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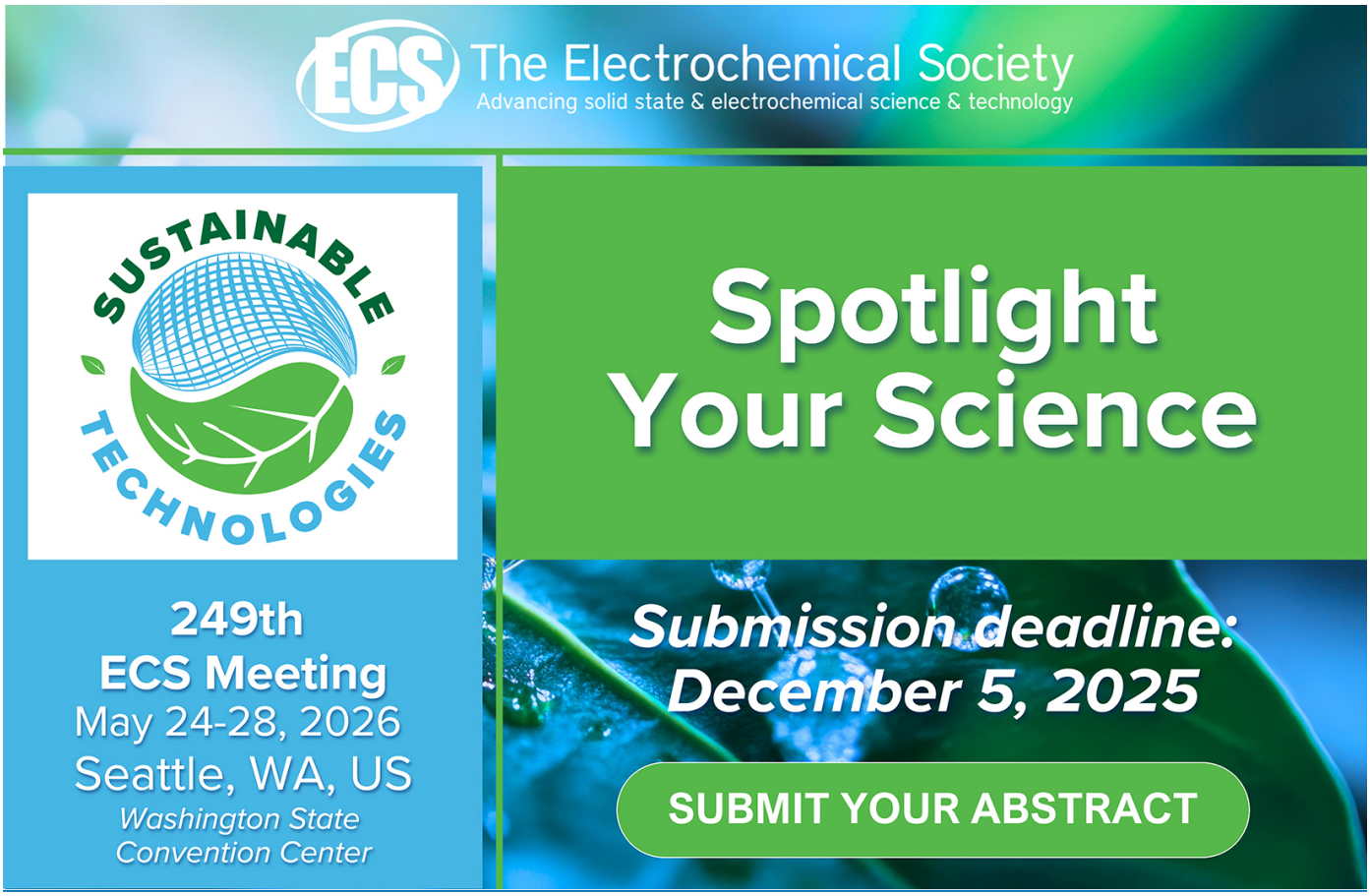
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Teaching based on models and transformations under the active learning approach

