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Managing the transition towards the EHEA through learning-style assessment and the adoption of concept maps

Calafate, Cano and Manzoni
Universidad Politécnica de Valencia (UPV)
Spain

1. Introduction

Being the widespread adoption of the European Credit Transfer System (ECTS) imminent, it is now time to analyze in perspective the process of adaptation followed by the different participants. This process includes methodology adaptations, assessment of the effectiveness of the efforts taken, and drawing of appropriate conclusions, using them as feedback for further improvements.

In this chapter we describe how we managed the transition of a course from a Degree on Documentation towards the European Higher Education Area (EHEA) at the Technical University of Valencia, Spain. Our work includes (i) a preliminary characterization of the student population in terms of their learning styles, (ii) a strategy to modify the course by taking into account that preliminary analysis, and (iii) a proposal to improve the accuracy and fairness of the evaluation process.

Learning style assessment was based on a proposal by Felder and Silverman (Felder & Silverman, 1988), which defines four learning style dimensions: active/reflective, sensing/intuitive, visual/verbal, and sequential/global. To assess the learning style of our educatees, we set forth a web-based survey involving students from a Degree in Documentation, as well as from two Computer Engineering Degrees for comparison.

Based on information drawn from the learning-style characterization process and from class feedback, we proceeded to adapt a specific 5th year course to the European Higher Education Area, with a special emphasis on changes to theoretical and practical classes, as well as to the evaluation process, which is the main promoter of change.

We altered the characteristics of the course by emphasizing on two main items: (i) the design of concept maps (to describe highly theoretical course materials), and (ii) individual practical works, developed in the laboratory sessions, to be presented and defended in class. The practical work consisted of a project that was developed individually, and where students have flexibility for choosing their preferred development path. In that project a strong emphasis is given to autonomous decisions and to the practical use of the concepts learnt. The evaluation of this project takes into consideration (a) the degree of progress, (b) the student's skills and (c) the capacity of integrating knowledge.

With regard to concept maps, their adoption sought to offer the instructor an Ausubelian perspective of the knowledge acquired (Ausubel, 1968) by allowing students to externalize their own mental trees of assimilated concepts to a simple format.
In terms of evaluation, concept maps offer the evaluator great insight and help at detecting misunderstandings and flaws in the students' learning process. However, one of the main drawbacks when evaluating concept maps has to do with the subjectiveness in associating a score with one particular concept map. In fact, different instructors evaluating the same set of concept maps are prone to assign different scores within a relatively wide range of values. To introduce more objectiveness into the evaluation process we propose a systematic approach that helps at reducing score variability, thereby improving the fairness of the evaluation process.
Overall, we are greatly satisfied with our strategy and the results obtained, and we recommend other teachers to follow such a systematic approach to guarantee their success in similar endeavours.
This chapter is organized as follows: in the next two sections we provide all the required background, setting the scientific basis for our subsequent analysis. Hence, in section 2, we introduce the learning style theories developed by Felder and Silverman. In section 3 we briefly present the results from our survey on learning styles, allowing the reader to better understand the discussion that follows. Section 4 describes the target course, where we introduce a two-step methodology proposed for upgrading it from a traditional style to an ECTS style. Section 5 addresses concepts maps, including a framework for objective evaluation of concept maps. The effectiveness of the metrics proposed in Section 5 are assessed in section 6. Finally, in section 7, we draw the conclusions of this work.

2. Theory on learning styles

The learning style basically determines the preferred way for students to learn. Hence, by knowing the students' learning styles, instructors can fuel up the learning process by selecting the appropriate methodology.
Several authors have focused their research on students' learning styles. Authors such as (Witkin & Goodenough, 1981) relate the learning style to the physical characteristics of the individual, especially to the dominant quadrant of the brain, defining four learning dimensions. Other works, such as (Swassing et al., 1979), relate the learning style to the information representation system, defining three learning dimensions. (James & Gardner, 1995) associate the learning style to the type of intelligence, defining nine different learning dimensions. Finally, authors such as (Kolb, 1984) focus on how information is processed.
The work done by Felder and Silverman (Felder & Silverman, 1988), and in particular the four learning dimensions they have defined, is a reference in terms of theoretical modelling of the learning process, being used as a basis for the current study. Hence, we now proceed by defining in more detail each of the dimensions they have proposed.
With regard to the first dimension - *active/reflexive* -, active learners prefer practical activities, interacting with the outside world based on information gained through group works. Reflexive learners prefer to do an exam or some sort of mental processing of information gathered by them.
The second dimension - *sensitive/intuitive* - allows distinguishing between sensitive learners that prefer to memorize data and solve typical problems through standard procedures

(sensitive), from intuitive learners that prefer to seek for solutions to novel and complex problems by applying principles and theories. Moreover, the former acquire new concepts more easily.

