Analyzing the students' preferences in an active-learning experience

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Abstract— In order to improve the students' motivation and their learning process a new student-centered methodology was introduced in a subject of Computer Science Engineering. It proposes a set of activities based on the combination of different autonomous and active learning techniques. From the methodology perspective, it is to provide them a continuous feedback about the obtained results and to consider the students' learning style to select the activities. To achieve these goals, we have combined questionnaires for identifying learning styles, conceptual maps for representing the acquired knowledge during the fulfilment of activities, and semantic technologies for the automatic assessment of this learning. Besides, a Web and service-oriented tool, called M-eRoDes, has been developed to support the proposed activities and to implement the evaluation system based on conceptual maps. The experience carried out proved that the desired improvements have been achieved.

Keywords—learning styles, semantics, learning technologies, conceptual maps, active learning.

I. Introduction

Computer Science Engineering teaching promotes the launch of different strategies to motivate students and foster the development of their transversal and formative competences. These teaching-learning strategies are usually based in the combination of information technologies and the use of active methodologies. The experience demonstrated that this approach has positive effects in the students [1]. They feel more motivated and they involve themselves in their learning process. However, from the teacher point of view, several key issues must be solved in order to follow a successful teaching-learning process. First, the students must receive a continuous feedback about their progress. The lack of tools for this feedback could generate an unmanageable amount of work. Secondly, it is necessary to know if the students acquire some basic transversal competences, like being part of a team, communicating effectively, being autonomous, etc. However, a third key issue is that not all the students learn in the same way, nor achieve the aims of the course in the same manner.

In this paper, we present a teaching-learning experience based in the use of ICT technologies and active methodologies in order to solve the previous commented issues. The experience has been developed in a subject of the last course of Computer Science Engineering, so that, the students already have several transversal competences necessary to tackle an active learning model (second issue). From a methodological point of view, the proposal consists, initially, on a program of several collaborative activities in which the students learn the formative aims of the subject and enhance the transversal competences. As part of the activities, conceptual maps are used for representing the knowledge [2] [3] and semantic technologies are used [4] to give continuous feedback to the students about their progress (first issue). Moreover, the learning style of the students is investigated (third issue), in order to identify and understand their preferences of different activities, and to assess if the proposed program is suitable for their characteristics [5]. The paper describes the context of the experience and the purpose of the study in Section 2. Section 3 explains the methodologies followed during the course. Section 4 presents and discusses the findings and results obtained, addressing the three issues previously commented. And, finally, Section 5 presents our conclusions.

II. Context and Aim of the Experience

This experience was carried out in the subject "User Centered Design. Design for Multimedia (DCU)" (4^{th} course, Computer Science Degree). The number of students registered in this subject is around 15 and 20 per course. For the last three courses, different student-centered didactic strategies have been introduced in the subject in order to actively involve students in their learning process and to increase their motivation [6]. The method proposed consists of different kind of activities including master classes, hands-on labs, project presentations and the creation of video resources for their classmates to learn with them. This approach differs from the usual scenario in which the teacher is the responsible of

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preparing the resources for the students. We consider that the guided searching of material available in the Internet, the generation of new resources using those materials, and that they are used by their classmates to understand and go deeper in new concepts, would be a stimulus for the students. The DCU subject facilitates this approach since one of its aims is to learn how to use and develop multimedia materials. Therefore, the creation of new learning resources becomes a specific application case.

Another key question is the method to evaluate the different activities. It is important that the students could receive an immediate feedback about the knowledge acquired. Due to the amount and variety of activities carried out in the course, it is desirable to have a continuous and automatic assessment. For this purpose, conceptual maps were proposed for representing the students' knowledge and a software system based in techniques of semantic similarity between conceptual maps was designed and implemented. The learning indicators obtained with this software allow quantifying the utility of the video resources for understanding or deepening the related concepts. In addition to assessing the students' acquisition of knowledge, it is important to know if the different activities were considered useful, interesting, difficult or motivating. These results are estimated by several opinion surveys and by questionnaires to determine the learning style of our students.

III. Methodology

In this section, a set of learning activities combining different active methodologies developed for involving students in their learning process is presented. The activities carried out with the students during the course 2016-17 in the subject "User Centered Design. Design for Multimedia", which are relevant for the purpose of the study, are following described in detail.

