Use of Learning Strategies of SWEBOK© Guide Proposed Knowledge Areas

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Abstract. This paper gives a general vision of the knowledge areas that compound the software engineering according to the IEEE SWEBOK (Software Engineering body of knowledge) guide, and starting at that point proposed a pedagogic strategy, to be applied as a cathedra complement at the Pedagogic and Technologic University of Colombia (UPTC), due the knowledge areas proposed at SWEBOK provide an appropriate structure that adapts itself to the teaching-learning process at the Systems and Computation engineering college. The strategy that square up the educational objectives of Bloom's Taxonomy cognitive domain is designed and later evaluated by an advisor and further applied to an study group belonging to the Software Engineering study line; taking the results as a base to define the viability of this propose to be extended to another knowledge areas proffered by SWEBOK guide.

Keywords: SWEBOK, methodological strategies, Software Engineering, Knowledge Area, Bloom's Taxonomy.

1 Introduction

Within the Systems Engineering and associated programs study, the Software Engineering is a changing area that requires the knowledge acquirement in an effective and long term way; also it is necessary an update in Software Engineering related tools use, hereby and taking as starting point the postulated knowledge areas in SWEBOK (Software Engineering Body Of Knowledge), that is a proposed IEEE guide that contains topics that provides a cognitive structure that can be adapted to any teaching-learning process of the main contents, that compose the Software Engineering study line. This current study is aimed to enforce the personal and collaborative knowledge, and it proposed practical methodological strategies for Software Engineering areas, based in the appreciation of the knowledge acquisition level by a part of the sample population which take the final test, in the given complex topic selected by the population, where a practice workshop is developed with a tutor collaboration, and taking as starting point the selected topic for subsequent application in a selected group.

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2 Preliminary Concepts

For better structuration of the adequate practice, and according with recent and important topics within Soft-ware Engineering area, it's important allow for some concepts like SWEBOK structure and definition and teaching-learning strategies' concepts.

2.1 What's SWEBOK©?

It´s a guide developed and approved by IEEE Computer Society and it was published in a formally accepted version in 2004, with the purpose of collect criteria that establish the adequate practices to accomplish a well-developed process of Software products and solutions, establishing 10 fundamental areas that must be allowed as essential components of Software Engineering.

The guide defined by IEEE, has as a main target to accomplish with the following areas:

- Define the body of knowledge required and best practices.
- Define ethical and professional standards.
- Define study plans for undergraduate, postgraduate and later studies.

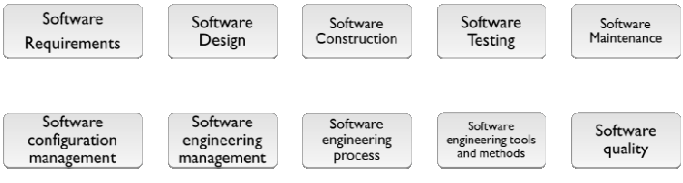

Fig. 1 Software Engineering Knowledge Areas. The SWEBOK guide document shows a 10 KA's (Knowledge Areas) division, and each one shows a subdivision of topics.

2.2 Teaching-Learning Strategies

The strategy refers to projection and direction; where someone projects, command and manages the operations to achieve the proposed objectives. Thus, the learning strategies are a set of cognitive operations that students implement to organize, integrate and develop information, and it can be meant as process or sequences of activities that underlie the achievement of intellect tasks and facilitates the building, permanence or transfer of information or knowledge (Campos 2000).

2.3 Bloom´s Taxonomy

This taxonomy let in a specific way to measure the level of the Software Engineering area students' skills accomplishing clearly to cognitive domain of Bloom's Taxonomy, defining the level of each specific topic proposed at SWEBOK within the fields shown in figure 2.