The third dimension – *visual/auditory* - allows differentiating between visual learners, which prefer visual information since their retention and comprehension is improved, from auditory learners. The latter are on the opposite pole, and therefore must listen to information, besides verbalizing them (for example, explaining the concepts to others), in order to improve comprehension.

Finally, the fourth dimension categorizes students in terms of *sequential/global* learning. Sequential learners prefer information to be presented gradually, and by increasing order of difficulty, usually following a linear line of reasoning to solve problems. Global learners prefer than certain complex concepts are presented beforehand, thus obtaining a global vision of the existing interrelationships. Once concepts are assimilated as a whole, global learners are able to synthesize them more easily, which allows them to solve more complicated problems.

3. Survey results and statistical data analysis

Based on the survey initially proposed by Felder[1], in this section we characterize our students according to the four dimensions proposed by this author.

Felder's questionnaire relies on a total of 44 questions. Each question has two options, which are related to the different learning styles for a same learning dimension. So, the score obtained on each answer is assigned values of either -1 or 1. At the end of the questionnaire, and for each learning dimension, the scores obtained are added up. This means that score values are in a range that goes from -11 to 11, and that only odd values are possible.

We developed a fully automatic web survey system, based on Felder's, accessible from any terminal with Internet connectivity to reach all students in a simple and straightforward way. Moreover, the generation, storage and later treatment of data can be made automatic, saving both time and paper resources.

University degree	**Degree in Technical Informatics**	**Degree in Informatics**	**Degree in Documentaction**
Numerus clausus	400	150+50	75
Number of students	2156	1320	227
Number of participants	119	245	36
Participation ratio	5,5%	18,6%	15,9%

Table 1. Characteristics of the student population under analysis

1 http://www.engr.ncsu.edu/learningstyles/ilsweb.html

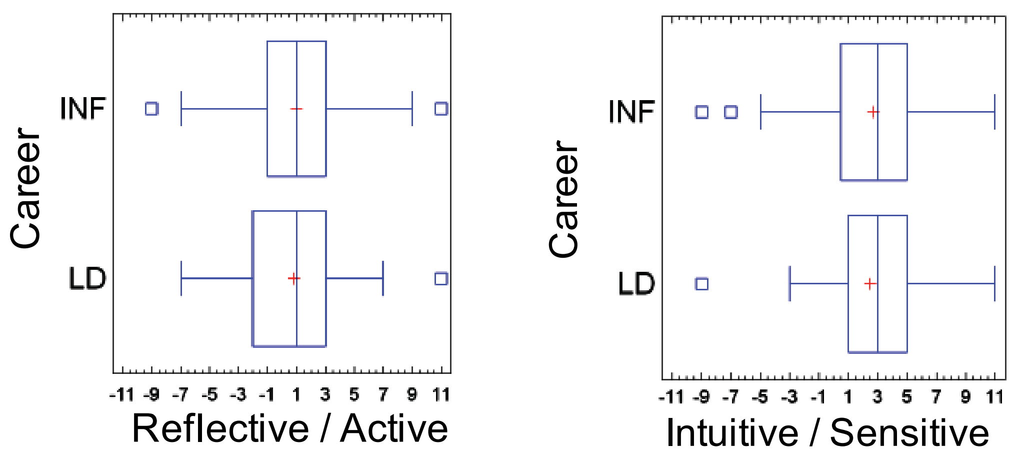

Fig. 1. Box plot for the active/reflective dimension (left) and the sensitive/intuitive dimension (right).

Concerning the student population, our survey involved students from two different degrees on Informatics and a degree in Documentation. The characteristics of the student populations under analysis are shown in Table 1. In the analysis that follows we grouped students from both degrees on Informatics since they present similar characteristics. With respect to the first dimension, Figure 1 (left) shows a box and whisker plot with the results obtained for both groups of students. Tags INF and LD refer to students from the degrees in Informatics and Documentation, respectively.