In first place, at the beginning of the course, students fulfilled two different questionnaires to identify their learning styles [7]: the CHAEA questionnaire [8] that considers four learning styles: active, reflexive, theoretical and pragmatic; and the Felder and Silverman questionnaire [9] that determines the preferred learning style in bipolar scales: active-reflective, sensing-intuitive, visual-verbal and sequential-global.

During the course, different kind of activities that varies from traditional master classes, to guided laboratory practices, flipped classes, debates, written reports, presentations, etc., have been carried out. Following, as an example, Fig. 1 describes a specific sequence of activities proposed to the students for creating learning resources and sharing and studying new concepts with them. This proposal incorporates team work aspects, individual work and peer and self-assessment.

In the Initial phase, the teacher proposes different topics for generating a learning video resource (VR). The students have to organize themselves in groups of three persons, attending to their preferences.

In the First phase, the team works in the search and classification of resources and materials that could be useful to create the learning video resource. The generation of the VR includes the creation of the storyboard, the generation of the audiovisual resource in video format, the generation of a conceptual map (CM-Ref) that represents the knowledge that should be acquired with the VR, and a multiple-choice test that facilitates the assessment to the learners' resource.

The Second phase of the activity is individual. A student must visualize the video created by the other groups and learn the subject's topics using these videos. For each one, the student must create a conceptual map (CM) that represents his/her understanding after working with the learning video resource.

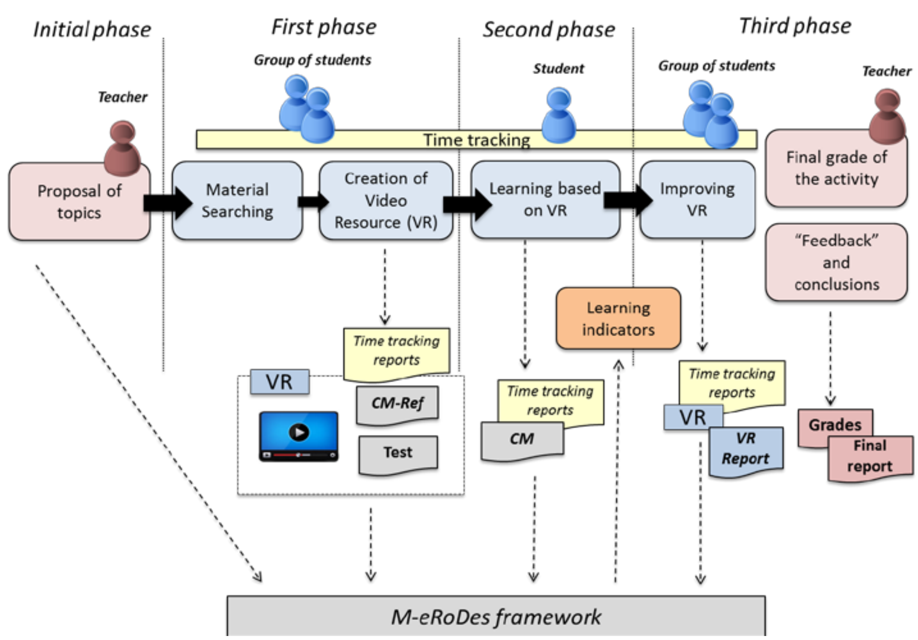

Fig. 1. Sequence of activities for the creation and use of learning video resources

The Second phase of the activity is individual. A student must visualize the video created by the other groups and learn the subject's topics using these videos. For each one, the student must create a conceptual map (CM) that represents his/her understanding after working with the learning video resource.

Finally, the Third phase corresponds with the improving of the video resources, in which students use the learning indicators and the feedback obtained by the teacher and their classmates, to elaborate a second version of their learning video resource. Each group also generates a written report with the process followed for the creation of the resource.

During all the phases, the teacher provides guide, helps and supervises the students' work in the practice laboratory classes and in tutoring sessions (either face-to-face or by e-mail).