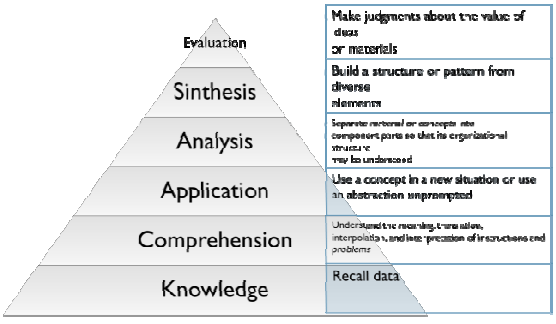

Fig. 2 Bloom's Taxonomy Cognitive Domain. It is part of the widely known classification of educational objectives of a teaching program being one of the focus domains of human being.

3 State of Art

Focusing in the educational context, it's observed that the use and implementation of the SWEBOK guide has had notable scopes, but as is shown in (Alonso et.al. 2011), the basic unities of a Software Engineering course was bound to a based reading format, so that at realize a effectiveness study to compare these learning techniques with others, like distance education or merged techniques, showing that of this form it's possible improve the student abilities, experience to develop maintain and acquire complex systems (Ardis et. al. 2011). In the international context as shown in (Lizhi et. al. 2009), the collaborative learning and the team work are fundamental components for the learning, but the use of web tools, magnifies the based instruction education paradigm without leaving behind the telecommunications infrastructure.

It has worked this guide as basis for the Software engineering enterprise progress, cases like the developed in Venezuela, where in the Universidad de los Andes de Merida, the guide was taken as a basis to develop a learning hybrid process of the software engineering based in an agile and disciplined software implementation process (Castillo 2010). Another important experience told in Costa Rica is described by Lizano Madriz and others (Madriz et. Al. 2011), where are shown, in first place, the SWEBOK guide implementation benefits and advantages, in an enterprise and academic environment, where are linked the systems and software engineering teaching of a concrete way and highlights the evaluation per competences of the model proposed by the SWEBOK guide.

On the other hand is important to mention important projects like the one developed at the *Pontificia Universidad Javeriana* (Payán 2010), which proposes a model for the establishment of good practices related to the first 4 areas proposed by SWEBOK: Requirements, Design, Construction and Testing. Undoubtedly the most valuable contribution to the integration of educational models that approach a business environment and supporting this research, is found in the project is

developed at University EAFIT, developed by Raquel Anaya PhD (Anaya 2006), where propose the student oriented paradigm from the practical aspect, ie, facing the students in their learning process to a business environment, showing that this is one of the biggest challenges presented in organizations.

4 Current Knowledge Transfer Model at UPTC

Currently at the UPTC a mixed model of knowledge transfer is implemented, so we have to allocate it or adapt it to one of the four models proposed at the Laval University of Canada (Becheikh, et al., s.f.):

- *RDD (Research, Development and Dissemination) models*: this kind of models focuses on the advancement of knowledge as the most critical factor for research utilization (Hargreaves 1999).
- *The Problem-Solving Models:* Within this kind of models the knowledge users are the initiators of change, and are direct responsible of needs' identification and formulation (Neville and Warren 1986), and this process has five fundamental steps: 1) needs identification, 2) articulation of the problem, 3) search for solutions, 4) selection of the best solution, and 5) implementation of the retained solution to satisfy the need.
- *The Linkage Models:* These models integrate the two ones and highlight the implementation of mechanisms to ensure linkages between producers and users of knowledge.
- *The Social Interaction Models:* These models emphasize the knowledge utilization as a result of multiple interactions of knowledge producers and users (Huberman 2002).

In Becheikh's formulation we can determine that the model of knowledge transfer that has a better adaptation to the current state of UPTC, is the linkage model, because the transfer mechanisms used between researchers and users are very specific and exclusive according to the user' needs so that the final users -in this case the Systems and Computation Engineering students of UPTC- has a narrow perspective of the specific knowledge that they need and there is a loss of opportunities to get broader knowledge, specificly in Software Engineering study line.