The box plot shows the values between the first and the third quarters, being the median represented by the line dividing the box in two. The cross represents the mean, and the squares near the edges represent atypical values (outside the range of normal values as defined by the box).

Statistical data show that the median and variance are similar for both student populations, though there is a better equilibrium for students of the degree in Documentation. As can be observed, in both cases there is a slight trend towards active learning methodologies. Such methodologies are currently experiencing great emphasis due to the changes introduced by the European Higher Education Area. Hence, we consider that such efforts are being conducted in the right way. Nevertheless, we should take into account that purely active methodologies are not the adequate solution and, therefore, an equilibrium between both methodologies must be sought when attempting to increase the effectiveness of the learning process by students.

With respect to the second learning dimension, Figure 1 (right) shows that, for this dimension too, there are strong similarities between students from both degrees, despite the presence of students leaning towards intuitive learning is more frequent in Informatics.

On the other hand, we should point out that, in both cases, about 50% of students show a lack of balance, leaning towards sensitive learning (information recollection). For a 25% of them the trend is quite worrying since it surpasses the 5 point threshold.

The small differences detected between both student populations are logical since it is expected that an engineers have developed more skills that allow them to use what they learned in completely new contexts, something not strictly required for students in the Degree in Documentation.

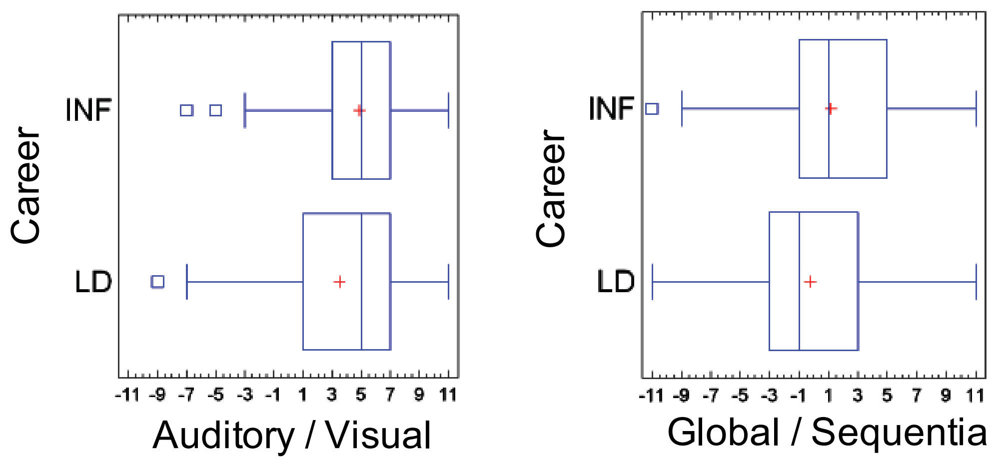

Fig. 2. Box plot for the visual/auditory dimension (left) and the global/sequential dimension (right).

Globally, we consider that the trend towards sensitive learning is quite worrying, and so alternative pedagogical strategies must be introduced so that students evolve in terms of intuitive processing of information as well, thereby achieving the desired balance.

Regarding the visual/auditory dimension, Figure 2 (left) shows clear differences between both student populations. In both cases, though, there is a strong trend towards visual learning. Moreover, for Informatics students, we find that it is difficult to find learners that prefer auditory information instead.

Globally we consider that, for this dimension in particular, the characteristics of students must be taken into consideration with the risk, otherwise, that they do not achieve the desired degree of comprehension and knowledge assimilation.

Finally, with respect to the last learning dimension (sequential/global), Figure 2 (right) shows that there are clear differences between careers. On both cases we are able to find students having difficulties to learn with one style or the other, which can be problematic when trying to set an optimum common strategy for classes.

In summary, we have analyzed the learning styles of students from two heterogeneous knowledge areas, finding that their characteristics are, in general, rather similar, being that a significant number of students presents learning problems when facing class styles strongly biased towards intuitive and auditory learning.

4. Details on the transition of our target course to the EHEA

In this section we describe the process we followed to adapt a traditional course from the Degree in Documentation – Information Organization and Networking – to an ECTS style course according to the guidelines defined by the European Higher Education Area (EHEA).

