VIEWS ON TAXONOMY AND LEARNING

Sandra Ozola
University of Latvia

Abstract
Taxonomy (from Greek '*taxis'* meaning arrangement or division and '*nomos'* meaning law) is the science of classification according to a pre-determined system. In this article taxonomy will be viewed as classification of thinking.
Instead of the traditional approach of directing instruction to the transmission of knowledge and defining objectives in terms of content to be learnt, student-centred approach acknowledges what the student does. An instrument like a taxonomy can be used for planning, learning and assessment.
Learning can be categorized based on the complexity of the thought process used. Teachers apply Bloom's Taxonomy in the classroom to enhance students' knowledge by helping them use increasingly complex reasoning. SOLO, which stands for the Structure of the Observed Learning Outcome, is essentially a hierarchy which has five stages or levels that attempts to assess the students learning based on the quality of their work.
The aim of the article is to study theoretically two taxonomies which complement each other.
The object of the research is similarities and diferences in SOLO and Bloom's Taxonomy.
The research method used in the article is the analysis of scientific literature on SOLO and Bloom's taxonomies.
KEYWORDS: taxonomy, levels of thinking, learning.

Introduction

The preconceptions of most students about the nature of teaching and learning and the practices of a majority of teachers are in stark contrast to the demands of the constructivist classroom. Traditional teaching practices hold the opinion that right answers for everything exist in the absolute and that the role of the teacher is to teach students. Knowledge represents a gradual accretion of right answers acquired through effort and obedience to the teacher. Traditional approaches emphasize the presentation of information, and define learning as its absorption. Excellence in learning equals the flawless recall and summary of information.

In contrast, an effective student-centred, learning-oriented classroom requires different perspectives from both teachers and students. Kember (1997) maintains that rather than covering content, the goal of teaching becomes the intentional intellectual development of students. This involves changing the way students think and encouraging them to confront what they believe in light of new facts and evidence. As claimed by Novak, J.D. & Gowin, D.B. (1984) at the same time, students must significantly alter their view of knowledge, the role of teachers and themselves as learners. They have to reconsider their own role that of an independent learner and the teachers' role as the facilitator of that process.

SOLO and Bloom's taxonomies represent a tool for planning and implementing the student-centered classroom because they give teachers a precise language for articulating the intended outcomes of their teaching expressed in terms of student learning. As a result, the focus of classroom teaching becomes the development of student skills and competencies rather than the teacher's academic knowledge or content coverage. According to Kurfiss (1988) teaching becomes an intentional activity in which teachers guide students and preventlearning difficulties along the way before those difficulties hinder the mastery of important course outcomes.

Reasons for using a taxonomy

Anderson and Krathwohl (Biggs, 2002) give six reasons for categorising objectives in a taxonomy:

- it permits educators to examine objectives from the student's point of view,
- it helps educators consider the panorama of possibilities in education — teaching for higher-order objectives and learning how to learn,
- it helps educators see the integral relationship between knowledge and cognitive processes inherent in objectives,
- it makes life easier — examiners can easily identify the 'demand' of a question by knowing the framework, so guesswork is removed,
- it makes more readily apparent the consistency, or lack of it, among the stated objectives for a unit, the way it was taught, and how learning was assessed,

- it helps educators make better sense of the wide variety of terms that are used in education — the precision in the taxonomy improves communication and understanding of what is to be learnt, taught and assessed.

The SOLO taxonomy developed by John Biggs (1982) is predicated on a system of constructive alignment, in which teachers define the outcomes of teaching and learning in terms of content and the level of understanding. Learning is constructed by what activities the students carry out - learning is about what students do.

The SOLO Taxonomy helps to map levels of understanding that can be built into the intended learning outcomes and offers a way of describing the growing complexity of a student's activity (Biggs, 1999). It can be used in two ways (Biggs and Tang, 2007):

1. To set learning objectives appropriate to where a student should be at a particular stage of their program.
2. To assess the learning outcomes attained by each student.

As learning progresses it becomes more complex, SOLO is a means of classifying learning outcomes in terms of their complexity, enabling teachers to assess students' work in terms of its *quality* not of how many bits of this and of that they got right. It describes level of increasing complexity in a student's understanding of a subject, through five stages, and it is claimed to be applicable to any subject area.

SOLO has fairly clear links with Bloom's taxonomy in the cognitive domain. Like pyramidal representation of Bloom, it is obvious that each level embraces previous levels, but adds something more.

SOLO has five levels of understanding (Biggs and Tang, 2007) where the first three are mainly quantitative and the last two - qualitative:

1. Pre-structural.
   No understanding demonstrated and the approach involves acquiring disconnected bits of information. Students miss the point.
2. Uni-structural.
   Students show concrete but fragmentary understanding of the topic. Simple and obvious connections are made but broader significance is not understood. The related learning verbs are: identify, memorise, do simple procedure.
3. Multi-structural.
   Students can understand several components but the understanding of each remains discreet. A number of connections are made but the significance of the whole is not determined. Ideas and concepts around an issue are disorganised and aren't related together.
   The related learning verbs are: enumerate, classify, describe, list, combine, do algorithms.
4. Relational.
   Students can indicate connection between facts and theory, action and purpose. They show understanding of several components which are integrated conceptually showing understanding of how the parts contribute to the whole. They can apply the concept to familiar problems or work situations.
   The related learning verbs are: compare/contrast, explain causes, integrate, analyse, relate, apply.
5. Extended Abstract.
   Students conceptualise at a level extending beyond what has been dealt with in the actual teaching. Understanding is transferable and generalisable to different areas.
   The related learning verbs are: theorise, generalise, hypothesise, reflect, generate.