As we can see in figure 3, the current model of knowledge transfer at UPTC' Systems and Computation Engineering Study Program has notorious failures regarding to the role that play the student in itself training process, where the teachers prepare their cathedra material based on the recent researches produced artifacts, but they doesn´t consider the students – or for the model, the knowledge users – feedback respect to the topics that they consider important in their transition to the enterprise environment, but is notorious that they have accomplish with the process of knowledge transfer that propose Becheikh (see figure 4).

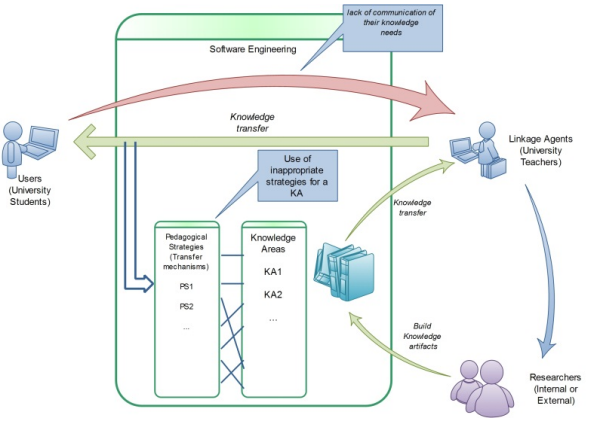

Fig. 3 Current knowledge transfer model at UPTC' Systems and Computation Engineering study program. Here we can see that additional to the lack of feedback of the students to the Linkage Agents (University Teachers), the knowledge transfer is based on pedagogical strategies that not always satisfy the knowledge assimilation needs of students.

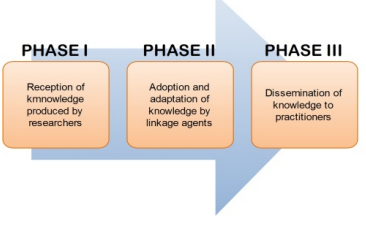

Fig. 4 Transfer of Knowledge from Linkage Agent's perspective. Of the linkage agent's role depends the success or the fail of the definition of a knowledge transfer model because they must do all the treatment to the knowledge for this be understandable.

Another important issue of this model to highlight is the fact that there are not standardized contents for the Software Engineering subjects, and each one of the teachers take the information that they consider relevant, whereby the classes turn into magisterial classes only, and there is a little use of pedagogical strategies for teaching, so that it probably has a negative impact in the training process of the student that want some variety in the knowledge transfer mechanisms not to fall into the routine.

It´s important to accentuate that in some cases inside the University, the Linkage Agents act as Researchers, but in a partial way, so some of them has this duality role that sometimes contribute to the student training process but sometimes reduce the capability of the student for belong in the course topics and learning strategies definition.

5 Proposed Knowledge Management Model

In order to improve the teaching-learning process of Software Engineering subjects at UPTC It's necessary to punctuate that there are determinants at the moment of define a knowledge transfer model, that implicates an analysis to establish the model that adapts better for the educational environment, without setting aside the organizational background that serves as transition between the educational and enterprise environments.

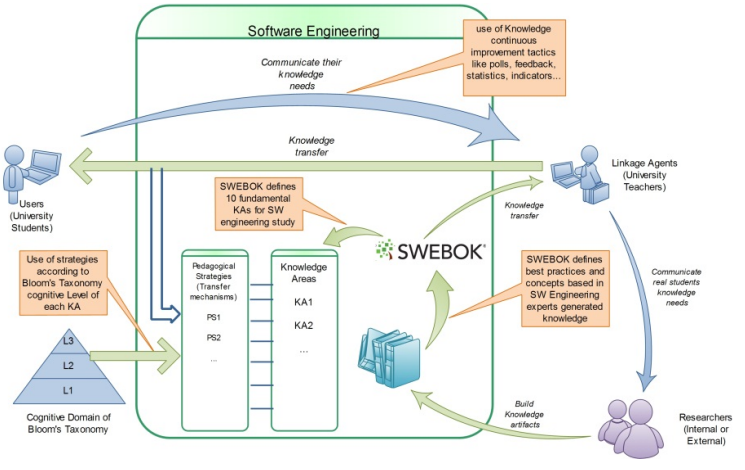

Fig. 5 Knowledge transfer model proposed with applied changes. This model pretend to cover the deficient aspects of the current knowledge management model of UPTC, improving the capability of the knowledge final users (students) to assimilate it in a better way.

