

# Software Engineering Assessments using Blooms Taxonomy

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**ABSTRACT:** Blooms Taxonomy has been exploited in numerous fields of studies. It has also been used in computer science education. The research on the use of Blooms Taxonomy into software engineering curriculum has not been done to a great extent. This paper shows software engineering assessment using Blooms Taxonomy. Trial questions are specified and categorized according to the pertinent Blooms Taxonomy levels. The main goal of paper is to give hands on software engineering teaching and learning; and perk up the excellence of software engineering education.

**KEYWORDS:** Software Engineering, Assessment, Blooms Taxonomy, Cognitive Domain.

## I. INTRODUCTION

Bloom's Taxonomy is cognitive domain and singly taxonomy which has been useful on many education fields, including computer science. The taxonomy is broadly used in nearly all recognized education field. It is still acknowledged and proved to be unbeaten in supporting education practices and teachings. There are countless types of assessment or 'testing' to access student's learning curves. However, written examination is the generally common approach used by any higher education institutions for students' assessment. Question is a component that is tangled with the examination. Questions raised inside the paper plays an imperative role in efforts to test the students' overall cognitive levels held each semester. Assessment of learning outcomes for software engineering courses can be enhanced effectively through proper application of the taxonomy. This paper initiates a move towards improvement in software engineering assessments using Bloom's Taxonomy.

## II. BACKGROUND WORK

In this research, Bloom's Taxonomy is worked as a channel to delineate software engineering education practices. In this section, we give a succinct explanation on Bloom's Taxonomy, and the interrelated education fields that have integrated the taxonomy in their assessment. It is a means of expressing qualitatively different kinds of thinking. Taxonomy is a classification system that is ordered in some way.

### A. BLOOM'S TAXONOMY

Benjamin Bloom was the creator of this taxonomy, as he made available his idea on the cognitive skills taxonomy in his book [1]. Bloom was the head of a group in the 1950's and 1960's that created the classic definition of the levels of educational activity, from the very simple (like memorizing facts) to the more complex (such as analyzing or evaluating information).

Bloom motto is that original Taxonomy is more than a dimension tool. He said it could provide as a:

- ✓ Common language about learning goals to make possible communication across persons, subject matter, and grade levels;

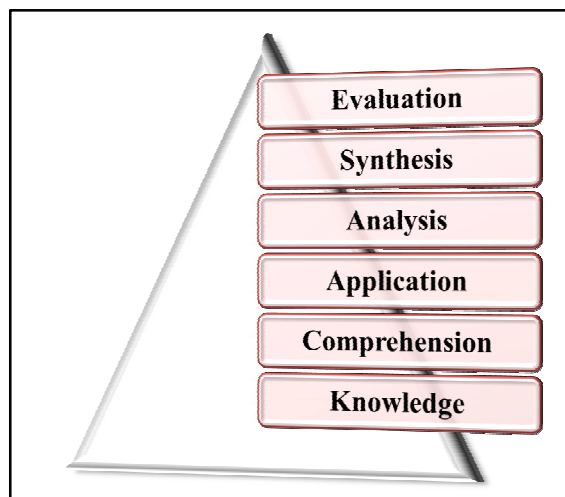
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- ✓ Basis for shaping for a particular course or curriculum the specific meaning of broad educational goals, such as those found in the currently established national, state, and local standards;
- ✓ Means for shaping the resemblance of educational objectives, activities, and assessments in a unit, course, or curriculum;
- ✓ Panorama of the range of educational possibilities against which the limited breadth and depth of any particular educational course or curriculum could be contrasted.

Bloom defined 6 levels of cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. The levels are shown in Bloom's Taxonomy hierarchy model.



**Fig. 1: Bloom's Taxonomy Hierarchy**

The pyramid is well-organized in such a way that the lowest possible level is the simplest form of detection, while the uppermost level is the majority intangible and multifarious form of cognitive skill. It provides a way to organize thinking skills into six levels, from the most basic to the more complex levels of thinking. It had been adapted for classroom use as a planning tool.

A more thorough explanation of every level is given as follows:

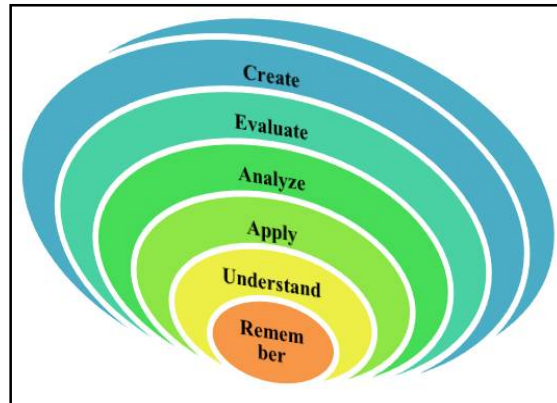
- Knowledge - ability to recollect
- Comprehension - ability to understand
- Application - ability to use knowledge
- Analysis - ability to separate component parts
- Synthesis - ability to put parts together
- Evaluation - ability to judge value of ideas

Bloom's Taxonomy was then modified in 2001 by Anderson et al. [2]. They made many changes and the innovative hierarchy is trampled on the top (see Fig. 2). This newly modified Bloom's Taxonomy is well-known as the Revisited Bloom's Taxonomy.

