Bloom's Taxonomy for CS Assessment - Summary

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1 Introduction

This paper [3] aims to apply Bloom's revised taxonomy in computer science education, particularly in introductory programming courses. By categorizing programming tasks according to Bloom's taxonomy levels, educators can better assess students' skills across different cognitive abilities. This approach allows for a more comprehensive evaluation of students' proficiency, from basic understanding to advanced problem-solving. To provide necessary background information, we first describe Bloom's taxonomy.

2 Bloom's Taxonomy

Bloom's taxonomy is a hierarchical framework used to categorize educational learning objectives based on their complexity and specificity. First introduced by Bloom et al. in 1956 [2], the most commonly employed version is a revised model by Anderson et al. in 2001 [1]. This updated taxonomy emphasizes dynamism by utilizing verbs to label its categories and subcategories, as opposed to the nouns used in the original taxonomy. These verbs characterize the cognitive processes through which individuals engage with and manipulate knowledge. The taxonomy comprises the following levels:

1. Remember
2. Understand
3. Apply
4. Evaluate
5. Create

This hierarchical structure illustrates the progression of mastery within a specific topic, where each level builds upon the preceding one, fostering higher-order thinking skills. Each level is encompassed by those that follow, meaning a student who has achieved proficiency at the *apply* level has also mastered the material at the *remember* and *understand* levels.

Furthermore, the revised model introduces a second dimension. In addition to the original Cognitive Process dimension, which delineates the learning process, the revised model incorporates the Knowledge Dimension, which denotes the type of knowledge acquired. Within the Knowledge dimension, we identify:

- Factual knowledge
- Conceptual knowledge
- Procedural Knowledge
- Meta-Cognitive knowledge

These two dimensions intersected creates a grid of 24 cells (see table 2).

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual	List	Summarize	Classify	Order	Rank	Combine
Conceptual	Describe	Interpret	Experiment	Explain	Assess	Plan
Procedural	Tabulate	Predict	Calculate	Differentiate	Conclude	Compose
Meta-cognitive	Appropriate Use	Execute	Construct	Achieve	Action	Actualize

Table 1: Each row denotes the type of knowledge learned and each column denotes the process used to learn.

3 Summary

3.1 Methodology

To align the concepts encountered in CS1 with Bloom's taxonomy, exams from six institutions in Australasia and the USA were analysed by a team of five authors. Each exam task underwent classification based on the revised taxonomy. Initially, there was disparity among the authors regarding the placement of tasks. One contributing factor was the contextual insight possessed by one of the authors, who had been involved in teaching the course and thus could better discern how concepts were imparted. This contextual knowledge led to the categorization of relevant tasks differently compared to those without such contextual understanding.

Utilizing the analysis as a reference and discussion point, the authors collectively developed a consensus regarding the categorization of tasks within the Bloom taxonomy.

3.2 Cognitive categories

Here follows some of the cognitive categories and tasks that fit them.

3.2.1 Remember

Tasks that required knowledge that students could have rote-learned.

- **List** the arithmetic operators in increasing order of precedence.
- **Define** the purpose of a constructor.

3.2.2 Understand

Understand is defined as "constructing meaning from instructional messages, including oral, written, and graphical communications". One type of task that fits this category is:

Look at this section of code and explain in plain English what it does.

```
public static int mystery(int[] x, int a, int b) {
 int z = 0;
 for (int i = a; i <=b; i++) {
 z = z + x[i];
 }
 return (z / (b-a+1));
}
```

Another task within this category is:

The students have been provided with the source code for a class. They are asked to: Identify the constructor(s) defined in this class by writing constructor signatures in the answer book.

3.2.3 Apply

Apply is defined as "carrying out or using a procedure in a given situation". Within programming this was interpreted to "that the process and algorithm or design pattern is known to the learner and both are applied to a problem that is familiar, but that has not been solved previously in the same context or with the same data or with the same tools". A task which falls under this category was:

The students have been given the code for a Circle class. The code is similar to an example used in the textbook but modified to reduce the amount of code and change some features. As well as the Circle class, the project includes Square and Triangle classes. Each class has the same code structure. Students are asked to: Create a Shape class as a superclass of these three classes that includes all the common methods.

3.3 Discussion

The objective of this study was to interpret Bloom's taxonomy within the realm of computer science. The authors successfully assigned different exam tasks to their respective categories within the taxonomy, albeit often relying on the educational context and how concepts were taught.

This interpretation holds significance for instructors in exam creation. By incorporating a range of tasks that span the taxonomy's levels, instructors can effectively assess students' cognitive abilities. Lower-performing students may excel at tasks within the *remember* and *understand* categories but struggle with those at higher levels, while the opposite may be true for high-performing students.

This educational framework, established in 1956, has demonstrated its enduring relevance across various disciplines. Considering its longevity and adaptability, integrating this interpretation into the design of upcoming exams in courses such as INF100 and INF101 would be interesting.

References

[1] Lorin W Anderson and David R Krathwohl. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition.* Addison Wesley Longman, Inc., 2001.

[2] Benjamin S Bloom, Max D Englehart, Edward J Furst, Walker H Hill, David R Krathwohl, et al. Taxonomy of educational objectives, handbook i: the cognitive domain. new york: David mckay co, 1956.

[3] Errol Thompson, Andrew Luxton-Reilly, Jacqueline L Whalley, Minjie Hu, and Phil Robbins. Bloom's taxonomy for cs assessment. In *Proceedings of the tenth conference on Australasian computing education-Volume 78*, pages 155–161, 2008.