USING CONCEPT MAPS TO ASSESS THE "ORAL COMMUNICATION" COMPETENCE WITHIN THE "MATERIALS FOR ENERGY APPLICATIONS" COURSE

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Abstract: Technical skills, even for technical positions, are insufficient for subsequent success beyond an entry-level position, since it usually requires proficiency in soft-skills areas such as: communication, leadership, conflict resolution and self-management, amongst others. Hence, helping technical students to develop and improve such soft-skills areas is of real need, and that is why generic competences are included in technical syllabus. However, the assessment of such competences is not an easy task, not to mention if we are not from such area of expertise. The aim of this manuscript is twofold. First, to present the use of 'concept maps' as a useful strategy to support the students' learning process. Second, and more specifically, to show the usability of a methodology to develop and assess the "oral communication" competence within a technical optional subject (Materials for Energy Applications), offered in two different Masters at the School of Industrial Engineering of Barcelona at the Universitat Politècnica de Catalunya-Barcelona Tech.

Keywords: soft-skills; oral communication; evaluation strategy; transversal competencies.

1. INTRODUCTION.

In 2010 the European Higher Education Area (EHEA) was launched to ensure more comparable, compatible and coherent systems of higher education in Europe. All Degrees and Master Studies adapted to EHEA must define a profile of competences that students should acquire, including both generic and specific competences [1,2]. The former are common to different courses and areas, but they may have different importance and depth of knowledge, depending on the field of study. It is interesting to note that these competences are the basis for the students' integration into working life and their professional development.

The Universitat Politècnica de Catalunya-Barcelona Tech (UPC) have included seven generic competences, already defined at a national level, and accepted by the Quality system department, in its Degrees and Masters. They are: entrepreneurship and innovation, sustainability and social commitment, third language, effective oral and written communication, teamwork, competent use of information resources, and autonomous learning [3]. It should be highlighted that during the last years, plenty of efforts have been devoted to develop different tools to assess these generic competences as reported in Refs. [4,5].

This study presents the use of concept maps as a strategy to develop and assess the *effective oral communication* competence. Moreover, this paper shows the usability of this methodology and assessment scale to support the students' learning process. Specifically, it is going to be explained how concept maps were used in a course entitled "Materials for Energy Applications", which is an optional one offered at the second academic year in the Master's degree in Materials Science and Engineering and the Master's degree in Industrial Engineering at the School of Industrial Engineering of Barcelona (ETSEIB) at the UPC.

2. CONCEPT MAPPING.

Joseph Novak [6] described the development of concept maps in the early 1970s as part of a longitudinal research project that assessed changes in children's understanding of science concepts over a 12-year period. This author remarks the potential of concept mapping to improve science education as a learning strategy, an instructional strategy, a strategy for planning curriculum, and a means of assessing students' understanding of science concepts [7].

A Concept map (CM) uses hierarchical order to link concepts together with propositions (i.e. linking words that highlight the relationship among concepts). In short, a CM is a graphical technique for representing the connection between several ideas or pieces of information. Since students are asked to construct a CM themselves without a template, their map represents their own interpretation of ideas (i.e. it can be seen as a portrayal of their mental model and knowledge about a topic). This tool is useful not only to organize knowledge and so help understanding, but also to

improve several generic competences (e.g. critical thinking).

Creating a CM can be seen as an iterative process. However, five basic steps are required:

1) To determine the key concepts.
2) To order these concepts from generic to specific.
3) To group and put them into a hierarchy, in order to clearly show the connection logic.
4) To write down the propositions (i.e. linking words) that will connect each group of concepts, making its reading and understanding easier.
5) To revisit the CM in order to assure its clarity and logic.

3. METHODOLOGY.

Subjects for this study were the students enrolled in the *Materials for Energy Application* course during the spring term of the academic year 2015-2016. Twenty-five students, from different countries (i.e. France, Spain, Germany, Austria, etc.), participated in these compulsory activities as part of their continuous assessment.

They were asked to create working groups of four (five students as maximum). During the semester each group had to do two different activities that involved to create a CM of an academic article and orally present it to the rest of classmates, with an allotted time of three minutes. The main difference between these two activities was that, in the first one, all groups worked with the same article (given by the professor), whereas in the second activity each group had a different paper (chosen by themselves from the academic databases available at the UPC and validated by the professor). Specific guidelines on the procedure and the presentation were given in advance. It was compulsory to all group members to participate in the preparation of their CM presentation, since for the three minutes speech one student from each group was chosen at random in class and just before their turn. They needed to be able to communicate the main ideas of the academic article in a way that all their peers understand, and also, the orator needed to maintain the attention from their peers during the presentation. Due to the short amount of time they had, the projection of their CM was crucial in order to help achieving this goal.

