an individual's knowledge of language, practical IT skills and attitudes towards those with whom he or she is communicating."

The interest and growing importance of key competencies in education are due to the deep and accelerated transformations that our world is carrying out in the 21st century. Indeed, globalization and modernization are creating an increasingly and interconnected world. To make sense of and function well in this world, individuals need to make sense of large amounts of available information. Individuals also face collective challenges as societies, in order to balance economic growth with environmental sustainability, and prosperity with social equity. In this contexts, the competencies that individuals need to meet their goals have become more complex, requiring more than the mastery of certain narrowly defined skills.

Taking into accounts the increasing incorporation of transversal competences at the international level in Higher Education Institutions, the Polytechnic University of Valencia (UPV) has assumed an institutional project in order to evaluate and accredit its students in a set of generic competences, beyond the content of each degree. When we talk about competencies, considering the characterization offered by the OECD, we refer to an identifiable and assessable set of knowledge, attitudes, values and skills related to each other that allow effective performance in real work situations, consistent with standards held in labor world.

From the OECD study, the literature on competencies often differentiates between generic or transversal competences, and specific competences. The former refer to competences transferable to a multitude of functions and tasks, while the latter refer to competences directly related to the occupation or tasks to be carried out in the workplace.

In our case, we will pay attention to transversal competences, with emphasis on their close relationship with three dimensions that are complementary: a) the educational dimension, b) the evaluative dimension, c) the dimension of quality assurance in higher education.

a) Educational dimension: The language of competencies is already part of the literature in the educational sphere in general. Its use has been generalized in the last decades, to the point of achieving an international socialization mainly based on reports, recommendations and institutional regulations, as well as academic studies and scientific articles. The competencies approach today has been incorporated both in the educational policy agenda and in the theoretical body of the education sciences. This extension in the use of the notion of competences sometimes provokes a certain ambiguity in its meaning. The aim is to define and clarify the meaning adopted in the context of its application, in order to avoid undue appropriations for unintended purposes.

b) Evaluative dimension: The competences, in their conception and in their application, are closely linked to the evaluation. In a scenario in which the relationship between supply and demand increases, the state assumes the role of evaluator. "The main task of the State (...) is to exercise an evaluation function. In assessing the performance of supplying entities, the State can indirectly influence supply and modulate its 'quality' " (see [3], p.4). Within the framework of the evaluating State, three so-called "E's" play an important role: managing resources in the best possible economic terms, ensuring that resources produce maximum effectiveness, and ensuring that resources are adjusted as foreseen in the program of tasks and activities (efficiency). All this is based in a set of beliefs, namely that the result of tasks can be predicted in advance, that it is possible to operationally define the result in the form of a measurable product, and that it is possible to standardize the measurement of the product in the form of indicators of the Performance -fixed and unchanging- in a temporal and contextual framework (see [3], p.6). These three vectors, and the beliefs they hold, that come from the business world, have been imported and applied by educational institutions to define programs and goals, and ensure quality.

c) The focus of quality assurance mechanisms is the results (conceived as products) rather than the education processes. Paradoxically, quality requirements are measured or mediated by

instruments and procedures that result in a powerful accounting industry of indicators, rankings and comparisons. This way of measuring education shifts from an institutional logic and educational purposes towards new logics that subordinate knowledge (knowledge's society) to economic interest (knowledge's economy). (see [4]).

From these variables, the thesis we hold is: Our teaching experience has shown that the identification of transversal competences as a measurable product has no direct effects on their acquisition and consolidation. Transversal competencies need to be evaluated. In other words, the operational identification of competencies is necessary, but not sufficient. While measurement (through a series of indicators) has a diagnostic and descriptive character, evaluation (meaning the issuance of informed value judgments), has a normative character, with effects in practice. We can use for the purposes of our reflection the following simile: registering competences can be like putting the thermometer to a patient, will indicate if you have a fever, but not how to cure it. What we suggest is a change of perspective: the consideration of transversal competences as a set of experiences to be carried out (that is, as a process that has to be lived or experienced to be learned), rather than as a finished result. Competences are skills that are shown in the action, not products that are acquired passively.

