LEARNING TO LEARN WITH CONCEPT MAPS: A DIDACTIC APPLICATION WITH FUTURE ENGINEERS

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Abstract

As is well known, the design of university curricula is focused on the acquisition of skills. Transversal competences stand out, which are key and transferable throughout life. They include cognitive, metacognitive skills, and instrumental and attitudinal knowledge. Its main characteristics are: integrative, transferable, interdependent, multifunctional and evaluable [1]. Four transversal competences are worked on and evaluated in the course presented in this work: CT04. Innovation, creativity and entrepreneurship; CT06. Teamwork and leadership; CT10. Knowledge of contemporary problems, and CT11. Learning to learn.

In particular, we pay special attention to the development of learning to learn competence, a key competence set by the European Commission [2]. We consider it essential for students to achieve a good level of acquisition of this competence, since it encompasses many useful skills and abilities for good professional performance (communication, information management, critical thinking, problem solving, interpersonal relationships, etc.). A complete review of the literature on the definition of this competence and its dimensions can be seen in [3].

In this work we present an experience carried out in a Business Management course, a compulsory subject at the master's level. The experience that we describe focuses on the elaboration of a conceptual map of the contents worked on in a part of the agenda that generally presents comprehension problems in the students.

Conceptual maps are a valuable tool that can help when there exist problems of understanding [4]. In this sense, a work strategy has been designed to allow conceptual maps to be incorporated into the teaching-learning process and to use this tool to build their own knowledge. In this context, learning is facilitated if the lecturer helps students to use appropriate information representation and summary techniques [5].

The experience has been positive for both the professor and the students. In general, the majority of students' value (qualitative evaluation), on the one hand, the level of organization and understanding acquired through the construction of the conceptual map and, on the other hand, the importance of teamwork through collaborative group dynamics. Discussions have allowed them to interact and have made them easier to increase their knowledge.

Moreover, the construction of the final conceptual map implies applying different learning strategies such as decision making, discussions, sharing, synthesizing information, ranking and presenting the concepts, etc., and allows them to extrapolate data to reflect on other topics. In addition, it favours the development of skills such as learning to learn, teamwork, leadership and communication (oral and written). Among the difficulties, students point out the lack of time and the novelty of the methodology.

Keywords: Conceptual maps, Learning to learn, Master Degree, Transversal skills.

1 INTRODUCTION

As it is well known, the design of the curricula for university degrees is focused in the acquisition of competences [6]. We can distinguish three types of competences in the higher education: General, Specific and Transversal skills. The first two refer mostly to the knowledge of a study field and the particularity of the knowledge and procedures of a given profession [7]. Generic competences identify shared elements that are common to a professional branch and are applied in a wide range of occupations and work situations, making easier the insertion as an added value that provides employment and motivates professional development and progress. Moreover, General competences can be classified as instrumental (cognitive, methodological, technological and linguistic skills),

interpersonal, or systemic [8]. Specific competences are specific to each profession, that is, each degree, and give identity to an occupation [9]. On the other hand, Transversal skills are key and transferable throughout life. They include cognitive and metacognitive skills, and instrumental and attitudinal knowledge. Its main characteristics are: Integrative, transferable, interdependent, multifunctional and evaluable [1].

In this work we pay special attention to the Learning to learn transversal skill, linked to Lifelong Learning and considered as a key competence by the European Commission [2]. We believe that it is essential for higher education students to achieve a good level of acquisition of this competence, as it actually encompasses many other useful skills and abilities for good professional performance (for example, communication, information management, critical thinking, problem solving, interpersonal relationships, etc.). A complete review of the literature about the definition of this competence and its dimensions can be seen in [3].

Learning to learn enables students to be able to actively incorporate, integrate and develop learning strategies. In this way, the student is able to establish his or her own objectives, design his or her learning strategy and extrapolate strategies from other areas or disciplines in an autonomous and self-regulated way. Learning, finally, is an object of didactics that, broadly speaking, we could characterize as follows: there is only one subject, the one who learns, who can be helped, oriented or directed, although these activities are not considered as learning; it is intended to apprehend an object or modify a behavior; experience shows that there are a variety of possibilities for learning: practice, observation of others' behavior, teaching and information received, and even personal discovery. We can consider learning as the process by which a person incorporates informative content, acquires practical skills or abilities, adopts new knowledge and/or action strategies, and appropriates habits, attitudes and values [10,11].