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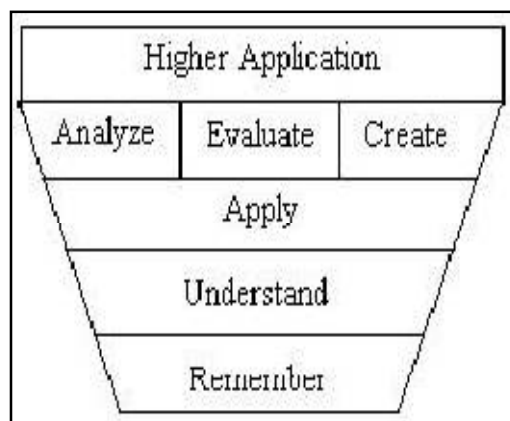


**Fig. 2: Revised Bloom's Taxonomy Hierarchy**

## B. BLOOM'S TAXONOMY IN RELATED FIELDS OF EDUCATION

Bloom's Taxonomy was applied on three computer science courses by Machanick [3]. His experience was then analyzed and he decided that Bloom's Taxonomy-based approach works healthy Software engineering is an element of computer science. Several research have been seen in many of computer science field of studies including computer science itself being associated to Bloom's Taxonomy. From live research, Bloom's Taxonomy seems to be extremely helpful for education purposes and is still much admired after more than 5 decades. It has been extensively used for learning objectives measurement and assessment.

But a query was raised in 2006 by Johnson et al. on whether the taxonomy is suitable for computer science [4]. They also recommended a new hierarchy that adds another level onto Anderson et al.'s taxonomy, which is the higher application level (see Fig. 3). This is given from their idea that application is the aim of computer science teaching. A closely related research was done by Thompson et al. earlier this year, but they focused on computer science assessment [5]. Their intend was to use Bloom's Taxonomy to assist in designing introductory programming examinations.



**Fig. 3: Bloom's Taxonomy Hierarchy for Computer Science**

Samples of programming questions were given for each Bloom's Taxonomy level. A more recent research was done by Starr et al. which focused on specifying assessable learning objectives in computer science [6]. They believed that their idea of integrating Bloom's Taxonomy with computer science curricular had made their faculty communication more

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effective and department's assessment program stronger. Their work is actually an extension to [7] which focused specifically on human-computer interaction curricular guidelines.

Other research work that were done for specific computer science areas of education using Bloom's Taxonomy include a test-driven automatic grading approach for programming [8], Bloom's Taxonomy levels for three software engineer profiles [9], and Bloom's Taxonomy for system analysis workshops [10].

## III. APPLYING BLOOM'S TAXONOMY IN SOFTWARE ENGINEERING ASSESSMENT

Learning outcomes of software engineering courses require assessors to distribute questions with different cognitive levels. This is to ensure students of software engineering courses that the assessment is done effectively and is imparted with the right level of knowledge and skill-sets. Assessments questions are either formative or summative in nature. These can be in the form of assignments, case studies, multiple choice questions, quizzes or formal examination. In this section we look at each level of the Bloom's taxonomy and demonstrate suitable examples.

### A. KNOWLEDGE LEVEL

This level is also known as "recalling of data" [1]. Knowledge in this context refers to the students' ability to recall software engineering concepts that they have studied in classrooms. Scott. T. [12] refers it as 'rote learning' or 'memorization'. Mainly this level serves as the lower level or the foundation level of the hierarchy. It is a level where students remember or memorize facts or summon up the knowledge they learned already. Knowledge level questions include the keywords define, identify, list, tell, arrange, order, match and state.

Following are a few sample questions that come under this level:

- Define Software Engineering.
- List core principles of Software engineering.
- State four attributes of well engineered software.
- State four types of traceability.

### B. COMPREHENSION LEVEL

Bloom in [1] describes this level as grasping the significance of information. The ability to extrapolating, interpret, translating, classifying, explaining are the concepts of these levels. Comprehension in this context refers to the students' ability to realize and restate or describe a learnt concept using their own language or wordings for explanation. Comprehension level questions include the keywords explain, describe, interpret, summarize, demonstrate, select, and predict.

Following are a few sample questions that come under this level:

- Describe 4 types of coupling in software design.
- Describe the Pareto Principle in Software Testing Principle.
- Explain PSP and TSP.
- Explain Software engineering as layered architecture.