Otherwise, three perspectives are taken into account to develop de model, the first concerning to the attributes and features of the knowledge, the second is the perspective of the actors involved in this knowledge transfer model, and Finally, the perspective of knowledge transfer mechanisms, that we can represent as the pedagogical strategies or resources that let a better knowledge transfer process.

5.1 Transferred Knowledge Attributes

As is known, the main source ok knowledge that is taken to define the model of knowledge transfer of Software Engineering is the SWEBOK guide, 2004 version, that define the required body of knowledge and recommended practices that could be defined in any educational curricula for undergraduate, graduate and continuing education concerning to the Software Engineering.

In the proposed knowledge transfer model, it's recommended that exists a classification of the knowledge according to de definition of Eraut of the types of knowledge that is acquired at an University classroom (i.e. Theoretical Knowledge, Methodological Knowledge, Practical skills and techniques, Generic Skills

and General knowledge about the occupation) and the mapping to the knowledge that is used in the Workplace (i.e. Codified Knowledge, Skills, Knowledge Resources, Understanding, Decision-making and Judgement) with the purpose of make special emphasis in the enterprise working contexts and variables (Eraut, 2004).

5.2 Knowledge Transfer Model Actors

Later an identification of main actors at the model was made, showing 3 type of actors that adapts to the model that is proposed. But also as propose Becheikh et. al., it is recommended to view the actors including in a knowledge transfer model from two perspectives: 1) the individual, that concern to the features of an actor as a person and 2) the organizational, that points to the characteristics of the actor that evolves institutional factors.

Table 1 Determinants viewed from actor's perspective. It's taken the individual and the organizational attributes.

Actors	Individual Attributes	Organizational Attributes
Researchers (Anis et al. 2004)	- Adaptation efforts - Contextualization efforts - Dissemination efforts - Researchers' credibility	- Experience in knowledge transfer - Emphasis given to knowledge transfer
Linkage agents (Beier and Ackerman 2005)	- Professional experience - Cognitive abilities - Social capital - Personal attributes	- Organizational structure - Resources dedicated to knowledge transfer - Policies to encourage knowledge transfer
Practitioners (Hemsley-Brown 2004).	- Time allowed to acquire and adopt new knowledge - Motivation to acquire and adopt new knowledge - Ability to understand research results	- Organizational climate - Organizational culture - Organizational structure - Organizational procedures and policies - Organizational resources

5.3 Knowledge Transfer Mechanisms

For a better definition of the pedagogical strategies (transfer mechanisms) that are appropriated for each Bloom's Taxonomy Level, it's necessary an exhaustive revision of each one of these with Pedagogical support, with the purpose of determine the more optimum to be applied in each topic defined at SWEBOK that are mapped to its correspondent Bloom's Taxonomy level.

Into the lowest level of Bloom's Taxonomy "Knowledge", it is necessary to define transfer mechanism that let student to make an appropriate and complete recollection of data. The products of this type of mechanisms are listings, ideas,

summaries, etc. Some of these mechanisms are Roundtable, Interview, Survey, Brainstorm or Portfolio. For the second level "Comprehension" it is necessary looking for strategies that let the student to understand problems and contribute with possible solutions. The products of this kind of strategies are generally manuscripts, diagrams, mind maps, conclusions, etc.; some strategies to apply to this Taxonomy level are conceptual map, problem-based learning, discussions, Buzz Groups, Pyramid or Snow Ball or learning by investigation. (USQUID, 2009).