2   METHODOLOGY

The subject in which the experience has been developed is Business Management, a compulsory course in the Master's Degree in Industrial Engineering that is taught at the Higher Technical School of Industrial Engineering of the Universitat Politècnica de València (Spain). The course consists of 6 ECTS, of which 3.2 correspond to theory and 2.8 to practices. This year, the Business Administration has a total of 323 enrolled students divided into nine theory groups that present the option of taking the subject in Spanish, English or Valencian; each one of these groups is divided into three for computer practices. Specifically, the activity presented in this work has been carried out in one of the groups with an afternoon schedule, and 18 students have participated in it.

The description of the course, as it is read in its teaching guide [12], is based on those basic and fundamental aspects that the student will need to correctly perform the functions of business management in changing and competitive markets and environments. The course contributes to the training of professionals capable of performing management, leadership and evaluation tasks in productive organizations. These tasks can be carried out in the general scope of the organization or in any of its functional areas, especially in production, human resources, quality management, R&D, financing, administration and accounting. Students' managerial skills are enhanced to elaborate and build strategic decision alternatives, both in relation to the understanding of problems, as well as in decision-making and the evaluation of the consequences that their own actions may have for the company and for the people. In the teaching guide, the practical nature of the course is also highlighted, as well as its introductory aspect: the topics covered on business creation, strategic planning, human resources management (leadership, teamwork, motivation, negotiation, etc.), strategic control systems, etc., cannot be addressed in depth given the available time assigned to the work sessions, so students are warned from the beginning that any of the covered topics is much more complex than which is reflected in the recommended material.

According to the contents presented in the description of the subject Business Management, the general and specific competences of the degree that are worked on and evaluated in the course are those observed in Table 1 [12,13].

Table 1. General and specific competences of the subject Business Management

General Competences	Specific Competences
CB6(GE) Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.	GS1(ES) Knowledge and skills to organize and manage companies.
CB7(GE) Students have to know how to apply the acquired knowledge and their ability to solve problems in new or little-known environments within broader (or multidisciplinary) contexts related to their area of study.	GS2(ES) Knowledge and skills of strategy and planning applied to different organizational structures.
CB8(GE) Students have to be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments.	GS3(ES) Knowledge of commercial and labor law.
CB9(GE) Students have to know how to communicate their conclusions - and the ultimate knowledge and reasons that support them - to specialized and non-specialized audiences in a clear and unambiguous way.	GS4(ES) Knowledge of financial and cost accounting.
CB10(GE) Students have to possess the learning skills that allow them to continue studying in a way that will have to be largely self-directed or autonomous.	GS5(ES) Knowledge of management information systems, industrial organization, production and logistics systems, and quality management systems.
GE3(GE) Lead, plan and supervise multidisciplinary teams.	GS6(ES) Capacities for work organization and human resource management. Knowledge of labor risk prevention.
GE5(GE) Carry out strategic planning and apply it to both constructive and production, quality and environmental management systems.	GS8(ES) Ability to manage Research, Development and Technological Innovation.
GE6 (GE) Manage technically and economically projects, facilities, plants, companies and technology centers.	
GE7 (GE) To be able to carry out general management, technical management and R&D project management in plants, companies and technology centers.	

As for the transversal skills, from the 13 that are considered in all the degrees of the Universitat Politècnica de València [14], this course is a control point of the following (that is, they are assessed):

- CT04. Innovation, creativity and entrepreneurship
- CT06. Teamwork and leadership
- CT10. Knowledge of contemporary problems
- CT11. Learn to learn

In the Business Management course, different teaching-learning strategies are used, such as case studies, gamification, role play and concept maps. All the strategies are aimed at students achieving the competences and skills listed in the teaching guide (general, specific and transversal). Activities are carried out in two-hour sessions.

The experience we describe in this work focuses on the concept map strategy, also referred to in the literature as cognitive map, cognitive schema and conceptual schema, among other names. In this context, intelligent learning involves the construction of schemas [15,16], which are cognitive or intellectual structures that represent the relationships between concepts and processes, on the one hand, and between various schemas, on the other, concept maps are intended to represent meaningful relationships between concepts in the form of propositions [4]. In this context, learning is facilitated if the lecturer helps students to use appropriate information representation and summary techniques [5].

For the development of this activity, methodology was first exposed to the students. Thus, the first part of the session was devoted to an introductory training on the concept mapping strategy: its definition,

its advantages in terms of meaningful learning, their elements, its main characteristics, the steps to follow and various examples. In the same presentation, it was clarified that the topic on which the students were going to prepare a conceptual map was Didactic Unit 2. Balanced Scorecard, from Module IV. Control systems, Accounting and Law, because it was the one they were working on in the theoretical classes.

