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Validating Bloom Computer Analysis Tools (B-CAT)

Russell Baker
rbaker1@ju.edu

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Russell Baker
Jacksonville University
rbaker1@ju.edu

Abstract

Bloom's Computer Analysis Tool (BCAT) is a software technology designed to analyze course objectives to determine to which category of Bloom's Taxonomy of the cognitive domain the objectives correspond. This paper describes the basic operational rational of the technology and describes its functional procedures. Additionally, analysis of 150 course objectives by both a human expert and the BCAT technology are compared to determine the validity of the BCAT analysis and identify any problems inherent in the software design and operation.

Keywords: Bloom's Taxonomy, course objectives

Introduction

Many educators focus on the selection of content, teaching method and instructional materials when planning course curricula. Although these are important elements in instructional planning, the entire process is more effective if attention is first directed toward the development of instructional objectives. Well-written objectives describe what students will learn and be able to do as a result of instruction. Gronlund (2004) described useful instructional objectives as those written in terms of the intended outcomes of instruction. When preparing objectives it is important to seek out a frame of reference that clarifies various types of learning outcomes. Bloom's Taxonomy is a scaffold for building a comprehensive framework for classifying verbs used to describe learning outcomes at each of the levels of Bloom's Taxonomy.

Bloom's Taxonomy

In 1956, Benjamin Bloom developed a system for categorizing educational objectives and published the results of the work in *Taxonomy of Educational Objectives: Book 1, Cognitive Domain*. Since its first publication, almost 50 years ago, the handbook has been translated into more than twenty languages. This work, commonly referred to as Bloom's Taxonomy, is widely used by educators today to formulate instructional objectives, categorize learning tasks, drive instruction and define assessments.

In the *Taxonomy* Bloom provides a theoretical framework for classification of behaviors resulting from educational processes and evaluation of the extent to which desired behaviors were learned by students (Bloom, 1956). The cognitive domain, predominant in a majority of educational courses, consists of learning that is demonstrated by recall of knowledge and intellectual skills including comprehension of information, organization of ideas, analysis and synthesis of data, application of knowledge, alternative evaluation and choice, and problem solving (dlrn.org, 2002). Bloom defined six levels of learning objectives within the cognitive domain. These levels represent a hierarchy of complexity of learning skills ranging from simple recall and fact recognition at the first level of the hierarchy to increasingly more abstract and complex mental levels culminating with evaluation reflected in the student's application of learned behaviors. Bloom's classifications of learning objectives in the cognitive domain as defined in Principles of Curriculum and Evaluation (Bloom, 1956) are:

1. Knowledge - remembering previously learned material
2. Comprehension - grasping the meaning of material

3. Application - using learned material in new and concrete situations
4. Analysis - breaking down material into its component parts and understand its organizational structure
5. Synthesis - assembling parts together to form a new whole
6. Evaluation - judging the value of material for a given purpose

Bloom viewed these objectives as the "intended behaviors which the student shall display at the end of some period of education" (Bloom, 1956) and a developmental process through the learning objectives hierarchy, each intended objective building on an achieved predecessor. By applying specific verb terminology related to each of the learning objectives it becomes possible to define specific behaviors to evaluate successful attainment of a learning objective. Some of the verbs related to each of Bloom's learning objectives include: (Almerico & Baker, 2004)

1. Knowledge: arrange, define, duplicate, memorize, recognize
2. Comprehension: classify, describe, identify, report, restate
3. Application: apply, choose, illustrate, solve, write
4. Analysis: analyze, categorize, criticize, distinguish, test
5. Synthesis: assemble, collect, manage, organize, propose
6. Evaluation: argue, assess, choose, value, evaluate

Almerico and Baker (2005) conducted an analysis of the research related to the labeling of learning objectives according to Bloom's Taxonomy. In their study they discovered many variations of lists which categorically defined action verbs according to Bloom's classification (Airasian, 2001; Bloom's Taxonomy, 2002; Borich & Tombari, 2004; Chatterji, 2003; DLRN's Technology Resource Guide, 2002; Gronlund, 2004; Hazari, 2002; Lane, 2002; Lee, 1999; McMillan, 2004; O'Malley & Pierce, 1996; Objectives in an Outcomes, 2002; Preparing for Clinical, 2002). Many of the verbs were assigned to more than one level or category within the hierarchy in a given list. Matters became more convoluted when they found verbs categorized across levels of the taxonomy in different lists. When educators chose action verbs to clearly convey instructional intent, precisely specify student performance, and pinpoint the level of cognition addressed, conflicting lists can lead to frustration and confusion. As a result of the analysis, Almerico and Baker developed a master list of illustrative verbs for each of the six levels of Bloom's Taxonomy (Illustrative Verbs Corresponding to the Cognitive Levels of Bloom's Taxonomy is available at: http://users.ju.edu/rbaker1/BloomVerbList.htm). The illustrative verb list provides a standardized record of verbs categorized in terms of specific types of learning outcomes that can be used as the basis for writing instructional objectives, planning and assessing instruction.