For the third level "Application", it is necessary looking for strategies that let the student to apply the acquired concepts to real or hypothetic problems, or current developments. The products of these strategies are generally report redaction, corrections, fixings or complements, etc.; and its strategies are study cases, role games, application Workshops, and Projects (Marquès, 2001). For the fourth level "Analysis", it is necessary looking for strategies that let the student to separate concepts, analyze texts, interpretation of organizational structures. The products of these strategies are generally written or oral productions, etc; and their strategies are like sustentation, audiovisual material making, presentations, posters, learning contracts, puzzles, or Press Writing (Rajadell, 2001).

6 Study Case at UPTC

6.1 Selections and Development of SWEBOK Strategy and Topics for Content Adaptation

In order to test the proposed model, it is necessary to develop some diagnosis and preferences tests in SWEBOK guide proposed knowledge areas, and this underlies the implementation in study groups at Pedagogic and Technologic University of Colombia (UPTC).

Survey Application

A Virtual Diagnosis Survey was performed, in 2011 2nd semester, using Google Docs Survey Tool and Paper Surveys too, applied to the six Software Engineering area teachers at Systems and Computational Engineering graduate program of Pedagogic and Technologic University of Colombia (UPTC). The Survey investigated about knowledge, importance, complexity, ignorance, difficult, and other aspects of each one of the SWEBOK proposed Software Engineering Knowledge areas.

SWEBOK topic selection

Once the SWEBOK topics of interest diagnosis Survey is performed, the target knowledge area Software Quality is defined for this research, but for following phase corresponding to the practical workshop design and pilot test execution, it is necessary to choose a concrete topic inside the KA "Software Quality", for which 30% of IX & X semesters Systems Engineering students was consulted because they know about the given topics at UPTC concerning this KA, looking for content preference referent to "Software Quality", and based in SWEBOK guide proposed topics, that let us make a low-scale study.

Design of Pedagogical Strategy

After selection of the specific topic "Techniques of Software Quality Management" and with the UPTC cathedra Software Engineering II tutor support, we proceed to build an educational workshop, since this strategy provides the student not only theoretical but practical possibility of the conceptual framework presented, according to their level within Bloom's taxonomy, it is clear that issues of "Techniques of Software Quality Management" reach the level of Application within that taxonomy, which provides a starting point for developing the strategy that want to be implemented.

Pilot test execution to population sample

After preparing the workshop concerning software quality, a group of software study line is selected to make a pilot test, and the group chosen was the "Software Engineering II" area. To perform the test, the group is divided in two parts, in which half of the group is given a master class, and the other group half performed the workshop with the relevant explanations. Finally, both group of population, are submitted to a final assessment that defines the effectiveness of pedagogical strategies applied.

6.2 Results Analysis and Conclusions

The Survey results (Fig 6 & 7), show that the more difficult and complexity knowledge area is Software Quality, therefore indicates that it is a critical and urgent care area within the software product development.