The assessment tool used was a scale of 4 levels (*1:* poor, *2:* average, *3:* good and *4:* excellent) and five criteria (Concept selection, Hierarchical organization, Propositions, Graphical representation and Oral communication) [8]. **Figure 1** shows the scale used to evaluate not only the CM itself but also the way it was presented. Two different boxes were added in order to detect the strengths and the points to improve in a more detailed way. Professors from different areas of expertise (i.e. the authors of this manuscript) and peers were involved in the assessment of the activity. A schematic representation for this methodology is represented in **Figure 2**.

LEVELS / EVALUATION CRITERIA	Excellent (4)	Good (3)	Average (2)	Poor (1)
Concept selection (15%) The map includes all the relevant concepts of the article.				
Hierarchical organization (30%) It is presented an appropriate structure of the concepts (from general to specific). There exists a hierarchy.				
Propositions (30%) The map includes valid relationships between different concepts. The type of relationship is well indicated by means of an arrow and a connector (word).				
Graphic representation (15%) The design of the map is clear and simple. The map shows an appropriate use of symbols and technical lexicon.				
Oral Communication (10%) A clear and concise explanation of the mind map, using an appropriate tone of voice, was done.				
TOTAL SCORE:				

Write a strength:
Write a point to improve:

feedback

Figure 1. Scale designed for the assessment of CMs activities.

An immediate oral feedback was given after the presentation, and a more detailed and personalized feedback, taking into account the marks and comments of the scales, was given within one week. This first feedback obtained helped them to prepare the second CM. By using such a tool and methodology, they received good quality feedback so they could improve their self-learning process [9-10].

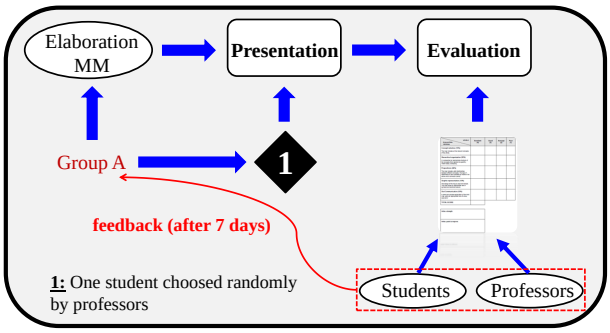

Figure 2. Schematic representation of the methodology presented here.

4. RESULTS AND DISCUSSION.

Figure 3 exhibits the detailed feedback supplied to each group within one week after their presentation. As depicted in this figure, it consisted in two different parts: *i)* feedback supplied by the professors, including the strengths and points to improve; and *ii)* collective feedback from their peers.

Part 1

CRITERIA	STRENGTH	POINT TO IMPROVE
Concept selection	More than the 70% of the main concepts are present	The main concept should be 1 concept (not a sentence)
Hierarchical organization	Main idea is clear and visible	Could be more clear
Propositions	Colours corresponds with explanation	Linking words are not appropriate Arrow directions Not clear Connectors should help to transform the figure into text
Graphic representation	Simple Creative idea Clear	All concepts should be in a square All arrows should have a direction
Oral communication	Clear Good tone of voice Good visual contact With the presentation it is easy to follow the mind map	You need to speak loudly

Part 2

General feedback supplied by the other groups:

Strength: Clear presentation and schema, visual, good colours and appropriate connection and well prepared.

Point to improve: The size of components does not correspond to their importance, closing ideas, leave the slide for the evaluation add numbers 1,2,3...and volume of the speech.

Figure 3. Structure of the feedback supplied within one week after the presentation.

After finishing these activities, a questionnaire was handed out to the participants in order to obtain their feedback on this methodology. Eighteen out of twenty-five students answered the questionnaire. **Table 1** presents the results.

Table 1. Students' feedback from the CM activities.