Therefore, we maintain the need to create favorable pedagogical conditions to carry out an evaluation that allows the student to lead the acquisition of transversal competences in their own learning process and improve it with teacher supervision. This means starting from at least two assumptions: a) emphasizing the educational process rather than the outcome (since the result is merely a reflection of a continuous process of learning that also requires continuous assessment), and b) give value to the educational experience, since the experience means the concretion in the practical of the learned theoretically, that is to say, the encounter between reflection and action. This is the principle that the pedagogue John Dewey summarized in his well-known motto: "learning by doing" (see [5]). For this thinker, thought and action are part of the same process. Without action (without the realization of operations that require elaboration and resolution) there is no understanding, and without understanding (without assimilation of the proper contents of a subject) it is not possible to perform operations or problem solving. Therefore, education requires planning of learning conditions through shared life-forms of social and educational practices. From this approach, on the one hand, the student ceases to be a mere receiver of learning objects, and becomes a major player in the construction of knowledge: study is active work and participation. On the other hand, the teacher is no longer a mere transmitter of knowledge: teaching is a planned dialogic intervention. The classroom ceases to be a static place, it becomes a workshop, in a field of exploration and experimentation.

In this sense, our proposal for evaluation of transversal competences has an experimental character; it is a scientific experiment that we have tested in the framework of our classes, which have given rise to a nursery of mathematical and pedagogical experiences. At the same time, these assumptions are inspired by the principles of educational innovation, which can be considered as one of the expressions of the creativity of action, by highlighting the human imagination structure that stimulates and enriches the advances and the progress of scientific knowledge.

From a methodological point of view, we suggest the combination of two methods of work to generate the best conditions of learning: a) the inverse class method (see [2]), and b) Problem-Based Learning (PBL) (see [6]). Both methods combine the quantitative and qualitative perspective, overcoming the dichotomy or opposition between them.

2 METHODOLOGY

As a general framework we have considered the 13 transversal competences that are being implanted in our university: TC01, Understanding and integration, TC02, Application and practical thinking, TC03, Analysis and problems solving, TC04, Innovation, creativity and entrepreneurship, TC05, Design and project, TC06, Teamwork and leadership, TC07, Ethics, environmental and professional liability, TC08, Effective communication, TC09, Critical thinking, TC10, Knowledge of contemporary issues, TC11, Lifelong learning, TC12, Planning and time management, TC13, Specific instrumental.

From these competences we have chosen the three transversal competences that best fit the characteristics of the subjects analyzed in this paper, evaluating two competences in each subject (see table 1). The records obtained by the students in each subject are of qualitative type (A=Excellent, B=Adequate, C=In development, D=Non reached) and to define it, each teacher designs the type of tests he deems necessary.
Table 1. Transversal competences evaluated in the three subjects studied in this paper.

<table>
<thead>
<tr>
<th>Competence</th>
<th>Algebra</th>
<th>Calculus</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC03, Analysis and Problems Solving</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TC06, Teamwork and Leadership</td>
<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>TC08, Effective Communication</td>
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2.1 Algebra

Algebra is taught in the first semester of the first degree year. In general, when students come to a university they are concerned about the relevance of the methods used and the degree of accuracy of the results obtained. However, it is also necessary that they understand from the beginning of the course that, in addition to these two factors, they must be able to express and communicate adequately as well as improve their ability to work individually and in a group.

These considerations have been taken into account in the programming and in the teaching methodology of the Algebra subject, where from several academic courses teachers lay emphasis on two specific aspects: first, in the literal description of everything that is reflected in written exams (not only formulas) and second, the performance of group tasks that are defended individually. Those have led to the consideration of the following two transversal competences: TC03, Analysis and problem solving, and TC08, Effective communication, as suitable for evaluation within this subject. In particular, the degree of acquisition of each of these competences must be qualitatively assessed, as discussed at the beginning of this section. However, we have considered that it should also influence the final grade of the subject with a value of 10% for each transversal competence, in order to motivate the student more. These aspects have been worked on in previous courses, but then they were not part of the final note. Now, such separate assessment makes students take them more seriously.

