

# Bloom's Taxonomy and the UCGIS Model Curriculum Learning Objectives

By

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## **Abstract**

The undergraduate model curriculum strawman document for geographic information science and technology (GIS&T) is now available for review on the UCGIS website. The document identifies both topical content and learning objectives. While one might anticipate that much of the review process will focus on content, I have chosen to examine the range of cognitive levels suggested by the learning objectives enumerated for each topical subject area. The well recognized Bloom's Taxonomy of educational cognitive levels ranges from knowledge, to comprehension, then application, analysis, synthesis, and finally evaluation. It contains an associated robust set of terminology for evaluating these levels. A text-based content analysis of the model curriculum learning objectives shows a highly variable set of cognitive levels for the subtopical areas but with most topical averages falling between Bloom's level 2 and 3. Based on the premise that all students graduating from a GIS&T program should be able to identify and solve spatial temporal problems this suggests that in general the curriculum is already at an appropriate level. These results should prove useful for both development of appropriate testing and evaluation materials and a continued dialogue about the appropriate knowledge level one should expect of undergraduate students for each topic.

## **Introduction**

In 1998 a small task force formed to examine the state-of-the-art in geographic information science and to "rebuild the GIS pyramid" (Marble, 1998, 1999)." Since its beginning it has subsequently modified its terminology to acknowledge both the science and the technology – hence its current use of the term geographic information science and technology (GIS&T). Composed of a dozen or so professionals from industry, education, and government, its mission was to create a model undergraduate curriculum not unlike that already in place in disciplines such as computer science (Gorgone, et al. 2002). Early on this effort was funded to various degrees by Environmental Systems Research Institute, GE Small World, and Intergraph Corporation to allow the process to move forward. Eventually the working group's activities were acknowledged by the University Consortium for Geographic Information Science (UCGIS) and are now sanctioned by the educational component of that organization. By 2003 (Task Force for the development of undergraduate curricula) a working "strawman" document was prepared and was placed in the UCGIS website for interested parties to read, review, and hopefully to provide constructive input. This article is a response to one portion of the working document – the learning objectives for the twelve identified concept areas.

The strawman document is a reflection of the task force's underlying objectives to define the current state of the body of knowledge, reduce the recognized shortage of well educated GIS&T personnel and correct the observed mismatch between the educational process and industry needs. As it exists today it is meant to be a living document, requiring substantial comment from interested parties and is based on six basic guiding principles (UCGIS strawman report). These principles are:

1. Disciplinary diversity
2. Defined curriculum core
3. Adaptability to different institutional missions
4. Include institutional context of GIS & T
5. Adaptability to content change
6. Focus on spatio-temporal problem identification and solution

I list these principles in different order from that within the document itself. I have reordered them to place #6 at the bottom of the list because it is this principle (the focus on problem identification and solving within a spatial / temporal context) with which this current piece of research is concerned.

The implications of principle #6 are that the student who successfully completes a program of study in GIS&T should, in general, not only be able to demonstrate a factual knowledge of GIS&T, and illustrate an understanding of its basic principles, but more importantly to employ them. This employment is most often characterized by a demonstrable ability of the student to identify and solve realistic moderately complex spatio-temporal problems using the GIS&T technology of the day regardless of vendor.

## **Problem Statement**

Among the things that have yet to be completed for the model curriculum is a determination of the relative importance that each topical level should have for appropriate job classifications and for different educational settings. While the guiding principles of the model curriculum development process suggest that a general minimum standard might be expected to be at or near a use or application level, the task force has not as yet determined if this should be the same for all of the 12 topical or concept areas listed below.