All this set of activities is technologically supported by M-eRoDes software system [10][11]. The developed software is a service-oriented framework based on last generation Web technologies, semantic and multimedia technologies. The functionality of the system has been integrated in a Web application that allows teachers to program and control the course activities and that allows students to participate in these activities and to access to their evaluations. More specifically, M-eRoDes provides support to: manage courses and users (teachers and students), create and store learning resources, relate resources with courses and users, create and stores conceptual maps (reference CM and final users CM), and automatic analyze students' progress by comparing conceptual maps using different algorithms based on similarity techniques and graph theory [12]. The result is a set of learning indicators that provide students feedback about their learning process. The similarity algorithms use the WordNet [13] and WordNik [14] databases. Moreover, M-eRoDes semantically labels the available resources attending to their concepts and relationships, and classifies them according to the IEEE-LOM standard [15], enabling their management in the different activities.

Throughout the course, and while the different activities have been performed, several opinion questionnaires have been requested to the students in order to verify their perception of different aspects of the experience: to assess the work develop by their own group (self-assessment of the created resource, the conceptual map and the test generated by the team, and also about the functioning of the working group), to assess the resources created by their classmates (peer-assessment of the contents and quality of the resources and tests created by the other groups), and, finally, a general assessment about all the activities carried out in the subject.

IV. Findings and results

In this section, the results of the experience are presented, after analyzing in detail the different aspects and assessment methods. The most interesting findings regarding the students' learning styles, the learning indicators automatically got, and the analysis of the opinion questionnaires, are exposed.

The results of the learning styles of our students, considering the CHAEA questionnaires are shown in Table I and commented below.

Style	Average	Scale (Informatics)
Active	9,41	Low
Reflexive	16,59	Moderate
Theoretical	14,65	High
Pragmatic	13,06	Moderate

TABLE I. CHAEA LEARNING STYLES.

Respecting the specific preferences of the group, we can highlight the following aspects:

- The average is "High" in the Theoretical style, but it is interesting to remark that 59% of the students show a "Very high" preference and 41% "Moderate" preference, with no "Low" or "Very Low" values.
- Either in the Reflexive and the Pragmatic style, the "Moderate" preference prevails (58% of the students).
- There is a very low preference of the Active style, with 52% "low" and "very low".

Considering these results, this group will have higher preference for working in structured situations and with a clear purpose. They prefer to work with data and models, establishing relationships between them and they require enough time to do this work with accuracy and rigor. They like to have the possibility to ask and question, and to face and unravel complex situations. The very low preference of the Active style suggests that they could have difficulties when facing new challenges without clear aims or for taking risks.

On the other hand, the Felder and Silverman questionnaire presents the following results regarding the students' group preferences:

- Regarding the pair Active-Reflective, only 5% of the students present "Very high" preference and 25% show "Moderate" preference for the Active style, against 10% of the reflexive style. In this duality, 60% show a balance between both styles (coinciding with CHAEA results).
- Analyzing the pair Sensing-Intuitive, the results show that 10% have "Very high" preference and 45% "High" for the Sensing style, with no High preferences of the Intuitive style. The Sensing style defines similar characteristics to the CHAEA Theoretical style, so that the results point in the same direction.
- There is a relevant preference for the Visual style (35% "Very high" and 40% "High"), with no cases of Verbal preference. Therefore, the students would remember better visual references as images, diagrams, films, timelines… against verbal information that they retain with more difficulty.
- The results about the Sequential-Global pair are not relevant, although there is a trend to Global.

All these results partially coincide with the research Felder and Silverman done specifically for engineering students, which have Sensing and Visual preferences. However, they don't coincide in the Active preferences of engineering students, as has been previously commented.