We will briefly explain the processes that are carried out to have elements that allow us to evaluate the two competencies mentioned. For the first one, once the course has started, and in a period where there is no overload of exams and work delivery, a small collection of problems is proposed as a task to students who must solve in a group. The work between them has two aspects; the positive one is that the students with more preparation and discipline of work can help to their colleagues, who feel quieter to ask at the same level. The negative is that inevitably many students copied the results. With our verification system, such methodology will not have positive results if the student has not understood how the task is solved. In fact, each student presents results with their work group and teacher asks him the part that considers. In this way, teacher can see the doubts that each student has, he can solve them and he can give the option to complete the work. In addition, teacher can note, by direct observation, the degree of comprehension of the exercises that each member of the group has achieved and their ability to explain what they have done. It is important to say that a work is not evaluated if students do not present themselves to the defense of the same, because a percentage of the students who present the task do not to defend it. For the another transversal competence, TC08, effective communication, students are informed that a part of the note reflect the degree of explanation of the exercises solved in written tests (written effective communication) and also that when they defend the proposed tasks (like the previous one) the degree of expository clarity is scored (effective oral communication).

Analyzing the method of evaluation of these two competencies, we say that it is made from several rubrics both quantitative and qualitative. Specifically, the transversal competence TC03, analysis and problem solving, is basically defined with the notes that the teacher takes in the defense of the proposed tasks, as well as in the delivery of works proposed through the flip teaching methodology (see [2]). For the transversal competence TC08, effective communication, the final note is obtained from two indicators: first, from a numerical note in each written test (which measures the degree of explanation of the answers presented) and second, from a qualitative note that the teacher takes in the defense session of the task mentioned above.

2.2 Calculus

Regarding the subject of Calculus, has been included officially and for the first time in this course 2016-17, the use of flipped classroom, taking into account the work of two transversal skills at the
University Polytechnic of Valencia, such as teamwork and leadership and analysis and problem solving, as it has been considered in our university control points in this subject, as in others. It has been completed with the study of cases in class allowing sometimes to the student to develop some of the ideas that are exposed on blackboard or are projected through the computer. Thus the degree of acquisition of knowledge can be observed, since the student can ask his doubts to the professor or to his peers while others students are thinking and solving the exercises.

We open the floor in the classroom to discuss and deepen what is being exposed at that moment. So the students could understand better exercises and concrete concepts that have more difficulty in understanding. We must put it for the student what is expected of him to work the skills that are control points in this subject. Thus we set three stages: define the content of each competence, establish the performance of both, the student and the teacher, and develop indicators or rubrics that allow us to evaluate the degree of acquisition of the mentioned abilities.

In relation to the flipped learning, we ask the student several tasks related to the previous study at home of some material to attend class. This material is available in advance in the PoliformaT platform, which is the university's e-learning platform where information is exchanged between the student and the teachers. Within the flipped learning the student is told the tasks of delivery on the platform of some exercises proposed. In the same way the delivery and defense of others tasks but individually in the teacher's office. Here we try to observe the degree of acquisition of the analysis and problem solving competence, commenting with each student on the way in which they have to analyze the proposed problems.

On the other hand the teamwork and leadership competence, has been worked both in theory and problems class, as in the laboratory of mathematics. Thus in some classes of problems, the work has been structured into groups of three students, proposing them exercises to deliver resolved. The teacher raises "in situ" some questions to the different groups, taking some notes to complete later the mark they get, because in the direct treatment the teacher can establish with more accuracy, small differences to evaluate them, on the other hand to our understanding, fair differences.

In the same way in the laboratory classes, we asked each group, previously formed, some exercises on the lesson developed in class to analyze and solve with Mathematica software. Here also has been observed and evaluated the work of each group, as a group itself, and each element of the group, the latter by direct questions to each component of the group.

The overall assessment of the subject is carried out taking into account the progress requirements of our university, which establish that no partial test can exceed 40% of the final qualification. Consequently in our teaching guide of the subject, we establish two theory and problems test with a weight of 20% each and two tests of laboratory practices with another 20% each test. To this must be added 10% of the evaluation of the analysis and problem solving competence and 10% of the evaluation of the teamwork and leadership competence. In addition, these competencies are evaluated, as shown below in the charts, with A = Excellence, B = Adequate, C = In development, D = Not reached. The numerical evaluation of these competences that we mentioned above is not really mandatory, although we think it is convenient.

On the other hand, at the end of the semester there is a test for students who have not yet passed the course, although they have achieved minimum objectives. This test consists of recovering one or two parts of the subject, those that have been worse. It is an already minimal test and it is not for all students.