The students formed four groups of 4-5 people at their discretion. First, they reviewed the materials on the topic, equal for all and shared on the virtual platform in order to extract the key concepts of the topic. Secondly, they put the identified concepts in common and discussed among themselves how to write them into the conceptual map; this phase is very enriching because students must argue the relationships between the concepts and there is a high motivation among them, at the same time, that they are working in group, which improve their learning. The professor was supervising the activity in the different groups and clarifying doubts about content or methodology that arise during the construction of the map. Next, on the map, they outline the location of the propositions, seeing the connectors (link words) and establishing connection lines. In this step they realized about the importance of considering two concepts as being of equal level or one subordinate to the other, that is, the importance of hierarchization. Subsequently, they agreed on the relationships that unite the different concepts of the conceptual map through cross relationships. The resulting concept maps can be seen in Figure 1.
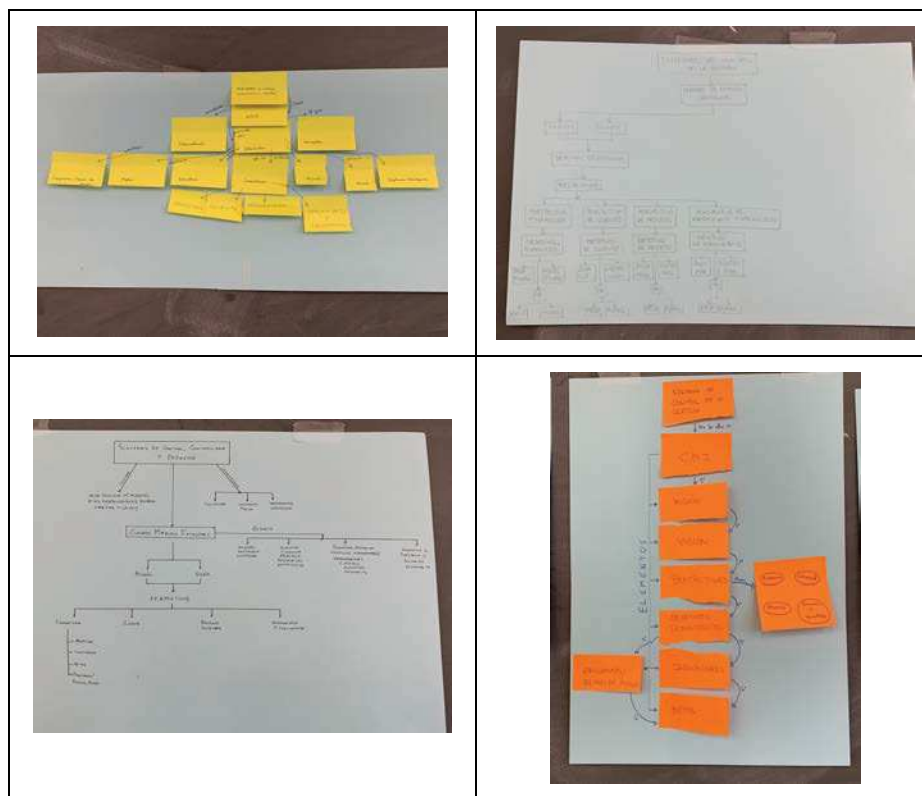

Figure 1. Conceptual maps.

Finally, to enhance/consolidate the meaningful learning that allows the development of this strategy during the session, the students explain in groups their concept maps to their peers, each providing new information regarding the previous presentations. With this part of the activity, the students develop the oral communicative skill, since they have to present the relationships established in their maps and argue them. Then, question time for those responsible for each conceptual map was opened for both the professor and the students.

3   RESULTS

Student's assessment of the activity carried out in the classroom with conceptual maps is presented below.

First, the strategies used during the development of the activity have been analyzed (Table 2). When analyzing the information provided, we have established two categories depending on whether the indicated strategies have been carried out at the individual or group level. In the first type, the majority (67%) have used information management strategies, followed by 50% of synthesis and elaboration of diagrams with the available information. In the group category, the majority (61%) highlighted the different strategies that have been developed in the elaboration of the group conceptual map, such as sharing, discussing and deciding what information to include, and drawing conclusions.

Table 2. Strategies used during the activity

	Strategies	**%**
Individual	Ask questions	5,56

	Collect information through:
	    Work on your own notes
	    Underline
	    Reading the course notes
		66,67

	Synthesize the information	50,00
	Make preliminary outlines of key concepts Make outlines	50,00
Group	Make decisions as a group Discuss key concepts with peers Debate Make conclusions Brainstorming	61,11

On the other hand, an important part of the transversal skill learning to learn is reflecting on the developed activity. In this sense, the students have manifested the learning they have acquired (Table 3). These results differentiate learning about the activity in general and learning derived from the use of concept maps. Moreover, they are complemented by actions that students would take if they had the opportunity to repeat the activity.