1. Conceptualization of Space
2. Formalizing Spatial Conceptualizations
3. Spatial Data Models and Structures
4. GIS & T Design Aspects
5. Spatial Data Acquisition, Sources/Standards
6. Spatial Data Manipulation
7. Explanatory Spatial Data Analysis
8. Confirmatory Spatial Data Analysis
9. Computational Geography

10. Cartography and Visualization
11. Organization/Institutional Aspects of GIS&T
12. Professional, Social, and Legal Aspects of GIS&T

Each of these 12 topical areas is further subdivided into more explicit topics through a suggested unit breakdown. For example, the strawman document breaks topical area #1, CS (conceptualization of space) into 4 subtopics as part of its unit breakdown. For this example the breakdown is as follows:

- CS1: Characteristics of Space
- CS2: Spatial Thinking
- CS3: Field-based vs. Object-based Views of Geographic Space
- CS4: Spatial Relationships

While this is even further decomposed, it is at this level that the document provides associated learning objectives. These learning objectives give some indication of the performance standards for each of these unit breakdowns. While the task force had originally considered the possibility of enumerating the performance level that might be expected of an undergraduate student for each of the twelve topic areas and their unit breakdowns the process was abandoned in favor of first providing a baseline body of knowledge linked to learning objectives.

Unfortunately, until the existing levels as suggested within the current document are quantified it is difficult to make the necessary adjustments for deciding the appropriate level for each topic later on. This is particularly important given that the overarching guiding principle of this work has been to adjust to a diversity of disciplinary, mission and institutional contexts. My research attempts to fill this gap by using a relatively rigorous, yet well established educational standard upon which to make this evaluation.

The standard to which I refer is called Bloom's (1956) taxonomy of cognitive levels. There are generally considered to be 6 levels based on Bloom's original work although some educators have employed seven. The levels are as follows:

1. Knowledge - memorization
2. Comprehension - grasping meaning
3. Application - adapting knowledge
4. Analysis - decomposing into component parts
5. Synthesis - recomposing to new forms
6. Evaluation - judging value for a purpose

Each of these levels has associated with it a series of mostly unique verbs that allow educators to relate specific behavioral objectives to these cognitive levels (Bloom 1956). As such they can formulate specific testing environments appropriate to both the cognitive level and to its necessary demonstrable action.

## Methods

I examined all the suggested learning objectives for each of the unit breakdown categories for each of the twelve proposed topical areas. By identifying action verbs and the context within which they are currently embedded I compared these to those suggested within Bloom's taxonomy. For example, under the first unit breakdown area for topical area one (characteristics of space – CS-1) the first learning objective states that the student should be able to “understand that there are different views of the world, depending on level of experience and application context.” The operational verb for this learning objective is “understand” which occurs at Bloom's level 2, indicating comprehension. This level shows that the student is not only capable of listing various views of the spatial world, but also comprehends that it is through the disciplinary context and viewer experience that these views are established. For this learning objective I recorded a Bloom's level value of 2. I performed this same procedure for each of the seven learning objectives for CI-1 then calculated its mean. I then continued the process for each of the remaining unit breakdowns. Once this was completed I produced a super mean, a maximum, and a minimum value for the concept area C1. The minimum and maximum values were determined so a range could be established for each general concept. I continued the process for the 11 concepts for which learning objectives were available within the document. Concept 10 (cartography and visualization lacked learning objectives). Finally, the results were graphed for visual inspection.

## Results

With the exception of concept 5, (spatial data sources, acquisition, and standards) all the concepts exhibited a range of at or near 2. Concepts 3, 4 and 9 (data structures and models, GIS design, and computational geography respectively) were the only concepts that exhibited learning objectives at the highest Bloom's level (6). Concepts 2 and 8 (formalizing spatial conceptualizations and confirmatory data analysis respectively) had maximum values at level 5. The remaining concepts ranged up to a maximum Bloom's value of 4 or below. Four of the concepts (1, 4, 5, and 6) had minimum values approaching level 2, while all remaining concepts showed minimum Bloom's levels at level 1.

The mean values were considerably more clustered than the ranges might initially indicate. With the exception of concept 4 (Mean = 4.50), all the concepts' means fell somewhere between 3.16 and 2.0.

Concept Category	Minimum Bloom's Value	Maximum Bloom's Value	Mean Bloom's Value
(1) Conceptualizing Space	2	4	2.35
(2) Formalizing Space	1	5	3.17
(3) Models and Structures	1	6	2.72
(4) Design Aspects	2	6	4.50
(5) Data Acquisition	2	3	2.86
(6) Data Manipulation	2	4	2.44
(7) Explanatory Analysis	1	3	2.51
(8) Confirmatory Analysis	1	5	2.45
(9) Computational Geography	1	6	3.05
(10) Cartography	N/D	N/D	N/D
(11) Organizational Aspects	1	3	3.00
(12) Professional Aspects	1	4	2.04

Table 1: Tabulation of minimum, maximum, and super mean Bloom's values for the GIS&T concepts.