Following, the main considerations after analyzing the

	Est 1	Est 2	Est 3	Est 4	Est 5	Est 6	Est 7	Est 8	Est 9	Est 10	Est 11	Est 12	Est 13	Est 14	Est 15	Est 16	Est 17
CCD	0,31	0,14	0,27	0,35	0,27	0,29	0,46	X	X	0,34	0,34	X	0,36	0,23	0,29	0,28	0,47
C-S	0,43	0,23	0,42	0,53	0,42	0,42	0,66	X	X	0,57	0,5	X	0,53	0,33	0,42	0,47	0,66
R-S	0,13	0	0	0,13	0	0	0	X	X	0	0	X	0,13	0	0	0	0,13
CaS	X	X	X	0,23	0,33	0,34	0,3	0,32	0,07	0,14	0,34	0,44	0,3	0,42	0,49	0,58	0,46
C-S	X	X	X	0,43	0,51	0,48	0,44	0,48	0,11	0,21	0,51	0,63	0,48	0,58	0,63	0,75	0,61
R-S	X	X	X	0	0,14	0,14	0,14	0	0	0	0,29	0,14	0	0,14	0,14	0,57	0,29
GI	0,3	0,14	0,21	X	0	0,23	0,21	0,26	X	0,07	0,32	0,28	0,29	X	0,33	0,18	0
C-S	0,4	0,2	0,3	X	0	0,33	0,3	0,37	X	0,1	0,43	0,37	0,37	X	0,47	0,25	0
R-S	0,11	0	0	X	0	0	0	0	X	0	0,11	0,11	0,11	X	0	0	0
MI	0,28	0,18	0,35	0,36	0,26	0,52	X	0,4	0	0,22	0,37	0,36	0,38	0,57	X	X	0,26
C-S	0,41	0,31	0,51	0,54	0,38	0,73	X	0,58	0	0,38	0,51	0,54	0,61	0,75	X	X	0,38
R-S	0	0	0,13	0,13	0	0,13	X	0,13	0	0,13	0,25	0	0	0,25	X	X	0
HRI	0	0	0,15	0	X	0	X	0,3	0	0,25	0	0,16	X	0,09	0,43	0,27	0,21
C-S	0	0	0,23	0	X	0	X	0,47	0	0,42	0	0,23	X	0,13	0,66	0,42	0,32
R-S	0	0	0	0	X	0	X	0	0	0	0	0	X	0	0	0	0
BCI	0,25	0,11	0	0,2	0	0,22	0,25	0,43	0,13	X	0,11	0,29	0,38	0,21	0,51	0,31	0,32
C-S	0,33	0,19	0	0,29	0	0,33	0,4	0,62	0,19	X	0,19	0,37	0,43	0,33	0,64	0,47	0,47
R-S	0,13	0	0	0	0	0	0,13	0,13	0	X	0	0,25	0,25	0	0,25	0	0
WD	0,26	0,21	0,32	0,26	0,12	X	0,31	0,26	0,47	0	X	X	0,35	0,46	0,15	0,51	0,23
C-S	0,41	0,31	0,48	0,44	0,21	X	0,44	0,48	0,69	0	X	X	0,51	0,58	0,21	0,73	0,33
R-S	0,17	0	0,17	0	0	X	0	0,17	0,33	0	X	X	0	0,5	0	0,5	0

TABLE II. LEARNING INDICATORS OBTAINED AFTER THE ASSESSMENT OF THE CONCEPTUAL MAPS.

Activities	**Mean**
Attention to master classes	4,76
Team work	4,15
Guided practices in pc lab	4,11
Search and selection of the material for the video resource	4,15
Produce the video storyboard (contents)	3,80
Produce the video resource (technical aspects)	4,11
Create a test about our own video resource	3,45
Create conceptual maps	3,75
Fulfill the tests of the video resources created by the other groups	4,11
Generate written reports	3,80
Do oral presentations or work defenses	4,00

TABLE III. STUDENTS' PERCEPTION ABOUT THE USEFULNESS OF THE ACTIVITIES.

results of the students' learning indicators automatically obtained with M-eRoDes system are presented. Table II shows the indicators calculated after assessing the conceptual maps created by each student (CM) against the reference conceptual map created by the teacher or the creators of the video resource (CM-ref).

Each column represents the indicators obtained by a specific student; while the rows correspond to the learning video resources used in the teaching-learning process (CCD: Child-Centered Design, CaS: Context-aware Systems, GI: Gestural Interaction, MI: Multimodal Interaction, HRI: Human-Robot Interaction, BCI: Brain-Computer Interface and WD: Wearable Devices). For each resource, the first row shows the global result, and the two following rows present the concept-similarity (C-S) and the relation-similarity (R-S) indicators, respectively. The quantitative results are automatically translated into colors for a better interpretation for teacher and the students: red represents and insufficient learning, yellow indicates that learning must be improved and green a suitable learning. The threshold of the colors is customizable by the teachers, and in this case has been decided from the experience of previous courses. Finally, the cells marked with "X" represent that the student does not completed that activity.

A global analysis of the indicators allows detecting problems in the learning process. On one side, the persons with more red indicators (for example students 2 and 9) are students that don't work enough the resources or that had not been able to represent with conceptual maps the acquired knowledge. On the other hand, if the reference conceptual map (CM-Ref) was not elaborated correctly (it does not reflect the main ideas of its contents), then the resource used to obtain bad results (for example the resource "Human-Robot Interaction", HRI).