### C. APPLICATION LEVEL

Application is defined by applying the idea to a certain state of affairs in [6]. Application in this research circumstance refers to the students' talent in using the theories learnt to crack the new problems. Application level questions include the keywords solve, classify, prepare, write, apply, choose, modify and interpret.

Following are a few sample questions that come under this level:

- Software is to be developed for Company "XYZ".  
The client is not sure of the final system requirements or how the system should be. Which software development model should be used for this project?  
Justify your choice of software development model.
- Given the following requirements, classify them to be either functional or non-functional requirement:
  - Security
  - Feature to calculate cost of item based on current discount policy.

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- Reliability
- Prepare a SRS (Software Requirement Specification) for Library Management System.

## D. ANALYSIS LEVEL

This level is helpful for students to breakdown data or definition into smaller but simpler parts and analyse each of it. This may entail depiction a relationship, distinguish, assumptions or classifying the parts. According to Thompson et al. [5], software engineering questions should contain the following: Draw DFD for various modules, classes, components or methods; systematize elements to achieve objective; recognize components of a development and distinguish nonrelated components or needs. In addition, it should be able to explain what exactly happens to remembrance when the designs are drawn step by step. Analysis in this research context refers to the students' ability to separate an entire into various module parts. Analysis level questions include the keywords compare, analyze, contrast, distinguish, categorize, differentiate, calculate and test.

Following are a few sample questions that come under this level:

- Give the benefits of verification and validation in software development and differentiate the techniques of verification and validation in the process of software development.
- Given that there are six members in a democratic team, calculate the number of communication paths needed.
- Compare and contrast the waterfall model with the prototyping model.

## E. SYNTHESIS LEVEL

If a student achieves this level, the student should be capable to combine and merge ideas or concepts by rearranging components into a new complete (a product, plan, pattern or proposal) [1] [12]. This level refers to the students' capability to narrate learnt software engineering concepts and produce a new idea. Synthesis level questions include the keywords design, create, construct, manage, develop, organize, predict, plan, and propose.

Following are a few sample questions that come under this level:

- Develop a SQA Plan for a software development project for library management.
- Develop Software Requirement Specification document for hotel management system.
- Draw Sample admission form and Design test cases for Admission Form.

## F. EVALUATION LEVEL

This is a final level where students own stand involves for judging, supporting, criticism or defending. Thompson et al. [5] discuss this level in Bloom's Taxonomy for CS Assessment. This level also includes commenting superiority of codes based on standards or execution criteria. Evaluation is defined as the ability of students to critic, judge and decides on value of ideas or materials. Evaluation level questions include the keywords debate, argue, recommend, justify, prioritize, and decide.

Following are a few sample questions that come under this level:

- Given two possible solutions, X and Y, to solving the given software development problem, decide on the best solution. Give your justification.
- Give your views about what is more important - the product or the process.
- Recommend which perspective model should be used for your college ERP system.

A variety of studies suggests various Bloom's verb but this effort presents the vagueness problem as per [13]. Several of the keyword may come out in other level as well in [14]. Yet, there are no exact measure verb keywords for each level so far. As a result, some researchers took their own initiative to provide related keywords [13]. Mastering lower levels is a precondition before students are able to move to more difficult levels [13]. However, it is not an excellent practice to directly assume a specific cognitive level for a question simply because a similar verb is found [5].

For instance, consider the following question:

*“Write test cases for Library Management Software”*

The question above requests the students to write test cases. We might assume that this question can be matched with the keyword **Write** because the word ‘Write’ appears in it. ‘Write’ can either be in Knowledge or Synthesis. If we

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watch closer at it, the question requires us to design various test cases for various modules and control present over it. Therefore, the suitable cognitive level for the question is Synthesis. A student with this level of learning should take previously learned concepts and apply them together to create something new in [12].

Table 1 summarizes each levels of Bloom's taxonomy as outlined by Bloom et al. [1].

Blooms Category	Definition	Sample Keywords
Knowledge	Recalling of data	Define, identify, list, tell, arrange, order, match and state
Compre-hension	Grasping the significance of information	Explain, describe, interpret, summarize, demonstrate, select, and predict.
Application	Applying the idea to a certain state of affair	Solve, classify, prepare, write, apply, choose, modify and interpret
Analysis	Breakdown data or definition into smaller but simpler parts and analyse each of it	Compare, analyze, contrast, distinguish, categorize, differentiate, calculate and test.
Synthesis	Combine and merge ideas or concepts by rearranging components into a new complete	Design, create, construct, manage, develop, organize, predict, plan, and propose.
Evaluation	Involves for judging, supporting, criticism or defending.	Debate, argue, recommend, justify, prioritize, and decide

## IV. CONCLUSIONS

We have presented the application of Bloom's taxonomy in software engineering education. This will assist educators in crafting their questions for software engineering assessments, given the level of question types. It will be helpful for assessment and ensuring that software engineering students' knowledge level and skills acquired are as defined by the learning outcomes

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