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Abstract. Requirements engineering is a fundamental part of the software development cycle and, therefore, must be present in the curricula of systems engineering programs. In this document, a set of training situations based on active learning principles is presented to facilitate the teaching of requirements engineering. In the application of the methodology, the subjects of the software engineering line of the systems engineering program of the "Universidad Francisco de Paula Santander, Ocaña, Colombia" were used, guiding the process for teaching requirements engineering in agile environments with a view from the model driven engineering and its implementation in a virtual environment as a complement to the face-to-face classes. The strategy allowed participants to be organized in teams to improve requirements engineering learning. An activity guide based on scenarios with real problems was used, which allowed to strengthen the relationship between theory and practice of the subject to generate models and transform them into the search for solutions to problem domain under study.

1. Introduction

The main objective of requirements engineering is to obtain information that allows the identification and understanding of the system to be developed. The obtaining of requirements allows to recognize the domain of the problem, and this way to understand what the client really wants and needs. This collection is critical, since the cost of incorrect requirements is very high [1].

Agile software development methodologies differ from traditional models such as waterfall or spiral, in that they allow increased flexibility to change requirements during the software development stage. In an agile cycle, the communication factor improves, because the iterations involve the client before the product is completed [2]. The application of an agile approach in requirements engineering and the use of models allows to address solutions with multiple perspectives in relation to the analysis of the problem domain [3] The teaching of requirements engineering has faced challenges. That is why the use of active learning approaches has gained interest, to propose practices that improve modeling activities in requirements engineering [4].

Active learning is a teaching proposal that gives students active participation in the academic process, enabling them to apply the concepts learned in real situations, as well as to make decisions, solve problems, formulate solutions and make judgments, all this in the midst of a controlled teaching but at the same time open to the exploration and achievement of intellectual processes of higher order. Active learning is promoted through constructivist pedagogical approaches [5] and constitutes an academic

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process where higher order intellectual activities are involved, allowing the student to achieve cognitive states such as analysis, interpretation, synthesis, application and deduction, mastering knowledge until being able to use it in a concrete situation.

The systems engineering program of the "Universidad Francisco de Paula Santander (UFPS)", Ocaña, Colombia, has been carrying out a curricular evaluation process with a view to obtaining accreditation of the program by the "Ministerio de Educacion Nacional (MEN)", which has led to changes in the development of subjects using didactic strategies at the teaching level. In the case of the subjects in the software line and especially the teaching of engineering requirements, and after analyzing the learning process and identifying the difficulties, the initiative was taken to implement changes that would result in improvements in the execution of classroom projects, finding in the active learning methodologies, the appropriate tools to implement strategies in the classroom that would contribute to overcoming the difficulties encountered, enhancing the skills of students.

This document presents a set of techniques and training situations to be applied in the development of software projects and especially in the initial phase, the requirements engineering, which allows students to live the learning in a meaningful way in real contexts, combining theory with practice, in a dynamic to bring the student closer to his professional activity.

2. Background

2.1. Active learning

According to Coloma & Tafur [6], active learning is the academic exercise that allows the incorporation of useful knowledge into the life of the individual, from authentically planned learning activities in such a way that the student must be actively involved in the construction of knowledge and the resolution of situations framed within the real environment.

Active learning is part of the currents derived from emerging pedagogical theories, specifically within constructivist theories. In the principles postulated by Vigotsky [7], it is found that students are given a certain degree of responsibility and independence in the exercise of learning, leading them to assume a role as active participants in the academic process, and indicates that the acquisition of knowledge in a constructivist manner enhances capacities at the interpsychological and intrapsychological levels, leading the individual to the development of higher psychological functions.

Thus, in Serrano & Pons [8], we find Brunner (1964), who affirms that discovery turns the subject into an active participant in the learning process and allows him to construct new schemes of knowledge, but also turns him into an independent being capable of self-gratification; he also considers that learning is achieved through active experiences coming into contact with the environment, where comprehensive memory is the basis for new learning.

For Duart & Sangrá [9], the constructivist approach is not only an approach that leaves aside the memorization of concepts, it is a theory that surpasses the acquisition of knowledge, to lead the student to gradually acquire autonomy, so that he learns to learn. This concept is closely related to what Ledesma [10] calls "mediation", where the transformation of the scopes of both the teacher and the student are rewritten around a learning situated at one's own pace to advance, the interests and potentialities of the student.