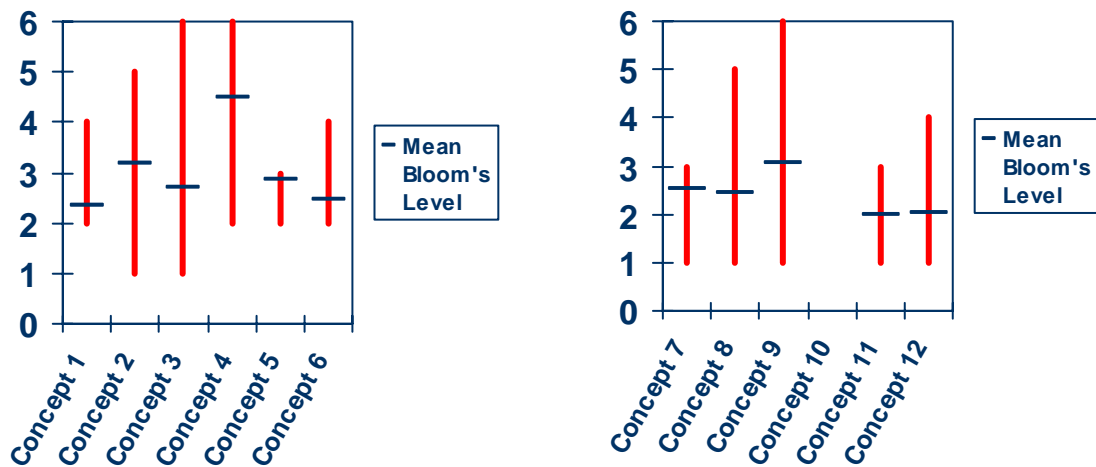


Figure 1: Graphical depiction of means, maximum, and minimum for all 12 concepts.

## Conclusions

Results suggest that, in most cases the strawman document suggests at least an average applications comprehension or applications level of knowledge (Bloom's levels 2 or 3) for each of the 11 concepts for which data exist. Given that some subconcepts might require either higher or lower values this seems an appropriate average level for an

undergraduate curriculum. It also strongly suggests that the curriculum, if properly employed, generally achieves the goal suggest in guiding principle #6; that of presenting the material at a level that requires the student to understand and, in many cases apply what they learn. It is highly unlikely that any undergraduate curriculum will result in students achieving Bloom's level 6 for more than an absolute minimum of topics. Results from this tabulation clearly demonstrates that this is only suggested for a very few factors. Based on this simple analysis of action verbs associated with Bloom's taxonomic levels it appears that the model curriculum as exemplified by the existing strawman document achieves the guiding principle of focusing on spatial temporal problem identification and solution. Given industry's demand for this ability, it is anticipated that, if properly implemented, the model curriculum is already in a form that will prove useful for satisfying these demands.

## **Discussion**

While this initial simple quantification of learning objectives is highly suggestive of a successful achievement of the guiding principle of spatial temporal problem identification and solution there are some important issues that remain to be addressed. The action verbs used in this analysis require interpretation by a human and thus do not allow for exact recreation of the study. This is particularly true because some of the action verbs occur in more than one level. Some of the learning objectives are also less explicit than others and either incorrectly apply action verbs or employ more than one action verb in each learning objective. Additionally some learning objectives are quite numerous while others are few in number. As has already been noted, topic 10 is missing learning objectives entirely. Finally, the learning objectives often reflect the personal interests of the team members who suggested them, their individual backgrounds, institutional contexts, levels of experience, and the nature of their audience.

In short, the results of this initial review of learning objectives should be viewed with a healthy level of cynicism. More importantly, the document should be examined by as many individuals as possible. Both the learning objectives and the Bloom's levels need to be re-examined as well. This should be done after substantial document feedback and, in particular, by rewording the learning objectives to specific, decomposed behavioral objectives. Finally for each behavioral objective there should be a single action verb explicitly tied to an appropriate demonstrable and hopefully quantifiable action.

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