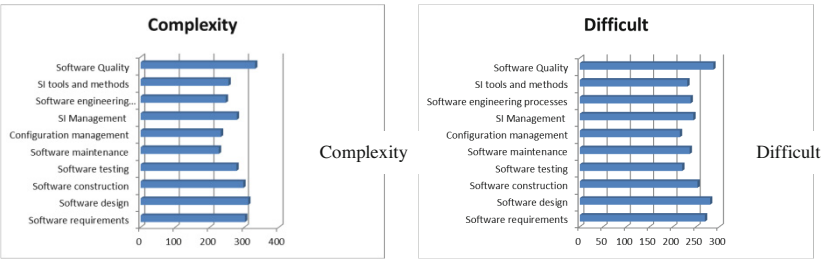

Fig. 6 & 7 Survey determined complexity and Difficult Level

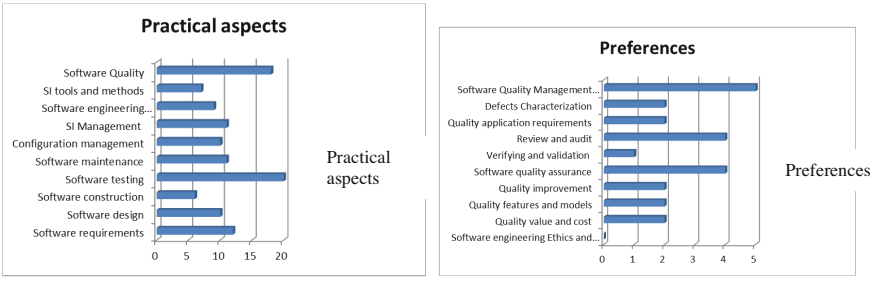

Fig. 8 & 9 KA's that require more practical aspects according to the group survey and Poll results of interest topics selection of Quality Software KA

For preferences poll in Figure 9, we see that the topic "Software Quality", selected from the results of the diagnostic test, it's considered important because it is a fundamental aspect in the software development. From the above poll we can conclude that the topic to be addressed in the teaching strategy is "Techniques of Software Quality Management" because it is one of the subjects according to respondents that produce more interest

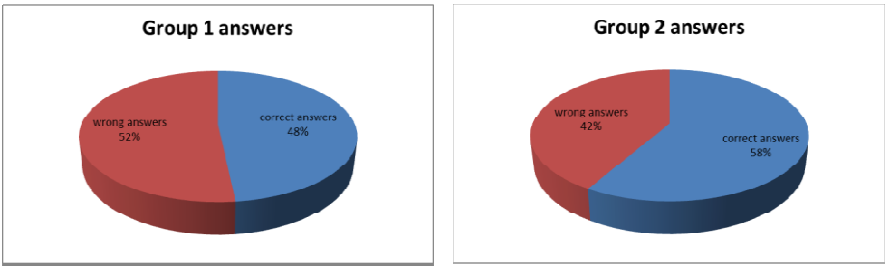

Fig. 10 & 11 Group Assessments (Master Class & Practical Workshop). it shows the percentage of questions answered correctly within the strategy of each group. The percentages indicates that the implementation and enforcement of workshops optimize learning and knowledge assimilation and that practice is essential to reinforce knowledge.

To the Learning factors Inquiry question (Figure 12), we see that for those receiving the application aspects of the workshop and practice, time and technology resources are very important when learning or assimilate knowledge. For people who received the lecture, knowledge and interest of the subject are quite relevant, therefore we conclude that the type of lecture caused a deficit of attention and interest on the topics, while practices awaken and motivate the student to acquire ever more knowledge.

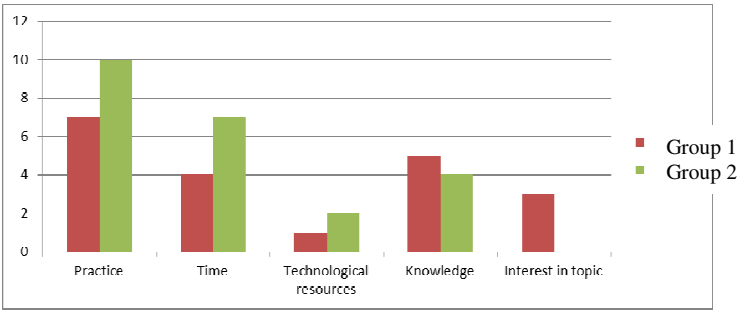

Fig. 12 Learning factors Inquiry question results. The results of inquire question to the students themselves that shows important issues that consider the two groups of the experiment (Master Class & Practical Workshop).

After of the respective test of the knowledge transfer model, we can conclude that

- SWEBOK areas are chosen for this research because each contains a cognitive structure adequate, easily adapted to the teaching-learning process, in addition to supplying all stages in the software development.
- Teamwork and participation of students, in all phases of software development, is critical to achieving high standards of quality.
- Is necessary a continuous improvement model that involve tactics that enrich the required knowledge and strategies pointing to the improvement of the teaching-learning context knowledge transfer, and this must be defined with the interest of the students in participation of curricula definition.

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