Regarding the activity in general, the indicated learnings are related to the development of different transversal competences, such as effective communication, understanding, synthesis, teamwork, problem solving. Regarding recommendations, students wanted to work previously in more detail the content.

Table 3. Assessment of the activity in general and of the concept map

	Lessons Learned	**If I had to repeat the activity, what I would do is…**
Activity in general	Improve communication Organize ideas Learn (active and fun) Teamwork, brainstorming and learning together (peers' points of view enrich) Assume theoretical content Synthesize and specify the information Solve problems because it allows applying an structured analysis Understand and write quickly and effectively Actively work about content	Before doing it, I would talk about the subject to delve into the content Make notes during the first reading (clearer) Read the topic before the start Greater clarity and detail

	Reflect on crafting	Improve link words
Concept map	Establish relationships between concepts	Rearrange and complete concepts
	Identify general concepts	Add more features to concepts
	Structure, order and prioritize concepts of a topic	Establish more relationships
	Quick display of information	Check the final concept map (the concepts of the topic are included)
	Clear concepts, before doing the concept map	
	Make drafts previously	
	Developing the concept map to explain it increases interest and attention	

The learnings that derive directly from the process of elaboration of the concept map are related to the identified threshold concepts, hierarchized, organized and related in the map. Students also refer to the learning process that involves understanding the contents and the reflection processes generated during its elaboration. We can see that to do to improvements in the connectors, to detail the characteristics, etc., are completely logical proposals, but require more time to do the activity.

Any learning process poses difficulties in the process that must be overcome. It is important for the competition to learn how to learn in order that the students would be aware of the difficulties they have and, especially, how they manage to overcome them. In this sense, in Table 4, we collect the difficulties that students have arisen according to four aspects that we have established from the contributions of the students. The first one focuses on the elaboration of the concept map; 33% indicate that it is difficult to make the hierarchy of the concepts, because this supposes having very clear the contents of the topic; 27% shows difficulty in the relationship between concepts. The second aspect focuses on the organization of the activity. In this category 17% think that information or more details are missing in the work materials. The third category refers to the strategy and only 11% indicate lack of prior knowledge, it was the first time that they made concept maps. Last, the fourth category includes the explicit contributions of the students, indicating that they have not had any difficulties (17%).

Table 4. Difficulties found in the development of the activity

Difficulties	Description	%
Preparation of the Concept Map	Make the correct hierarchy of all the concepts that you wanted to capture, break down key concepts	33,33
	Relate some concepts	27,78
	Synthesize the topic in a few words	11,11
	Apply theoretical concepts to practice due to little practice when doing it	
Organization of the activity	Lack of detail in the slides, in the power point structure, lack of information	16,67
	Lack of time to properly understand and assimilate concepts	11,11
	Unclear initial objective	
Strategy	Lack of prior knowledge	
	Not having given the subject previously	5,56
None	Without difficulty	16,67

In general, the found difficulties have not been very significant, however, these can be used for a reflection for the professor to improve the activity in future years. Finally, students indicated improvement proposals (Table 5), which we have grouped according to whether they referred to the professor, on a personal level, or to the material or others. We would like to highlight that they propose spending more time (preparation, explanation, reflection, with more examples), which ultimately entails an interest in learning better, in more depth, so we could say that the objective of working on the learn to learn skill is achieved through the design of this kind of activities.

Table 5. Improvement proposals

Professor	Student	Material or others
Explain the topic in more detail before	Read the practice before	More examples
More help when we ask	Arrange before the exhibition what we should say, how and who was going to do it	Previous explanation or tutorial videos
More time to review and reflect on the work done		
Focus the subject to teach us to apply the tools that lecturers give us		
Teach with the approach and development of a clear example of what to do		

4   CONCLUSIONS

The experience has been positive for both the professor and the students. For the professor, this was a useful methodology to promote meaningful learning in the classroom, to understand the content, and helped to work on the transversal skills of teamwork and communication (oral and written). For the students, it meant learning some new content and technique, which can be extrapolated to reflect on other topics. In addition, they learned to synthesize information and to hierarchize and present concepts, clarifying their ideas. In this sense, the strategies most used by them were the collection of individual information through their own notes and notes from the course, and group strategies on decision-making, discussions, sharing knowledge, brainstorming, etc. The difficulties were related to the lack of time and the novelty of the methodology.

ACKNOWLEDGEMENTS

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