Teaching Global Software Engineering: Planning and Preparation Using a Bloom's Taxonomy

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***Abstract*— In this paper I have discussed my experience of teaching global software engineering course using Bloom's Taxonomy. I have discussed how one should plan and design courses based on Bloom's Taxonomy. It was observed that a Bloom's Taxonomy can play a vital role in order to effectively plan and design courses. Overall the six levels of Bloom's Cognitive domain were helpful, in my teaching, in which I transformed students learning from the "knowledge" level to the "evaluation" level. Different challenges relating to six levels of Bloom's Cognitive domain are discussed in this paper. It was also observed that if Bloom's Taxonomy is used with other available teaching guidelines then one can improve the overall plan and design of different courses.**

***Index Terms*— Bloom's Taxonomy, Global Software Engineering, Software Engineering Teaching**

I. Introduction

OVER the last decade, many firms in Europe have started global software engineering in order to reduce software development cost. Previous work suggests that half of the companies that have tried global software engineering have failed to realise the anticipated outcomes which has resulted in poor global relationships, misunderstanding of the projects' requirements, high costs and poor services [5; 11]. There are many reasons for these failures [6; 12-15; 24]. Most of these reasons are due to the lack of effective training programmes which can provide with sufficient knowledge and skills relating to global software engineering [14]. In addition, a small number of academic institutions are providing different courses on global software engineering which are not sufficient to satisfy the requirements of different employers.

In the past two decades there has been much concern in the UK about the need for higher education to develop the personal competences of its students in particular academic disciplines [27]. This concern has motivated the redesigning of undergraduate and postgraduate degree courses, with a stronger emphasis on the needs of employers [23]. In addition, the advances in software engineering have not been matched by equal advances in the development of new courses in academia which has resulted in a gap between the software industry and academia.

The objective of this paper is to share the experience of teaching a global software engineering course based on Bloom's Taxonomy. In this paper I have discussed how one should plan and design software engineering courses based on Bloom's Taxonomy.

This paper is organised as follows. Section 2 describes the Bloom's Taxonomy. In Section 3 the plan and the design of the global software engineering course has been discussed with reflection based on Bloom's Taxonomy. Section 4 provides the conclusion and discussion.

II. Introduction to Bloom's Taxonomy

There are number of ways that a person can learn and these are referred to as learning styles [1; 4]. Learning style is the preferred way(s) in which individuals interact or process new information across the three domains of learning identified in the Bloom's Taxonomy of education objectives: cognitive (intellectual capability, i.e., knowledge, or think), psychomotor (manual and physical skills, i.e., skills, or do) and affective (feelings, emotions and behaviour, i.e., attitude, or feel) [3]. Academics often refer to these three domains as Knowledge (cognitive), Skills (psychomotor) and Attitude (affective). This taxonomy can be thought of as the goals of the learning process. That is, after the learning session, the learner should have acquired new knowledge, skills and/or attitudes.

The three domains of learning are organised as a series of levels or subdivisions, starting from the simplest behaviour to the most complex. These levels can be thought of as degrees of difficulties. It is suggested that one cannot effectively address higher levels until those below them have been covered and provides a basic sequential model for dealing with topics in the curriculum. These divisions are not absolutes and some revision has been suggested by other academics [2]. However, Bloom's Taxonomy is easily understood and is probably the most widely applied one in use today.

The cognitive domain is the most commonly used domain of Bloom's Taxonomy. This domain involves knowledge and the development of scholarly skills. The focus in the cognitive domain revolves around knowledge, comprehension, and thinking through a particular topic.

There are six levels in this domain, moving through the lowest order processes to the highest (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation).

The Psychomotor domain was established to manipulate development relating to manual tasks and physical tasks. It also covers modern trends such as communications and operation IT equipment, for example telephone and keyboard skills, or public speaking. The Psychomotor domain usually focuses on change and/or development in

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behaviour and/or skills. Bloom never completed work on this domain, and there have been several attempts to complete it [8; 9].

This affective domain provides the framework in which we deal with things emotionally, such as feelings, values, motivations, and attitudes.

III. Planning and Preparation of Global Software Engineering Course Based on Bloom's Taxonomy

For the design of a global software engineering course I have adapted the Bloom's Cognitive domain [3] as it provided me with opportunities to teach students in different stages, i.e. from knowledge to evaluation. In addition, in my teaching area of global software engineering the focus is on understanding the theories first and then application of those theories into practice. Another reason for adapting Bloom's Cognitive domain was because my senior colleagues have given me a positive feedback about Bloom's Cognitive domain (i.e. it helped them in transforming global software engineering theories into practice and application).