Instead of adopting a radical transition from a traditional educational paradigm to an ECTS style course, we preferred to do it in two steps. In the first step, and based on the student characterization we have done, we introduced several small changes to assess the responsiveness of students to different methodologies. Based on the feedback obtained from that process we then devised the most appropriate strategy to adopt for the second and decisive step heavily based on active learning and the use of conceptual maps. The choice on which methodologies to use on both steps depended heavily on the results of our survey on students' learning styles, which helped at identifying possible issues that could result as problematic.

We now briefly describe the course being adapted in terms of traditional contents and methodology. We proceed by detailing the changes introduced to the course on both steps of this process, evidencing the relationship between the methodologies introduced and the conclusions from our learning styles survey.

4.1 Course description

Information Organization and Networking is a course of the 10th semester in the Degree in Documentation. The number of students is typically reduced (between 10 and 20), which facilitates the introduction of active methodologies and alternative evaluation techniques.

Its learning goals include the understanding of the Web and the Internet, with emphasis on the different protocols involved in a client-server interaction.

The course is organized in five units as follows:

1. Computer networks and communication protocols
2. Basic applications in the Internet
3. Internet and the WWW
4. Client-side programming: HTML and Javascript
5. Server-side programming: ASP and PHP

Classes are organized in three types: (i) theoretical classes, (ii) practical classes and (iii) laboratory sessions. Theoretical classes (2 hours/week) follow the standard lecturing approach, which are complemented by practical classes (1 hour/week) where students use computers to solve small exercises that are quite meaningful in terms of knowledge assimilation. In laboratory sessions (2 hours every 2 weeks) students are guided to solve more elaborate problems based on the knowledge acquired on both theoretical and practical classes.

Concerning evaluation, it traditionally relied solely on a final exam that includes questions about all the course's contents. The characteristics of the course described up to now apply to all the academic years previous to the transition process promoted by the EHEA (up to and including 2004/2005).

4.2 Step 1: probing student's responsiveness to new methodologies (2006/2007)

Probing students for their responsiveness to novel methodologies is important to avoid introducing activities that do not offer the desired reward in terms of knowledge acquisition. Therefore, taking as reference the original course style, quite traditional in terms of contents and teaching style as referred above, the first stage of the adaptation process introduced gradual changes, proposing optional tasks with an emphasis on active methodologies.

By analyzing the characteristics of the five course units defined in the previous section, we identified two different areas requiring a different methodology: units 1 to 3, more theoretical, and units 4 and 5, more practical. Accordingly, we proposed to our students two different tasks:

Task 1. A research work on a subject related to the course (units 1 to 3).

Task 2. Design of a web involving uploading data from the client to the web server (units 4 and 5).

While the first task perfectly adapts to the theoretical nature of units 1 to 3, the second one is obviously practical as required. Both consisted in autonomous student works that fall under the category of active learning methodologies. Our choice was based on the EHEA guidelines and on the results of our survey related to the active/reflective dimension. We found it was effective at making students more participative in the class and also promoted learning. Since, as shown in section 3, a significant amount of students prefers reflective learning instead, we offered the possibility of doing these works alone or in groups, thereby improving adaptation to both learning styles. In fact, while some of the students were enthusiastic about working in group, others showed great relief by having the possibility of doing it alone.

For the first task, based on research of a related topic, presentation and defense before the class group was mandatory. The purpose was to promote auditory skills in those students presenting the work, a skill that was shown in section 3 to be often scarce.

This first task was evaluated by both students and instructors. Evaluation between peers is common in the research field and often at companies too, and so we considered that this sort of responsibility should be promoted while still at the university.

One of our dilemmas was how to make the effort required by this first task attractive to students in terms of final score, while maintaining the possibility of being evaluated through a single final exam (requirement of the educational center). After considering several different possibilities, we opted for an additive approach to the score: the work allowed adding up to 20% to the final score. We confirmed that such a generous strategy was indeed effective at getting students involved.

The second task, practical and autonomous by nature, directly replaced one of the questions in the exam. This strategy was successful too, being that all students attending classes participated in such tasks despite them being optional.

Finally, we surveyed the students from this course to have a feedback on their experience, emphasizing on the new activities introduced. About 90% of students participated, and the overwhelming majority expressed their satisfaction about taking part in the proposed activities.

4.3 Step 2: transition to ECTS (2007/2008)

Based on the experience acquired from both the first step experiments and the results from our survey on learning styles, we took a decisive step in transforming the course by eliminating the final exam and basing evaluation mainly on the work done by students throughout the course. This requires adapting the whole course to the new scenario, and completes the transition process towards an ECTS style course in terms of teaching methodology.