Questions	Mark
Making CM is useful for understanding the concepts of the course or articles related to the topic of the course (Q1)	3.2 ± 0.7
Making CM is useful for developing synthesis capabilities (Q2)	3.8 ± 0.4
Making CM in groups is an appropriate strategy (Q3)	3.7 ± 0.6
The CM activity was correctly planned (good timing for preparation and explanation) (Q4)	3.3 ± 0.8
It is interesting to present the CM in front of the class (Q5)	3.5 ± 0.7
I think that choosing randomly one of the members to make the presentation is good for the group dynamic (Q6)	2.8 ± 1.0
It is valuable to participate in the assessment of your peers (Q7)	3.2 ± 0.5
The scale given to you includes all the crucial points to assess (Q8)	3.6 ± 0.5

Note: The marks presented in this table are over a maximum value of 4.

As it is appreciated in **Table 1**, in general there is a positive opinion about the use of CM and the methodology proposed, with a qualification ranging between good (3) and excellent (4).

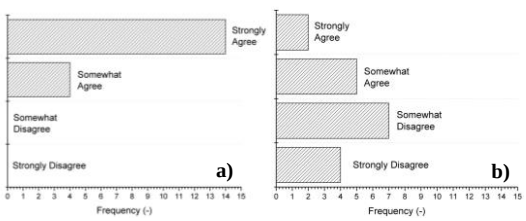

Figure 4. Detailed representation for the data summarized in **Table 1** through a statistical analysis for Q2 (a) and Q6 (b).

Figure 4a highlights that making CM is useful for developing synthesis capabilities. This observation also is clearly presented in **Table 1** in question 3 (Q3). Moreover, it is possible to mention that making CM in groups is a good strategy as each student can highlight different points of view, and thus, a better way to discuss the main concepts related to the topic and course. In short, it can be seen as a good strategy for collaborative learning. However, some weaknesses were detected. In some cases, all the members of the group did not work equally (i.e. there are free riders). Furthermore, sometimes it is difficult to reach a consensus. Students consider that the fact of choosing one member randomly, and in the very last moment, to do the presentation is not the best strategy for the group dynamic. They apparently feel more comfortable knowing beforehand who should perform the oral presentation. It is interesting how they see as not beneficial this common practice used to boost the cooperative learning by drawing attention to the individual responsibility in a working group [11].

It is interesting to point out that students consider this methodology not only useful to develop oral communication and teamwork skills, but also to develop critical thinking and synthesis capabilities. They also mentioned that it had helped them to have a global overview of the subject and that CMs are good tools to summarize and understand the papers. Moreover, they consider that it is positive for them to get involved in the evaluation system (peer assessment), since they became more conscious on what they are doing and learning. Moreover, they affirm to really appreciate the feedback received from their peers.

It should be noted that students prefer to choose their own papers for constructing the CM, since they feel more motivated to get involved in such activity, not only during the preparation of the map but also during the presentation (listening to the same explanation is not 'cool'). Likewise, students mention the need to have more time to work on the CM (due to the overload of task of the rest of the subjects, one week it is not enough for them).

Figure 5a, represents the final marks' comparison, taking into account all the evaluation criteria and players. As it clearly shows, the students' marks are higher than those supplied by the professors. Furthermore, one could infer from the small scatter associated with each point that peers and professors can objectively evaluate the CM activities. As it is clearly observed, a slightly improvement in the teachers marks is appreciated after the first CM, which highlights that feedback supplied to each group between both CMs' activities helps them to improve. In order to get more information about if the methodology presented in this research is appropriate to improve the oral competence, a representation of the oral communication criteria mark

got from peers and professors is presented in **Figure 4b**. It denotes a slightly improvement of the oral communication competence. However, this result may be attributed to two different factors: *i)* the methodology presented here is suitable to improve this generic competence; and *ii)* the student randomly chosen to present the CM has good communication skills. In order to shield more light in this sense, it is necessary to apply this methodology more times in order to get statistical significance.

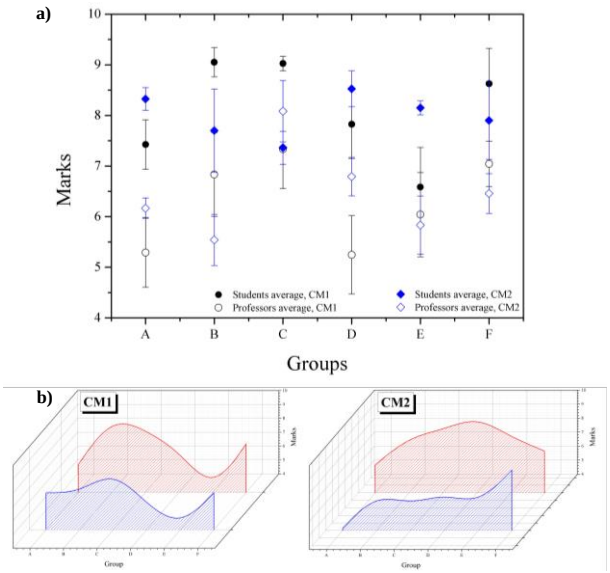

Figure 5. (a) Final marks representation for both CMs activities, and (b) Representation of the oral competency marks' trend.