Porlan, Martín & Rivero [11], classify constructivism in: "cognitive constructivism based on Piaget's psychology and genetic epistemology" and "constructivism of socio-cultural orientation", postulate that considers the construction of knowledge as an individual and internal process, led by the learning subject, where the structures of ancient knowledge are relevant, since they allow the acquisition of new knowledge, when they are activated by the learning process and where their evolutionary development is related to their mental and constructivist attitude, the environment being a space that hinders or favors learning.

A second approach known as social constructivism or socio-constructivism inspired by the ideas of Lev Vygotsky, who confers to the cultural context in which the student develops, influence the progress of the individual, considering that its evolution is highly related to the conditions of the environment.

This author introduces the concept of proximal development zone, transforming the roles of the learner and the counsellor in the teaching-learning process, paving the way for active learning practices.

In any case, it is not a question of comparing one approach and another, but of understanding the theoretical contribution that each one contributes to the study of active learning and with this interpretation to recreate the strategies that allow the students of the systems engineering program to orient themselves in the practices of active learning, recognizing the connection that is found between this and constructivist practices. But is the engineering of requirements a subject to approach from a collective intervention? If it is a question of continuing with the proposal of group work, from the curricular, the classroom projects contemplate themes that go from the life cycle of software development such as the use of models and the transformation towards high level models and from the pedagogical, we begin to analyze the individual scope as opposed to the one that can be achieved when one can learn among peers. Dillenburg, Baker & O'Malley [12] are quoted as saying that from Piaget's point of view, social interaction is considered a "catalyst" of individual changes, while in Vytgoski's point of view, social interaction is defined by the degree of individual development of the subject, where his or her individual changes are reflected in his or her social interactions.

2.2. Agile requirements engineering with model-driven engineering

In model-driven engineering (MDE), during the different phases of the life cycle of software development, the use of models is appealed to and their transformation into high-level models that allow separating the business logic from the implementation in a given platform [13]. MDE uses several levels, the first called computation-independent model (CIM), which is associated with the requirements engineering and serves as input for the following levels [14,15]. According to the object management group (OMG) specification, the CIM level is represented through the use case diagrams.

The requirements of the engineering processes went from being linear to iterative in nature. From it, the change management, documentation, and maintenance of the requirements show the state of the software to be developed in a transversal process present during the life cycle of software development [16]. In the agile world, requirements are expressed as user stories.

The application of agile approaches to the bidding process facilitates the design of models to represent the system to be developed and, through the use of these diagrams, improve communication with interested parties [17]. User stories can be represented visually through user story mapping. Mapping allows the functional level detail of user stories to be viewed in a transition where user stories called coarse-grained stories are broken down to a level of refinement of their own for implementation called fine-grained user stories [18]. Based on a user story diagram that is represented from the mapping, it is possible to transform user story diagram models into usage case diagram models [19].

The agile requirements engineering course with MDE, available online through virtual platform of the institution, contemplates a set of thematic units and proposes a series of practical activities for the student to acquire competences based on active learning.

3. Results

The application of a strategy based on active learning allowed, through the use of an online course, to guide the students of the systems engineering program of the UFPS, Ocaña, Colombia, through formative situations for the teaching of agile requirements engineering with MDE. The formative situations were applied from their association with the following objectives of the subject: (i) To develop a classroom project, that allows the students to live a real scenario applying the engineering of agile requirements with MDE. (ii) Define strategies to achieve in the student the development of skills for teamwork, through their active participation in the project.

Table 1 shows a set of determining elements inherent to active learning and requirements engineering with an MDE approach, which were effective when proposing the training situations framed in the proposed activities of the subject. It was proposed to use a scenario based on real problems based on the needs of companies in the region or of a national nature. The teacher organized working groups using roles according to the abilities of each student. Then, each group defined a guided work plan according

to the agile methodologies, which includes a set of sprints with their respective delivery plan during the academic semester. In Figure 1, the guide of formative activities is shown with its delivery plan, according to the methodology and objectives of the subject.