One of the challenges involved was finding evaluation methods that adapted to the course's characteristics. To evaluate the more theoretical part of the course, the strategy adopted for our previous task 1 was not appropriate since our purpose was to evaluate the understanding of the whole class material (instead of a specific research topic). So, we preferred using conceptual maps instead (Novak & Cañas, 2006). These we are able to grasp the degree of understanding that students have about the different concepts involved, and allow scaling up without much effort. Besides, the survey on learning styles shows that most students are prone to sequential and sensitive learning, a trend that we consider should be somehow countered. Development of conceptual maps forces students to gain a global vision of concepts for their execution, and also promotes intuitive learning. Hence, we consider that they positively affect the learning process.

For this endeavor we recommended using the CMAP tool[2] because it is freely available for different platforms, and also because it is specifically designed to support development of conceptual maps. In terms of evaluation, we measured the accuracy, complexity and completeness of the conceptual maps designed by students. These maps accounted for a 40% of the final score obtained in the course.

Concerning the practical part of the course, it was evaluated through a case study. The use of case studies in education has proved to be an adequate strategy (Kreber, 2001; Christensen, 1981). Also, they are one of the best alternatives to enforce active learning processes. In order to fully integrate the case study with the course's activities we altered the laboratory sessions contents so that they now focus exclusively on developing the case study proposed. That way we were able to decrease the amount of autonomous work at home, while increasing the participation in the laboratory sessions.

Since originally the course units related to the case study were only presented near the end of the course, we had to reorganize their ordering in theoretical classes to accommodate to the new requirements. So, the course is now organized as follows:

1. Basic applications in the Internet
2. Client-side programming: HTML and Javascript
3. Server-side programming: ASP and PHP
4. Internet and the WWW
5. Computer networks and communication protocols

In terms of concepts related to computer network, we initially followed a bottom-to-top approach, which had to be dropped in favor of a top-to-bottom approach. Since concepts are still presented in a sequential and coherent manner, we consider that this option does not affect students with either sequential or global learning styles.

In terms of score, the case study accounts for the remaining 60% of the mark obtained in the course.

Concerning results, we experienced a high degree of participation, being that the number of drop-outs was maintained at values close to those of previous years. Also, the know-how demonstrated by students by the end of the course was significantly higher compared to previous years, especially in terms of web development. In terms of the mean score, we did not appreciate any significant differences in neither of the steps.

From this experience we found that one of the issues requiring further scrutiny is the methodology to evaluate concept maps since it tends to be complex and subjective. This topic is addressed in the following section.

[2] http://cmap.ihmc.us/

5. Objective metrics for concept map evaluation

An important characteristic of concept maps is that they tend to be unique for every student. This means that different students should never provide a same representation of a same field of study, no matter whether they studied together, attended the same classes and did the same exercises. Such uniqueness aids at preventing plagiarism. However, uniqueness also prevents the instructor from doing a quick evaluation of their work since the object of evaluation is not right or wrong, being more complex, elaborate and precise in direct relation to the interiorization and understanding of the students about the concepts that are object of their study. Therefore, the evaluation process is prone to be complex, time-consuming and, in general, quite subjective.

In this section we set forth an experimental framework were we make use of 10 representative concept maps to derive a set of metrics that allow making the evaluation process of our students much more objective, as well as reducing the variability due to the different factors involved.

The concept maps used were developed by students for evaluation during the two previous academic years. These concept maps were then handed-over to five different instructors for evaluation using the traditional method. In terms of evaluation, we measured the accuracy, complexity and completeness of the concept maps designed by students.

The proposed evaluation technique attempts to mitigate evaluator-dependent variability by splitting the evaluation process into different steps, and defining a set of criteria and heuristics to assign a score to each of these steps. The proposed fragmentation of the evaluation process takes into consideration the different parts involved in creating concept maps themselves. We then derive a formula that aggregates the individual scores in a comprehensive manner.

5.1 Number and significance of the concepts

The first step when creating a concept map that describes, e.g., a course unit, is to discriminate the most meaningful concepts from the rest so as to make them the skeleton of the concept map created. Obviously, secondary concepts can also be included and indeed offer more richness to the concept map developed. Thus, the first step taken by the instructor should be to determine which are the most essential concepts (those that the student should not obviate), to list them and, finally, to count them. This number will be denoted as N, and for our experimental framework it takes the value of 32.