Finally, from **Figure 5a** and **5b**, it can be clearly observed that the feedback given is a powerful tool to help the students in their personal development.

5.- CONCLUSIONS.

From the analysis of the results obtained in this research related to the methodology presented above, the following conclusions can be drawn: *i)* concept maps are useful for understanding the topics of the course; *ii)* presenting the concept map to classmates is useful, as it helps to develop and improve their oral communication skills; *iii)* choosing randomly the person responsible for the presentation is seen as a good strategy to improve the teamwork competence - it forces all members of the group to be prepared and to fully comprehend the concepts (i.e. to be aware of their individual responsibility in the group); *iv)* participating in their peers' assessment is considered as a good way to identify their own mistakes and points to improve; and *v)* the scale provided for the assessment of the activities includes the main criteria to objectively assess concept mapping and their oral communication skills.

5.- ACKNOWLEDGEMENTS

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6.- REFERENCES

[1] Lasnier, F. "Réussir la formation par competences" Mont-real : Guérin, p. 481, 2000.

[2] Institut de Ciències de l'Educació, ICE. "Guia per desenvolupar les competències genèriques en el disseny de titulacions". Barcelona : Universitat Politècnica de Catalunya, 2008 (http://www-ice.upc.edu/ca/innovacio-docent/publicacions_ice/arxius/resum_competencies_eng.pdf, Accessed June 30, 2016.

[3] C. Social, "Marc per al disseny i la implantació dels plans d'estudis de grau a la UPC. DOCUMENT CG 16/4. 2008-Bing". https://www.upc.edu/slt/ca/pla-llengues-upc/acords-llengues/marc-per-al-disseny-i-la-implantacio-dels-plans-destudis-de-grau, Accessed June 27, 2016.

[4] Martínez, M., Amante, B., and Cadenato, A. (2012) Competency assessment in Engineering courses at the Universitat Politècnica de Catalunya in Spain. World Transactions on Engineering and Technology Education, 10, 46-52.

[5] Martinez, M., Olmedo, N., Amante, B., Farrerons, O., and Cadenato, A. (2014). Analysis of assessment tolos used in engineering degree programs. International Journal of Engineering Education, 30:6, 1689-1696.

[4] Novak, J. D. (1990). Concept mapping: A useful tool for science education. Journal of research in Science Teaching, 10, 923-949.

[6] McClure, J. R., Sonak, B., Suen, H.K. (1999) Concept Map assessment of classroom learning: reliability, validity, and logistical practicality. Journal of Research in Science Teaching, 36:4, 475-492.

[7] UPC. Institut de Ciències de l'Educació (2008). L'avaluació en el marc de l'espai europeu d'ensenyament superior. htt://www-ice.upc.edu/ca/innovavio-docent/publicacions_ice/arxius/2_avaluacio.pdf. Accessed June 30, 2016.

[8] Canto del, P., Gallego, I., López J. M., Medina, E., Mochón, F., Mora, J., Reyes, A., Rodríguez, E., Salami, E., Santamaría, E., and Valero, M. (2011). Follow-up and feedback processes in the EHEA. Journal of Technology and Science Education JOTSE, 1(1), 12-22.

[9] Nicol, D. (2007). Principles of good assessment and feedback: Theory and practice. REAP International Online Conference on Assessment Design for Learner Responsibility, 2007. Retrieved from, https://www.york.ac.uk/media/staffhome/learningandteaching/documents/keyfactors/Principles_of_good_assessment_and_feedback.pdf

[10] Boud, D. and Associates (2010). Assessment 2020: Seven propositions for assessment reform in higher education [online]. Sydney: Australian Learning and Teaching Council. http://www.iml.uts.edu.au/assessment.futures/Assessment-2020_propositions_final.pdf. Accessed June 29, 2016.

[11] Johnson, D. W, Roger, Johnson, T. y Smith K. A. (1991). *Active Learning: Cooperation in the College Classroom.* Interaction Book Company.