When I was asked to design and deliver a postgraduate course on global software engineering, the real challenge for me was in designing a piece of work that can motivate students. Another challenge was to manage a large class of diverse students. There were many international students in this course; however, no disabled students were enrolled on the course. I had some formal discussions with my senior colleagues about these topics. They provided me with the guidelines about "how to motivate students", "how to manage the large class of diverse students" and "how to design effective courses based on existing learning models". I have also reviewed the literature about student motivation [10], teaching a large class [17] and existing learning theories [3]. It was clear to me that in order to effectively manage the large class and to motivate students I needed to create a welcoming and engaging environment in the classroom. It was also clear to me that I needed to provide equality of opportunities in terms of access, treatment and outcome [18]. For this I have used the following guidelines for the design of the course:

--I have increased the difficulty of the course as the semester progressed (i.e. from knowledge to evaluation level of Bloom's taxonomy [3]).

--Based on the discussions with my senior colleagues, reading relevant literature [17] and my experience of teaching, I have used a variety of teaching methods, i.e. small group work and case studies (during tutorials) and discussion (during lectures and tutorials) in order to improve students' motivation and to create a welcoming and engaging environment [19].

--Instead of going over all the material provided in the handout, I have used most of my time to go over the difficult points and then provided students with additional examples in order to better understand the difficult parts of the topics.

In the global software engineering course preparation I tried my best to provide students with real life knowledge and skills that are required in current software industry. This is to ensure that when software engineering graduates join the software industry they will already be familiar with the applied skills and knowledge they have learned in their universities.

A. Reflection on Planning and Preparation of the Global Software Engineering Course

The following section illustrates the application of the six levels of Bloom's Cognitive domain in the planning and preparation of the global software engineering course.

--**Knowledge (**Learners are expected to store or recall in their mind data or information of previously-learned materials):

I have designed review questions after each lecture to encourage my students to recall the contents of the lectures. In these questions I used keywords such as define, describe, identify, list or state.

Knowledge level of Bloom's Cognitive domain has helped my students to recall the contents of my previously delivered lectures. However, this level did not seem appropriate for higher caliber students because the contents used in the "knowledge" level was tiring and even tedious for these students, and was called by my students, in the teaching evaluation survey, as "simple". This is because the high caliber students were more matured students and it was expected that they would like to prove their academic skills in a higher level, rather than being restricted to the lowest level of this cognitive skills. In the design of global software engineering course I should have ensured that the students are presented, in the first few lectures, with a course contents which were adequate to their intellectual skills. This issue should be considered for any new course design in order to provide students with adequate intellectual skills relevant to their caliber. However, the use of "knowledge" level seemed more appropriate for those students who appreciated the discussion of the basic concepts and principles of global software engineering. I have noticed this appropriateness during conversation with my students and in the teaching evaluation survey. For example in the teaching evaluation survey I found the following comments from my students:

"*Lectures and lab classes taught me all I needed for final project"*.

--**Comprehension (**State a problem in one's own words using one's own understanding or interpretation of facts):

I have covered comprehension by providing students with more understanding of the basic concepts using different lab sessions. I have designed different software engineering models and students have to translate those models into simple English. Similarly, I have given my students different scenarios in simple English and I asked them to translate those scenarios into different models such as use case diagrams and context diagrams.

The "comprehension" level of Bloom's Taxonomy seemed appropriate for all levels of students as I have observed in the labs that students were able to produce different models and diagrams based on their understanding of problem domain. This level helped students to move from "recalling" state to "understanding" state [3] in which they

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were able to state a problem in their own words based on their understanding. For example at the end of each practical I asked students to write a summary of 200 words about what have they have learned in this practical and most of the students were able to write that summary. Other evidence, which I have observed, was that my students were able to convert different models and diagrams into plan English during different lab sessions.

--**Application (**Application of new knowledge, learned in the classroom, into novel situations in the workplace):

For this level I designed different practical and tutorials in which students have to apply concepts and theories learned in the lectures to practical situations. Students also have to construct graphs and models and they have to demonstrate the correct usage of methods or procedures. In addition, I have used application questions during the lectures in order to direct students to apply the concepts in different context. For example I asked students: Considering a typical post office system, produce a use case diagram for selling stamps, renting post office boxes and delivering mail to postal customers.

For "application" level I have observed that some of the international students (from Asia) have difficulties in applying the concepts and theories, learned in the lectures, in the labs. They needed more support and supervision in creating different models or diagrams in the labs. For example there was a task in the lab that "considering the typical post office system; identify possible actors and use cases, and draw a use case diagram". Most of the international students were unable to complete this task. After discussion with these international students I have observed that the education systems in their home countries has been designed in such a way that they got less opportunities in applying the concepts and theories learned in the lectures to practical situations. This type of situation has led me to address the diversity of students issues [21; 25; 26]. In order to address this issue I developed a new practice in which I tried to address the individual needs of students. I have created a specialist support for such students in the form of providing them with extra time and resources. For example I asked my demonstrators to give these students extra time in the labs. Special attention was given to such students where I tried to provide them with easy application questions first and then moved them to slightly harder questions in the labs.