When analysing the concept map developed by an individual student, the instructor should first count the total number of essential (n_e) and secondary (n_s) concepts involved. Afterward, we propose using the following equation to derive a first score with regard to concepts:

$$S_1 = \frac{n_e}{N} \cdot \log_N (n_e + n_s) \quad (1)$$

This formula allows combining the student's effectiveness in detecting essential concepts with the total size of the concept map developed.

It is also important to define a maximum value (M_1) according to the instructor's criterion on what should be the maximum ratio between n_s and n_e to achieve the maximum score.

For our evaluation set we consider that, to get the maximum score, students must include four times as many secondary concepts compared to essential concepts. In such case the value of M_1 becomes:

$$M_1 = \log_N (N + 4 \times N) \tag{2}$$

Having thus defined the criteria for the evaluation of the concepts appearing in the concept map, we now move on to evaluating the relationships between these concepts.

5.2 Degree of meshness and relationship accuracy

The second step when creating a concept map is to relate the different concepts involved to construct a meaningful information structure. Usually a linear construction with no loops and minimal concept linking is considered as a poor construction, lacking the richness expected from well-designed concept maps. However, not all concepts have relationship with other concepts, and so the optimum number of relationships is usually much lower that the upper bound (R_{max}) for full connectivity between concepts. Notice that this upper bound is:

$$R_{\max} = \frac{n \cdot (n-1)}{2} \tag{3}$$

where n refers to the total number of concepts involved, that is:

$$n = n_e + n_s \tag{4}$$

Therefore, we propose a metric to assess the degree of meshness (DM) of the concept map that compares the total number of relationships (r) against the minimum number possible (R_{min}) in the following manner:

$$DM = \frac{r}{R_{\min}} = \frac{r}{n-1} \tag{5}$$

Notice that in very large concept maps very high degrees of meshness are untypical and even counter-productive due to visualization problems.

In Figure 3 we show the Degree of Meshness results for the different concept maps being evaluated. As can be seen, the values are typically quite low, being that most students do not go beyond 1.1.

Taking these results into consideration, we propose the following meshness score (MS) assignments according to the DM value obtained:

$$MS = \begin{cases} 0.7 & \Leftarrow DM < 1.04 \\ 0.85 & \Leftarrow 1.04 \le DM < 1.08 \\ 1 & \Leftarrow DM \ge 1.08 \end{cases} \tag{6}$$

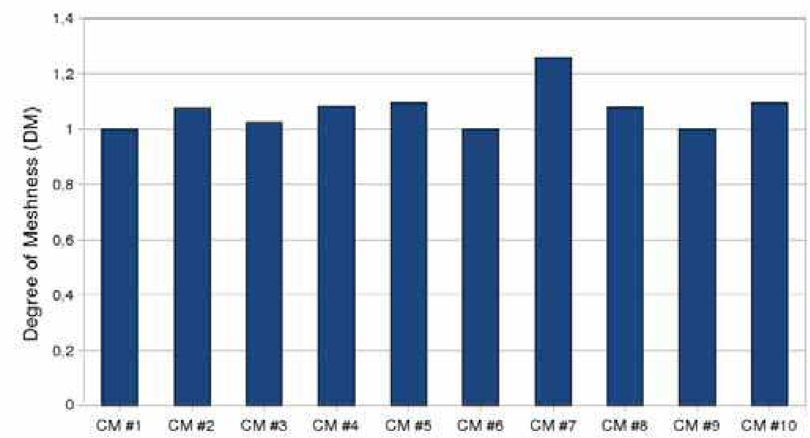

Fig. 3. Degree of Meshness values for the different concept maps under study.

The proposed score assignments penalize by 15% maps with low degree of meshness (less than 1.08), and by 30% maps with a very low degree of meshness (less than 1.04).
Besides the degree of meshness (*DM*), which is a strictly objective metric, a qualitative evaluation of the relationships proposed must also be introduced. This new metric, which we denote as Relationship Accuracy (*RA*), is a score between zero and one assigned by the evaluator where he/she subjectively evaluates the overall correctness and accuracy of the relationships proposed. So, while the *DM* metric attempts to detect whether the amount of relationships between concepts allows for a strong bonding between them, the *RA* metric reflects the coherence of such relationships. A straightforward way to obtain a value for *RA* would be to calculate the percentage of correctly defined relationships. However, when the relationships are correct but poorly defined, the evaluator should further refine such criterion.