### 2.3 Mathematical Methods

In the Mathematical Methods subject, several first-grade mathematical concepts necessary for the degree in Geomatics and Topography are studied, which have not been studied in the two subjects described above (see [7]). The first block is dedicated to the study of plane and spherical geometry. Another block contains the basics of descriptive and theoretical statistics. In both blocks the transversal competence TC03: Analysis and problem solving is evaluated, which has already been commented on in the two subjects analyzed in previous sections. This transversal competence acquires greater importance in the block of geometry in which the students work with the calculation of areas on plane figures and with the resolution of problems on the sphere. Specifically, the teacher evaluates the strategy used by each student in the calculation of areas of plane surfaces, for which he must decompose the area using other figures whose area can be calculated with the problem data: plane triangles, circular sector, circular segment, parallelogram, etc. In the case of geometry on the
sphere, with the geographical coordinates of two points located on the Earth sphere, the shortest distance between these points must be calculated. It is also necessary to determine the geographical coordinates of the cut-off point between the maximum circumference, passing through those points, and other curves such as the equator, a parallel or a meridian.

Among the statistical problems that are studied in this subject we can highlight the calculation of probabilities using different probability distributions for discrete and continuous variables, as well as the calculation of confidence intervals and hypothesis tests on the mean and standard deviation of a variable with normal distribution. The degree of acquisition of the TC03 competence is assessed by integrating these concepts into the resolution of a real problem and obtaining conclusions based on the results obtained.

The part of descriptive statistics is studied in the practical classes of this subject using the methodology of flip teaching, which are taught in groups with a number close to thirty students. The way to evaluate this part is through a work to be solved in groups formed by a maximum of three people. This work has a weight of 10% in the final note of the subject and it serves to evaluate another of the transversal competences of that subject: the TC06 transversal competence, Teamwork and leadership.

Each working group, consisting of two or three students, has to search for a set of data with two variables, X and Y, which have some kind of relation to each other. Then, they must perform a descriptive statistical analysis of these data using the methodology proposed by the teachers, in which group members can investigate the application of different statistical methods described in the texts developed by the teachers or other references of this subject. The work is given to the teacher and is exposed in one of the classes of this subject, in which the members of the group have to answer possible questions of the teacher and other students.

The teacher values the resolution of the work in this way:

a) Technique of the case (2.5% of the final note of that subject). It involves the analysis and resolution of a situation that presents problems of multiple solutions, through reflection and dialogue for a group learning that is integrated and meaningful.

b) Academic work (5% of the final note of that subject). The resolution of each part of the work is valued until arriving at the final conclusions.

c) Observation technique (2.5% of the final note of that subject): The presentation of the work done by each member of the group is evaluated as well as the answers to the questions of the teacher or other students.

The above will also be used for the evaluation of two transversal competences: TC03, Analysis and problem solving and TC06, Teamwork and leadership. The calculations leading to the final conclusions of the work will be carried out using the statistical program, Statgraphics Centurion.

3 RESULTS: DATA AND ANALYSIS

3.1 Algebra

To what extent can the inclusion of skills acquisition help the teaching-learning process? In our case we have not observed important advances but a change of tendencies that we try to explain. For this we will analyze in a summary form the numerical data of which we have. In Fig. 1, we can see the quantitative results (over 10 points) obtained in the subject of Algebra in the two transversal competences that are evaluated, both in number of students (bar chart) and in comparative form of percentages (pie chart).
Fig. 1 show that there is a greater correlation between the final note of such subject and that obtained in TC03, Analysis and problem solving (Pearson's correlation coefficient is equal to 0.5862) than between the final note and that of TC08, Effective communication (with a Pearson’s correlation coefficient equal to 0.4876). On the other hand, this Pearson’s correlation coefficient between both competences is low (0.2362). It is worth commenting on other data such as the average notes (weighted on the numerical value 10): the average of final note is equal to 4.4104, the average of the TC03 is 5.3714 and the average of the TC08 is equal to 3.3246, which in general are very low.

Let’s look at some reasons that may explain this behavior. First, the subject we are discussing is taught in the first semester of the first year of the degree and most students are surprised all. On the other hand, the transversal competence TC03, Analysis and problem solving, is treated simultaneously in the subject of Calculus, which helps to obtain better results than in the transversal competence TC08, Effective communication. However, we have to indicate that although the results in this last transversal competence are very low, it has positive effects later, since we have observed that many students acquire the habit to explain briefly what they are doing, as it is verified in the subjects of mathematics that they follow later. We complete the above data with the total qualitative assessment of those transversal competences that is reflected in the record of each student (see Fig. 2).