Bloom's Taxonomy is established, well-known, comprehensive, hierarchical in design and contains actions verbs which succinctly describe learning outcomes. Well-stated objectives can provide a description of the intended learning outcomes in performance terms – that is, they identify verbs that describe observable behaviors students demonstrate to show acquisition of the knowledge, understanding or skill described by the objective (Gronlund, 2003). By delineating the performance that they are willing to accept as evidence of learning, educators can provide a focus for instruction, student learning and assessment.

Bloom's Computerized Assessment Technology (BCAT) © ®

Baker (2003) proposed a framework for the development and evaluation of online distance learning courses based on the levels of cognitive learning in Bloom's Taxonomy. Ensuing studies (Baker & Papp, 2003; Baker & Papp, 2004) developed this framework into a matrix that provides for the evaluation of course objectives to determine which level of Bloom's cognitive domain that the objective is written to achieve. The evaluation procedures used in the matrix are predominantly manual. Following these studies Blooms Computerized Assessment Technology (BCAT) was developed to automate the analysis of course objectives to determine the level of Bloom's cognitive domain that the objective addresses. The logical function of the BCAT is simple. The program uses the aforementioned list of Bloom's Taxonomy Illustrative Verbs (Almerico & Baker, 2005) as the dataset. Course objectives copied into the BCAT software are searched for verbs that match those in the dataset. When an objective action verb matches a dataset verb, the software returns the taxonomy-level of the matched dataset verb. The following describes the operational characteristics of the program.

BCAT Operational Procedures

Upon initializing the BCAT software the program reads the taxonomy dataset into memory then displays the following window.

