Revised Bloom's Taxonomy for Assessment in Engineering Education

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Abstract - The goal of every faculty is to guide students to learn fundamental concepts and also improve thinking skills. Curriculum questionnaires must be framed, which would facilitate students to improve their thinking skills. Improving thinking skill is a difficult task and one of the ways to achieve this is to frame questionnaires using Bloom's Taxonomy. Bloom's Taxonomy helps the faculty to assess the students in a systematic approach which involves students performing successfully at each level in a systematic manner. In this paper, we have discussed on Revised Bloom's Taxonomy and how to frame our questions based on the taxonomy for assessment. We have also presented mapping the questions with the taxonomy table which shows the mapping of the questions in knowledge and cognitive domain.

Keywords—Bloom's Taxonomy, Assessment, Questions

I. INTRODUCTION

One of the important roles of a faculty is to teach, encourage, assess the students and also enable them to gain in-depth knowledge of the course and innovate. Faculties are trying their best to come up with innovative new assessment ways to enhance student's involvement in the course. Bloom's taxonomy is used to formulate questions for assessing the students in the continuous internal evaluation and semester end examinations. It helps students in inculcating higher level of critical thinking and logical reasoning.

When objectives, activities and assessments are aligned learning improves as shown in Figure 1.1. Objectives specify what student should be able to do at the end of course. Activities makes student to achieve those objectives. Assessment is a system to know to what level the student has gained knowledge.

A course can be aligned by using a learning taxonomy. One of the taxonomy is Bloom's taxonomy which is used for assessing. Bloom's taxonomy [1] was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom in order to promote higher forms of thinking in education such as analyzing and evaluating concepts,

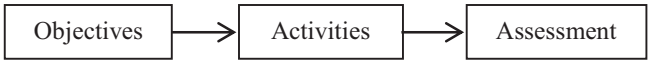

Fig 1.1 Alignments of Objective, Activity and Assessment

processes, procedures and principles. The learning objectives are classified into three domains: Cognitive, Affective and Psychomotor. This taxonomy can be reflected as "The Goals of learning Process" that is the learner should have acquired a new skill, knowledge and attitude after the learning is happened. The most used domain is cognitive domain. It provides a hierarchy of levels of intellectual skills involving the acquisition and use of knowledge that ranges from simple recall to ability to judge and evaluate learned material.

The Bloom's taxonomy assists faculty in designing performance tasks, creating questions, providing feedback on student-work and assessing student learning. Faculty can assess students in a systematic way which involves students' performance at each level. Assessing them at the lower levels first and then to the upper levels as far as students can go. The two advantages would be feedback from this type of assessment can be used to redefine the planning of next phase of learning. Another advantage would be students can remember the learned concepts for a longer time.

II. LITERATURE SURVEY

Mahmood Niazi[3] as discussed his experience on teaching global software engineering course using Bloom's Taxonomy. According to him Bloom's Taxonomy plays a vital role to plan and design courses. He has also mentioned the key challenges and his solutions related to all levels of Bloom's Cognitive domain in the course taught by him. Mahbubul Hasan et al. [4] have presented the reflection of the Bloom's revised Taxonomy on social science question paper of secondary school certificate examinations. They analyzed the question papers of four years 2009–2012. The main aim of the authors was to find out the impact of Bloom's taxonomy in the question paper and also to compare the level of applying revised Bloom's taxonomy after adding creative questions. The result of the study shows that still there is a short come in the creative question system and they have also recommended some measures to be included to enhance the quality of questions in creative question system. Nazlia Omar et al. [5] Proposes a rule based approach in determining the category based on bloom's taxonomy for examination questions. They apply natural language processing techniques to assist in the identification of the category of a question and have used a set of 100 questions on computer program course domain.

Richard Gulge et al. [6] have designed a web based tutorial on Bloom's Taxonomy which trains computer science faculty on application of Bloom's taxonomy in classifying program assessment questions. The tutorial contained 12 example questions and asked the 10 participants to classify to which cognitive process of Bloom's taxonomy the questions belonged to. The paper contains all the twelve questions and the category to which it belongs. Ganesh Kumar et al. [7] have conducted a comparative case study of the question papers set by faculty of 2 institutions as per revised Bloom's taxonomy. They also have discussed recommendations for both the institutes for improvements in the teaching methodology which would enable students develop critical thinking. S. Sangeetha et al. [8] have proposed preparation of questions using Bloom's taxonomy. They have accessed answer script of each student and classified them under different levels of Bloom's taxonomy using K-Means Clustering algorithm. With this kind of categorization, faculty can get to know weakness of each student and put more efforts in improving student's performance.

III. REVISED BLOOM'S TAXONOMY

Anderson et al. brought major changes to the original taxonomy to retain updated. The major change is the move from one dimension to two dimensions: Knowledge dimension and cognitive process dimension [2]. It is a tool for defining learning objectives, planning instruction and choosing assessments.

Knowledge dimension has four categories:-
a) Factual b) Conceptual c) Procedural d) Metacognitive

Factual Knowledge – is knowledge of basics of specific disciplines. The necessary facts, terminology, details or elements which the students must be conversant to comprehend a discipline or crack a problem in it.
Conceptual Knowledge – is the knowledge of learning interrelationships among the basic elements within a larger module that allow them to function together.
Procedural Knowledge – This dimension refers to knowledge of course specific skills, techniques and methods. Student will be conversant when to use appropriate procedure.
Metacognitive Knowledge –This dimension includes self-knowledge, strategic knowledge and knowledge about cognitive task. Students will be able to gain relevant contextual and conditional knowledge.

Cognitive process dimension has six categories as shown in Figure 3.1. They are:-
Remembering: Highlights recollecting and recognize pertinent information. Describing, retrieving, finding appropriate information will descent in this dimension.