3.2 Calculus

In Fig. 3, 4 and 5 we show some graphs by means of bar chart and comparative graphs of the performance obtained in the two skills that have been approached in the subject Calculus, both from the point of view of numerical and non-numerical evaluation.
Figure 3: Results obtained for the TC03 skill in the subject Calculus. A=Excellent, B=Adequate, C=In development, D=Non reached.

Figure 4: Results obtained for the TC06 skill in the subject Calculus. A=Excellent, B=Adequate, C=In development, D=Non reached.

Figure 5: Numerical results obtained for the skills TC03 and TC06 in the subject Calculus.

We have translated numerically the data in Fig. 3 and Fig. 4 in a mark that we show together with the two competences in Fig. 5, where clearly it is observed that the student has as more course done, at least in Calculus, in what is the teamwork and leadership competency since the average obtained from the numerical evaluation is 7.01 compared to a average of 3.33 for the analysis and problem solving competence.
3.3 Mathematical Methods

In the subject of Mathematical Methods we have considered the results obtained in the 2016/17 academic year only in the block of plane and spherical geometry and in the statistical block, since at the moment of writing this article we only have results on them. Fig. 6 and Fig. 7 compare the numerical results obtained in the competences TC03 and TC06. The note that appears in them has been evaluated discreetly with a score in a natural number between 0 and 10.

![Figure 6: Results obtained in the numerical evaluation of the transversal competences of the subject of mathematical methods. TC03 has been evaluated over 82 students, while 68 students participated in the TC06.](image)

In the transversal competition TC03, there are few students with a score higher than 6 because most of them must improve their skills in the selection of the correct data and methods, as well as in the analysis of the coherence of the obtained solutions. For example, most of them find difficult to calculate areas of plane figures and to develop a statistical analysis of a real problem. On the other hand, there is a greater number of students who acquire the TC06 transversal competence more quickly, partly because the work groups are of two or three people and the teacher allows the students to choose the partners with whom they want to form the group.

![Figure 7: Results obtained for the TC03 and TC06 transversal competences in the subject of mathematical methods. A=Excellent, B=Adequate, C=In development, D=Non reached.](image)

4 DISCUSSION AND CONCLUSIONS

The analysis of the data seen in the previous section leads us to the conclusion that in this process of competences evaluation there is still a lot to do. Although teachers design a program with activities, combined practices between different subjects and tests of control of various types aimed at students getting a habit of work, a degree of commitment on the part of the students is necessary. In fact, in our university some centers require that in certain experimental groups, students sign a contract where they commit to follow the methodology implemented in the subjects. In our case this does not happen, but we observe that from one course to another, students are becoming aware that they must know how to work in groups, both to provide solutions and to discuss or recognize what is not known about
the topic to be addressed. Students should be able to study a problem, find different solutions and analyze them in order to obtain the optimal solution, and they must also be able to effectively transmit the problem-solving process.

The low score obtained in the transversal competition TC03, analysis and resolution of problems, compared to other skills, is not surprising data because students usually suffer from not knowing how to deepen and analyze well the problems in mathematics, when they starts their studies in the University. On the other hand, teamwork is usually done with more interest, perhaps because it happens among people of the same level who usually communicate better, overcoming shyness as well. Another reason to take into account is that having to deliver individually and defend a series of exercises in front of the teacher some students do not perform the task because they have not gained sufficient confidence in what they do. On the other hand, if the teacher does not establish a filter in the delivery of works it is observed that there is a lot of repetition between them. Demanding the defense of each work, some students try to understand what others have explained, which is positive because after all it is a question of understanding what is being done, either by the explanation of the teacher or their colleagues.

This paper shows the need for a profound change in perspective, to rebuild the social value of the scientific knowledge and education a common good (see [8]). In the end, the value of transferring skills depends less on account-ability and more on creating meaning (sense-ability). Therefore, tools that help in measuring the quality of education must be at the service of educational values, that is, the real emancipatory purposes that have guided the development of higher education.

REFERENCES