Another important fact that can be deduced after analyzing the indicators is that, in general, students are able to identify the key issues of a resource (C-S, "Concept-similarity"), but they have lot of problems to represent the relationships between those concepts (R-S, "Relational-Similarity"). The process of correctly represent the relationships is complex and requires a deeper level of reflection and maturity. Besides, the skills and the experience of the students working with conceptual maps, also influence in the results; and, in our case, most of the students have not work with this kind of knowledge structures before.

Finally, we present the results of the analysis of the different questionnaires used in order to know the opinion and perception of the students about the different tasks and activities performed during the entire course. Following the more relevant results are commented.

A survey was given to the students to indicate their perception about the easiness and the utility of each activity. A Likert scale was used, with values from 1: no easy/no useful to 6: very easy/very useful).

The results of the usefulness of the activities are presented in Table III.

The most well-valued activities have been, curiously, the attention to master classes, followed by the team work together with search and selection of the material for the video resource. The activity that they consider less useful is to create a test about their own video resource, although they give a considerable higher punctuation to fulfill the tests created by the other classmates. It is also interesting to notice that the activity of creating conceptual maps obtained the penultimate position regarding usefulness.

The results obtained about easiness are not shown in a Table since they do not present surprises. The mean scores of each activity range from 3.50 the lowest (Create Conceptual Maps) to 5.44 the highest (Guided practices in a pc lab). The order clearly corresponds with the requirement of time, work and commitment.

Regarding the opinion of the students about the easiness and utility of the use of conceptual maps as a tool for representing knowledge, 55% of the students perceived the generation of conceptual maps as a difficult task (values between 1-3) while 60% found it useful (values between 4-6).

In general, these results are highly correlated with the results of the preferences in learning styles obtained with the CHAEA and Felder and Silverman questionnaires. The order in the utility of the activities is directly related with the Theoretical style preferences. In addition, the easiness is directly related with their learning styles, since the guided and structured activities are the easiest for them (against the more creative and unstructured ones).

Finally, we were very interested in the level of motivation and involvement of the students in the experience. For inquiring about these issues, two open questions have been asked in anonymous surveys:

1- Would you participate again an educational experience in which you have to create video learning resources?
2- Would you recommend this experience to other colleagues? Why?

The answers of these two questions are very encouraging. 89% of the students commented they would participate again in developing their own learning resources and they would recommend other persons to be involved in this kind of experience. It is interesting to go deeper in the reasons for recommending this experience. More than 62% considers that the creation of the resource allow them to acquire deeper knowledge, that was one of the objectives of proposing these kind of activities. 56% considers very important that the experience made them put in the place of the learner, allowing them to learn while the others learn. Only 18% focused their responses in more technical aspects, commenting that the experience allows them learning the use of multimedia edition programs.

V. CONCLUSIONS

In this paper, a set of activities based on the combination of different autonomous and active learning techniques and considering the learning styles of the students, has been presented. The main goal of these activities is to make students play a relevant role in their teaching-learning process by increasing their motivation, promoting autonomous learning and self and peer-assessment. The plan of activities for carrying out this process includes: team work, creation of educative resources, visualization and learning from the classmates' created resources, knowledge representation using conceptual maps. These activities have been automated in a service-oriented framework, called M-eRoDes, which is based on the integration of web, semantic and multimedia technologies. M-eRoDes also provides the students with an automatic continuous feedback about their learning progress by using conceptual maps for knowledge representation.

The findings and results of the experience reflect that students are motivated and value positively the use of new and active methodologies. They are satisfied with their active and protagonist role, and with the video resources created. These perceptions and opinions coincide with the results of the learning styles questionnaires, since they value the sensing and visual aspects, and therefore the multimedia resources are attractive to them.

However, we must think about the assessment method based on conceptual maps. The students do not perceive easy to elaborate conceptual maps. Although considering Felder and Silverman styles, conceptual maps could be interesting for sensing and visual styles, the CHAEA moderate preference of the pragmatic style may contribute in this perception of difficulty.

The analysis of the groups' learning styles helped us to understand the activities preferred by the students. Nevertheless, in the near future, the goal is to consider the students' learning styles for designing different set of activities specially designed and customized for them.

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