This practice worked well as I have observed that the learning of these international students, about application of knowledge, was improved as these students were able to answer questions and also they were able to complete tasks in the labs**.** In addition my demonstrators have also provided me with a positive feedback about the learning improvement of these international students.

--**Analysis (**Examine and break information into parts so that its causes can be understood):

For the analysis part I gave students different problems for analysis in the labs as well as in their assignments. In some cases students have to break down the bigger problem into smaller components in order to better understand it. After analysis they have to provide solutions for each component. In other cases I asked students to identify different parts of the systems, analyse the relationship between these parts, and provide solutions for each part.

For the analysis level of Bloom's Cognitive domain I have observed, in the labs, that some students were facing difficulties in breaking down the bigger problem into smaller components in order to better understand it. In order to address this problem I have provided students with simple problems first and then I moved them to harder problems. I discussed with demonstrators if there were any improvements in students learning after using this technique. I received positive feedback from demonstrators that students have learned that large and complex problems cannot be managed and controlled as a whole, and that they need to be broken down into smaller components in order to achieve the required control and ability to monitor progress. After a few weeks I have observed through their marks in the assessed practical sessions that most of students were able to analyse given problems and they achieved good marks in their labs (i.e. the average marks for global software engineering course labs were 50% with highest marks of 99%). Another, evidence was a positive feedback from students in the teaching evaluation survey, i.e. "The practical work was extremely enjoyable".

--**Synthesis (**Put parts together to form a whole, a new pattern or alternative solutions):

I encouraged students to create something new by making predictions and solving problems. For different assignments or final project reports, I asked students to synthesise different solutions to form a new portfolio. I gave different templates to students which can be used for synthesis. For example I asked students to:

--**Design** different level 1 data flow diagrams and combine them into a single diagram.

Students have mix responses for the "synthesise" level of Bloom's Cognitive domain. Some students were able, without any help, to synthesis different solutions to form a new portfolio and this was depicted in their final marks where most of the students (i.e. 60%) have passed this course. However, some students have inconsistency problems, i.e. they have synthesised irrelevant solutions to a single portfolio. For example, some of the students designed different level 1 dataflow diagrams and when I asked them to synthesise these different diagrams into a single new diagram then they had synthesised irrelevant diagrams into a new single diagram. In addition to my own observation, my demonstrators have also reported the same problem to me. I have overcome this problem by providing students with more examples of synthesis. Students learning about synthesis was improved as they have achieved good scores in their assessments (i.e., assignment 1 average marks were 68%, 19 students passed with high distinction and 72 students passed with distinction). However, I had a feeling that these types of problems need more attention and students can better understand synthesis issues if we give them scenarios or examples from real world problems. I also think that such preliminary exercises should be done at a high school level so that when students come to Universities they should be able to understand and can complete more complex synthesis problems.

--**Evaluation** (Make judgments about the value of ideas or materials based on a set of criteria):

In the labs and assignments I have designed different scenarios in order to judge different problems and to propose suitable solutions. I encouraged students to use their personal judgments to provide solutions to different problems in the labs and in the assignments. For example I asked students:

"Based on the given scenario, consider you are given a job of requirements elicitation; critically evaluate which method is the best method for requirements elicitation".

Students had some minor problems in the "evaluation" level of Bloom's Cognitive domain. Some of students did evaluation based on limited knowledge, limited research and using limited factors. For example I asked students in the tutorials to evaluate which method is the best for requirements elicitation (i.e. interviews, questionnaire, observation etc.). Some of students identified interviewing as the best method without looking into sample size and the geographical locations of the stakeholders. This problem was reduced with the passage of time and by doing more practices of evaluation [4].

IV. Discussion and Conclusion

Although Bloom's Taxonomy has been criticised for its simplicity [20], it provided a useful framework in my teaching disciplines [7; 16; 22] where it helped me in transforming theories into practice and application. Overall the six levels of Bloom's Cognitive domain were helpful, in my teaching, in which I transformed students learning from the "knowledge" level to the "evaluation" level. However, the "knowledge" level of Bloom's Cognitive domain is not appropriate for higher caliber students because the contents used in the "knowledge" level are often referred as simple. The "comprehension" level seemed appropriate for all levels of students as I have noticed in the labs that students were able to produce different models and diagrams based on their understanding of problem domain. Many international students were having problems with the "application" level as they were unable to apply the concepts and theories in the labs. For the "analysis" level some students were facing difficulties in breaking down the bigger problem into smaller components in order to better understand it. Students had mix responses for the "synthesis" level of Bloom's Cognitive domain. Students had some minor problems in the "evaluation" level of Bloom's Cognitive domain. However, if we use Bloom's Taxonomy and other available teaching guidelines then we can improve the overall design and delivery of these modules.

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