5.3 Other quality factors

Besides the characteristics defined above, there are other quality details that illustrate the student's dedication and interest when creating the concept map, and are thus worthy of merit. Such quality details include (a) segregating the most important concepts from the rest through some sort of highlighting (font, color, box shape, etc.), (b) including representative figures or icons, and (c) linking to outside elements such as web pages, applications or even other concept maps.
The evaluator should thus establish some basic criteria for determining the quality parameter (*Q*), which takes this extra effort into account by assigning a score between zero and one. Nevertheless, the instructor should not invite an excessive decoration of the concept map that could become a drawback when achieving the ultimate goal of evaluating the assimilated concept mesh of the student.

5.4 Proposed formula for objective evaluation

Up to now we have described a set of metrics that are related to each of the three steps involved in creating a concept map: (a) concept definition, (b) relationship definition, and (c) the introduction of auxiliary information (highlighting, figures, links, etc.). Based on those metrics, we now proposed a final formula that seeks to integrate these different metrics in order to assign the students' concept maps a final score. The proposed formula is the following:

$$Score(\%) = \alpha \cdot \frac{S_1}{M_1} + \beta \cdot MS \times RA + \chi \cdot Q \qquad (7)$$

where α, β and χ are weights between zero and one assigned to each of the three components of the evaluation. Obviously, these three weights should add up to one, and in general we recommend to evenly split most of the weight among the first two factors, and provide a residual weight to χ depending on the topic and requirements. In particular, for our case study we have used values $(\alpha,\beta,\chi)=(0.6, 0.35, 0.05)$ since they fit all of our basic requirements.

6. Validation of the proposed metrics

The final step required was to validate the objective metrics proposed through a set of experiments whose purpose was to assess their effectiveness at achieving two different goals: (a) to reduce the score variability associated to the specific instructor involved in the evaluation process, and (b) to maintain a similar average mark as for the legacy technique (the metrics should not make the evaluation process significantly more generous nor significantly more punitive).

With these goals in mind we re-evaluated the 10 concept maps used for our analysis relying on the proposed set of metrics instead. Thus, these concept maps were handed-over to five different instructors, which were asked to evaluate them with and without the objective metrics proposed.

The results obtained are presented in the box and whisker plot shown in Figure 4.

In terms of the average score, the two crosses shown in evidence that the differences are low (less than 6%); the trend towards lower values achieved with the objective metrics is expected since more strict criteria tend to decrease the scores. With respect to the median, though, its value remains practically unaltered.

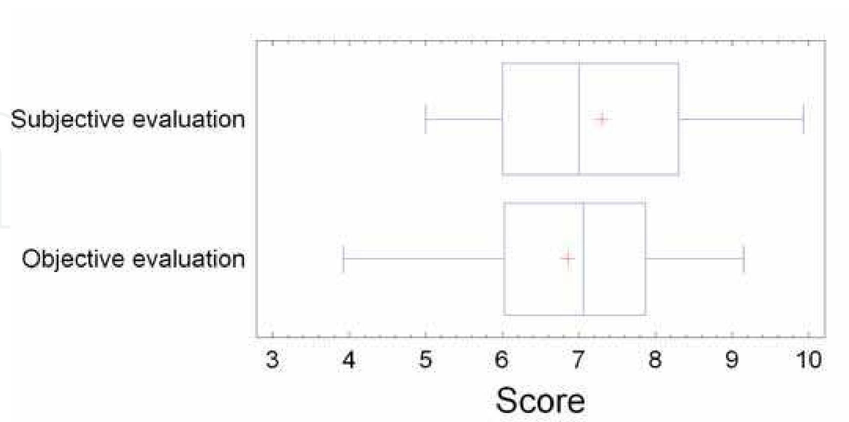

Fig. 4. Box and whisker plot representing the student's scores obtained through both subjective and objective evaluation methods.