The final delivery process was supported by a set of supports made by the students that made up each group, according to the dates stipulated for the delivery of the result of the sprint and also a validation process was carried out through the follow-up of the result using the virtual platform of the institution for each delivery of the devices.

The implementation of the strategy in the systems engineering program of the UFPS, Ocaña, Colombia, allowed to show with respect to previous semesters a greater number of students with appropriation of the subject matter, which was reflected in the correct resolution of the problem raised in the classroom project. All this, through active learning, involving each student directly in a real scenario for the construction of their own knowledge.

Table 1. Elements for the design of training situations.

Item	Description
Relationship between theory and practice of the subject [6,7,8]	Demonstrate students' skills through the acquisition and application of theoretical knowledge in practice to solve problems.
Teamwork and improved communication [12]	Ability to solve problems cooperatively, contributing among peers reciprocally to reach a correct solution.
Adaptation to change [16]	Confront the proposed problem, understanding that the requirements during the software development process will change.
To know the environment [7]	To recognize the scenario in which the student develops, and the topic will be developed for the construction of knowledge.
Create models [13,14,15]	Represent the requirements as models with a high level of abstraction for a better understanding of the system to be developed.

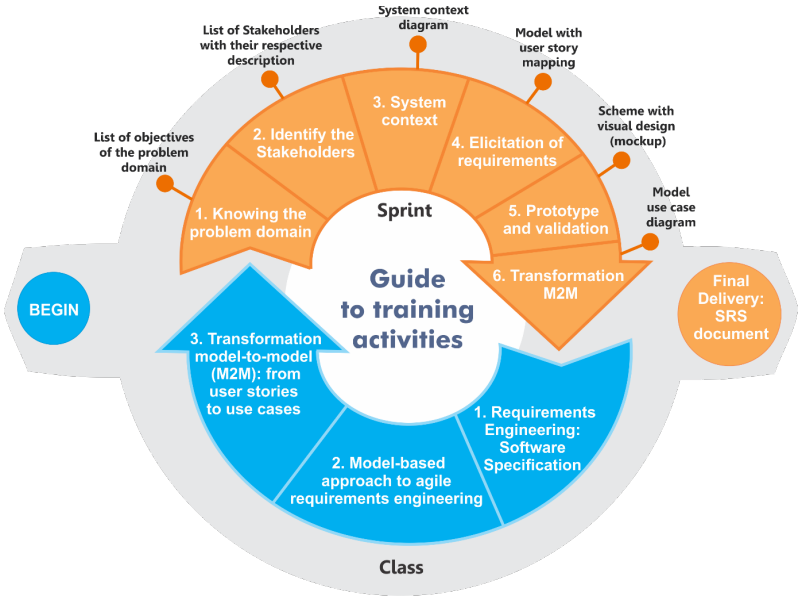


Figure 1. Guide to training activities.

4. Discussion

Active learning allows participants to approach content from the field of experience using previous knowledge and contributes to the improvement of the student's interest and learning by facing real situations and resolving them effectively [5,6]. In this way, skills such as teamwork arise, which allow group situations to develop with a communication full of trust and reciprocity that generates scenarios of cooperation to successfully achieve common objectives of stakeholders.

For the realization of the set of formative activities for the subject on requirements engineering with MDE approach, it was important to include situations to teach knowledge through higher order thinking skills [7], represented in the following tasks: (i) to make prototypes that allow to make judgments, check and validate the system requirements to be developed through meetings with stakeholders and (ii) construction of models, which define abstract representations of the system that facilitate the understanding of the problem posed and its respective solution.

5. Conclusions

The active participation of the student in the learning process, through autonomous work in small groups with practical scenarios and real environments, allows him to acquire responsibility for his own learning and obtain significant feedback through communication between peers.

The formative situations based on the active learning silver in this document for the subject on the engineering of requirements with MDE approach, allowed the students of the program of systems engineering of the UFPS, Ocaña, Colombia, to find sufficient motivation when interacting with real situations, that resulted in a greater retention of the learned and the development of abilities of critical thought and of interpersonal relations.

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