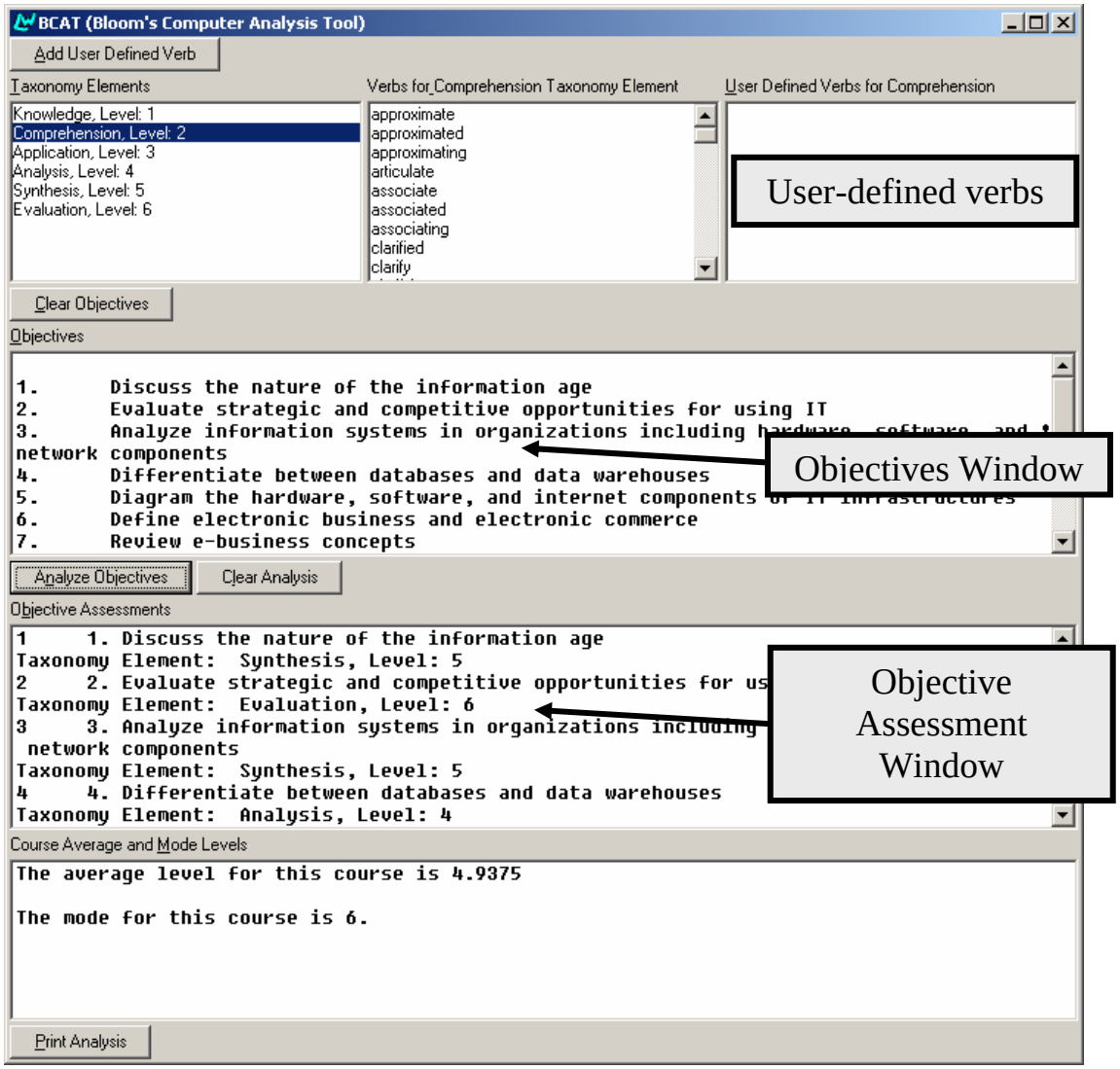

Figure 1. BCAT Software Initialization

The current version of the software requires the instructor to copy course objectives and paste them or type them into the objectives window. After entering the course objectives, clicking the Analyze Objectives button displays the following windows that prompt the instructor to enter the course title and instructor's name.

Figure 2. BCAT Prompt for Instructor and Course Title

Upon entering this information the BCAT evaluates the course objectives and returns the taxonomy level for each individual objective, along with the mean level for the course and modal value for the cumulative objectives.

Recognizing that no dataset can be totally comprehensive, the program is designed to allow the user to add verbs to the dataset in the desired taxonomy categories. Objective-evaluations are returned in one to six values corresponding to the taxonomy levels, with one being knowledge through six being evaluation. If there is no corresponding verb in the dataset, the software returns a zero.

Purpose

The purpose of this study is to determine the validity of the objective evaluations of the BCAT software by comparing these evaluations with objective-evaluations generated by a human expert using the Bloom's Taxonomy Illustrative Verbs (Almerico & Baker, 2005) as the basis for their evaluation.

Methodology

The BCAT software was used to evaluate 150 objectives taken from thirteen courses in various subjects of two universities. The objectives were copied into an Excel spreadsheet with all identification of course numbers and university affiliation removed. This list was provided to the human-expert evaluator along with a copy of the Bloom's Taxonomy Illustrative Verbs list. The expert was asked to evaluate each of the objectives and assign the most appropriate taxonomy category. Simultaneously, the objectives were analyzed using the BCAT software. The two sets of objective-analysis results were then compared with each other.

Hypothesis

Ho: 1 <= 2, the BCAT software will generate the same Bloom's Taxonomy level course objective analysis as the experts in field.

Ha: 1 >= 2, the BCAT software will not generate the same Bloom's Taxonomy level course objective analysis as the experts in field.

Results

The results of both the expert analysis and BCAT analysis of the 150 assorted course objectives are as follows:

Total Objectives	150
Matching	110
Different	40
Badly written objectives	9
BCAT analysis incorrect	31

Figure 3. Results of Analysis of Course Objectives

When the objectives were initially evaluated by the BCAT deficiencies in the software function were revealed. Objectives containing apostrophes, hyphens, colons, or semicolons caused the program to crash. Removing these punctuation marks and rerunning the objectives resulted in successful. Additionally, the software does not add user-defined verbs to the dataset as intended. During this evaluation user-defined verbs were manually entered into the dataset prior to objective analysis.

Perhaps the most serious malfunction of the software is its inability to deal with objectives containing multiple verbs or words which may be used as verbs, nouns, adjectives or adverbs. Although proper objective construction purports one action item per objective, objectives written with more than one identified verb result in the software returning the highest category of the verbs identified. For example, BCAT returns a value of five for the objective "Explain and discuss strategic and competitive opportunities for using IT". The fact that two action verbs are included in the statement results in a possible erroneous response and differs from the human-expert response. These are identified in the above table as "Badly written objectives".

Even more problematic is an objective line "students will discuss the importance of writing and evaluating proper course objectives". An objective like this contains verbs as part of a prepositional phrase. The BCAT identifies this objective as evaluation (level 6) because of the word evaluating. These are identified in the above table as "BCAT analysis incorrect".

Conclusion

Although the BCAT software exhibits significant promise, the problems inherent in the program described above need to be corrected. The code needs to be modified to any non-text punctuation or symbols (excluding periods and commas which are already recognized in the code) from objectives before analysis. Additionally, user-defined objectives are not retained in the dataset. Consequently, when objectives containing user-defined action verbs are evaluated the program finds no corresponding verb in the dataset and returns a zero. Again, this requires modification of the code to insert the user-defined verbs into the appropriate taxonomy category in the dataset.

The initial comparison resulted in 40 variations between the human-expert and BCAT evaluations. A subsequent evaluation, conducted with the punctuation and dataset problems corrected, objectives containing multiple parts (two objectives per objective statement), and objectives containing verbs used in non-verb context removed resulted in a 100 percent correlation between the BCAT and human-expert evaluations.

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