Minimal differences were also found in terms of standard deviation values (1.324 vs. 1.356). However, the objective evaluation results distribution has a slightly wider range than the subjective evaluation process, despite the inter-quartile range is slighted reduced. This is because the kurtosis of the distribution is reduced to about half.
With respect to instructor-dependent variability, Table 2 shows a summary of results that highlight the improvements achieved at reducing the differences between different evaluators in terms of score when the proposed objective metrics are used.
The standard deviation value shown refers to the scores assigned by different evaluators. As can be seen, the objective metrics proposed offer a 45% reduction for this parameter. In terms of min-max differences, we see that the average values have been reduced by 47%, while the top min-max difference was reduced by 2.24 points over 10 down to 2.14. This means that, for all the concept maps evaluated, the differences between two evaluators in terms of score for a particular concept map was never greater than 2.14 points over 10.
Despite the benefits of our solution are evident, further refinements should be developed to reduce differences between evaluators to a minimum.

Metric	*Subjective evaluation*	*Objective evaluation*
Range	4.93	5.24
Standard deviation	1.12	0.62
Avg. Min-max difference	2.76	1.46
Top Min-max difference	4.38	2.14

Table 2. Summary of improvements of the objective metrics proposed at reducing the differences between different evaluators.

7. Conclusions and guidelines for future research work

In this paper we presented the process followed to adapt the course Information Organization and Networking, belonging to the career Degree in Documentation of the UPV, from a traditional style to an ECTS style according to the guidelines of the European Higher Education Area.
To accomplish our goal we first surveyed the student population to assess their learning styles according to a taxonomy proposed by Felder and Silverman. We then proceeded to adapt the course in two steps (two consecutive years). In a first step we introduced optional works related to active learning methodologies with a probing purpose: assessing the responsiveness of our students. The success experienced in terms of participation ratio and survey results motivated us into proceeding to the second and final step, where the final exam was eliminated and active learning methodologies where introduced. Evaluation relied instead on two autonomous works. To handle the acquisition of knowledge of a more theoretical nature we proposed developing conceptual maps. Practical skills in terms of web programming were evaluated through a case study developed in laboratory sessions and at home.

When the new EHEA course was at the end of its first year of activity we noticed that evaluating concept maps was a rather difficult task characterized by great variability. To mitigate this problem we presented a novel strategy to reduce the subjectiveness associated with the evaluation of concept maps. The strategy basically consists in splitting the evaluation process into different steps, and defining a set of criteria and heuristics to evaluate each of these steps. The proposed partitioning technique takes into consideration the different parts involved in creating concept maps themselves. Our proposal includes a formula that is able to integrate these different parts in a comprehensive manner to generate the final score.

To validate the formula developed we make use of several concept maps developed by our undergraduate students; these concept maps were part of the evaluation process in two previous years, representing a 40% of the final score. Comparing the evaluation results obtained with five different reviewers we found that our systematic approach aids at reducing the differences of these results by up to 23%. Such achievement demonstrates the effectiveness of the proposed objective metrics at mitigating evaluation subjectiveness.

Additionally, we found that the objective metrics proposed do not cause the mean and the standard deviation of scores to suffer relevant differences, thus achieving the expected goal in this matter too.

Overall, we are greatly satisfied with the results obtained and the degree of student participation, and we recommend other teachers to follow such a systematic approach to guarantee their success in similar endeavours.

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Edited by Aleksandar Lazinica and Carlos Calafate

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The widespread deployment and use of Information Technologies (IT) has paved the way for change in many fields of our societies. The Internet, mobile computing, social networks and many other advances in human communications have become essential to promote and boost education, technology and industry. On the education side, the new challenges related with the integration of IT technologies into all aspects of learning require revising the traditional educational paradigms that have prevailed for the last centuries. Additionally, the globalization of education and student mobility requirements are favoring a fluid interchange of tools, methodologies and evaluation strategies, which promote innovation at an accelerated pace. Curricular revisions are also taking place to achieved a more specialized education that is able to responds to the society's requirements in terms of professional training. In this process, guaranteeing quality has also become a critical issue. On the industrial and technological side, the focus on ecological developments is essential to achieve a sustainable degree of prosperity, and all efforts to promote greener societies are welcome. In this book we gather knowledge and experiences of different authors on all these topics, hoping to offer the reader a wider view of the revolution taking place within and without our educational centers. In summary, we believe that this book makes an important contribution to the fields of education and technology in these times of great change, offering a mean for experts in the different areas to share valuable experiences and points of view that we hope are enriching to the reader. Enjoy the book!

How to reference

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InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820

Fax: +385 (51) 686 166
www.intechopen.com

Fax: +86-21-62489821

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