Understanding: Students grasp meaning of information by inferring and converting what has been learned.

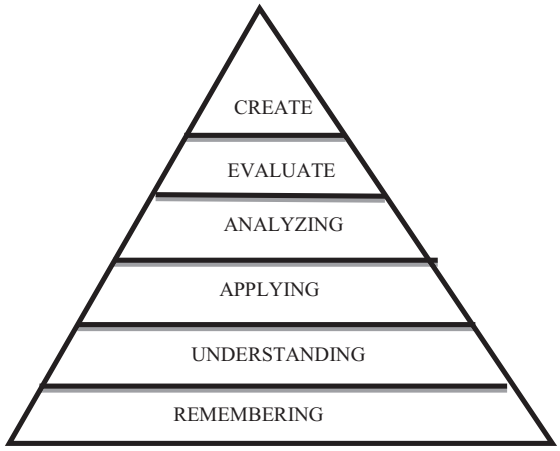

Fig 3.1 Cognitive Process Dimension of Revised Bloom's Taxonomy

Applying: make use of information in a context different from the one in which it was learned.
Analysing: The dimension highlights on breaking learned information into its parts to best comprehend that information.
Evaluating: Comprises decision making based on in-depth reflection, criticism and assessment.
Creating: Generating new ideas, products, or ways of viewing things. Designing, constructing, planning, producing, inventing.

The taxonomy table in Table 3.1 helps to approach the course systematically and effectively, focus learning efforts on learning objective and decides assessments that promote to student learning [9].

Table 3.1 Taxonomy Table

THE KNOWLEDGE DIMENSION	THE COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDER-STAND	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE						
CONCEPTUAL KNOWLEDGE						
PROCEDURAL KNOWLEDGE						
META-COGNITIVE KNOWLEDGE						

IV. PREPARATION OF QUESTIONS BASED ON REVISED BLOOM'S TAXONOMY – CASE STUDY

4.1 Remember

Remember emphasizes on recognizing or recalling relevant knowledge, facts or concepts. Some of the key verbs that can be used are Recognize, Recall, Repeat, List, Mention, Draw, Define, Describe, and Recognize.

Example 1: Define Data.
Example 2: Describe Single Linked List.
Example 3: A linked list is a ----------
a) Static data structures b) linear data structures c) dynamic data structures. d) None

Example 1,3 relates to factual category in knowledge dimension and Example 2 relates to conceptual category.

4.2 Understand

The student will be able to construct meaning from instructional messages. Some of the key verbs that can be used are Classify, Explain, Select, Summarize, Identify, Locate and Convert.

Example 1: Classify the different types of Data Structure.
Example 2: Distinguish arrays and linked list.
Example 3: Assume name as an array of 15 character length, What is the difference between the following two expressions? name+10 and *(name+10)

Example 1, 2 and 3 relates to conceptual category in knowledge dimension.

4.3 Apply

Apply involves using ideas and concepts to solve problems. It is closely linked with procedural knowledge. Some of the key verbs that can be used are Apply, Illustrate, Choose, Compute, Interpret, Demonstrate, Implement, Predict.

Example 1. Illustrate the application of stacks to solve tower of Hanoi problem.
Example 2. Apply the concept of linked list to add two long integers.

Example 1 relates to procedural category in knowledge dimension and Example 2 relates to conceptual category.

4.4 Analyze

Analyze involves breaking a system into components and determining how the components are related to one another and to an overall structure. Some of the key verbs that can be used are Analyze, Calculate, Compare, Differentiate, Identify, and Examine.

Example 1: Identify whether a class template can be used to store elements of different data types on the same stack. If yes, justify your answer.

Example 2 : In the following program how would you print 50 using p?

```
main ()
{
  int a[ ]={10,20,30,40,50};
   char *p;
  p= (char*) a;
}
```

Example 1,2 relates to conceptual category in knowledge dimension.

4.5 Evaluate

Evaluate involves making judgments based on criteria and standards. Some of the key verbs that can be used are Compare, Choose, Evaluate, Discriminate, Judge, Defend, Monitor, and Check.

Example 1: Compare the performance based on time complexity for selection sort and quick sort, given varying sizes and arrangement of elements in an array.

Example 1 relates to conceptual category in knowledge dimension.

4.6 Create

A new pattern or structure can be formed by putting elements together. Some of the key verbs that can be used are Develop, Design, Construct, Plan, Produce, Compose, Create and Invent.

At the Creative level we can give students mini projects which include many modules and integrating them to form a new model. Also the student can find solution to the problem by combining existing algorithms.

Table 4.1 The Taxonomy Table showing the mapping of Questions

THE KNOWLEDGE DIMENSION	THE COGNITIVE PROCESS DIMENSION					
	REMEMBER	UNDER-STAND	APPLY	ANALYZE	EVALUATE	CREATE
FACTUAL KNOWLEDGE	x					
CONCEPTUAL KNOWLEDGE	x	x	x		x	
PROCEDURAL KNOWLEDGE				x		
META-COGNITIVE KNOWLEDGE						

The x mark in the table indicates the mapping of the questions discussed above in the knowledge and cognitive process dimension. Once the questions are prepared using Revised Blooms Taxonomy and been mapped in the taxonomy table, the resulting table helps to judge whether the questions are aligned at all levels. Depending on the course the questions should be distributed across the levels.

CONCLUSION

This paper provides an insight for faculty to prepare the question papers as per Revised Bloom's Taxonomy. It has been shown that by mapping the questions to the taxonomy table one can assess whether the questions prepared fall into the knowledge and cognitive dimensions. By preparing questions using Revised Bloom's Taxonomy the faculty can assess the student's performance at each level.

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