Traditional Hierarchy of Thinking Processes

In 1956, Benjamin Bloom wrote Taxonomy of Educational Objectives. The Cognitive domain and his six-level description of thinking has been widely adapted and used in countless contexts ever since. His list of cognitive processes is organized from the most simple, the recall of knowledge, to the most complex, making judgments about the value and worth of an idea.

Bloom's Taxonomy of Educational Objectives (Traditional)

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis

6. Evaluation.

Today's world is a different place, however, than the one Bloom's Taxonomy reflected in 1956. As Pohl (2000) points out that educators have learned a great deal more about how students learn and teachers teach and now recognize that teaching and learning encompasses more than just thinking. It also involves the feelings and beliefs of students and teachers as well as the social and cultural environment of the classroom.

Revised Bloom's Taxonomy

In 1999,a cognitive psychologist Anderson (2001), a former student of Bloom's, and his colleague educational psychologist Krathwohl (2001) published an updated version of Bloom's Taxonomy that takes into account a broader range of factors that have an impact on teaching/learning and that reflects a taxonomy more closely tied to 21st century learning. Unlike the 1956 version, the revised taxonomy differentiates between "knowing what," the content of thinking, and "knowing how," the procedures used in solving problems.

Change in terms

Anderson and Sosniak (1994) support the statement that Bloom's Taxonomy has stood the test of time. Due to its long history and popularity, it has been condensed, expanded, and reinterpreted in a variety of ways.

Basically, Bloom's six major categories were changed from noun to verb forms. Additionally, the lowest level of the original, knowledge, was interpreted as remembering. Finally, synthesis is understandood as evaluation. The highest level in today's version is creating. Taxonomy reflects different forms of *thinking*, which is an *active* process that is expressed by verbs but not nouns that denote status or facts.

Expanded Taxonomy of Learning

1. Remembering
2. Understanding
3. Applying
4. Analyzing
5. Evaluating
6. Creating

Professionals from Center of Teaching, University of Iowa, Florman and Johston (2008) have adapted revised Bloom's taxonomy and worked out their variant adding there classroom roles of students and a teacher.

Thus, the expanded taxonomy of learning can be described as follows:

- ***Remembering***: retrieving, recalling or recognizing knowledge from memory and is the lowest order thinking skill which is defined as the knowing of previously learned material or retrieving, recognizing, and recalling relevant knowledge from long-term memory. Students demonstrate they **remember** by recalling specific bits of information.

The related learning verbs are: *tell, list, describe, name, repeat, remember, recall, identify, state, select, match, know, locate, report, recognize, observe, choose, who, what, where, when, cite, define, indicate, label, memorize, outline, record, relate, reproduce, underline.*

Classroom roles for remembering:

- Students – respond, absorb, remember, recognize.
- A teacher – directs, tells, shows, examines.

- ***Understanding***: constructing meaning from information. It is the ability to make one's own meaning from working with educational material such as reading and teachers' explanations.

The related learning verbs are: explain, restate, find, describe, review, relate, define, clarify, illustrate, diagram, outline, summarize, interpret, paraphrase, transform, compare similarities and differences, derive main idea, arrange, convert, defend, discuss, estimate, extend, generalize, give examples, locate, report.

Classroom roles for understanding:

- Students – explain, translate, demonstrante, interpret, summarize.
- A teacher – demonstrantes, listens, questions, comapres, examines.

- ***Applying***: using methods, concepts, principles and theories in new situations. It involves the lower order thinking skills of *understanding* and *remembering.*

The related learning verbs are: apply, practice, employ, solve, use, demonstrate, illustrate, show, report, paint, draw, collect, dramatize, classify, put in order, change, compute, construct, interpret, investigate, manipulate, modify, operate, organize, predict, prepare, produce, schedule, sketch, translate.
Classroom roles for applying:

- Students – solve novel problems, demonstrate, use knowledge constructs.
- A teacher – shows, facilitates, observes, criticizes.

- ***Analyzing***: breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Analyzing distinguishes between facts and inferences and determines how the parts relate to one another and to an overall structure. It involves lower order thinking skills, such as *applying, understanding* and *remembering.* Clark (2007) claims the *analyzing* level signifies a transition from *lower order* thinking skills to *higher order* thinking skills.

The related learning verbs are: analyze, detect, test, deconstruct, distinguish, examine, focus, find coherence, survey, compare, contrast, classify, investigate, outline, separate, structure, categorize, solve, diagram, determine evidence and conclusions, appraise, break down, calculate, criticize, debate, experiment, identify, illustrate, infer, inspect, inventory, question, relate, select.
Classroom roles for analyzing:

- Students – discuss, uncover, list, dissect, compare and contrast.
- A teacher – probes, guides, observes, acts as a resource.

- ***Evaluating***: making judgments based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation. It was the original highest order thinking skill in Bloom's (1956) original taxonomy. It is achievable after *analysis* and it involves the lower order thinking skills.

The related learning verbs are: coordinate, judge, select/choose, decide, debate, evaluate, justify, recommend, verify, monitor, measure the best way what worked, what could have been different, test, appraise, assess, compare, conclude, contrast, criticize, estimate, explain, grade, interpret, rate, relate, revise, score, summarize, support, value.
Classroom roles for evaluating:

- Students – judge, dispute, form opinions.
- A teacher – accepts, lays bare the criteria, harmonizes.

- ***Creating***: putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. As explained by Ferguson (2002) creating requires users to put parts together in a new way or synthesize parts into something new and different a new form or product. This process is the most difficult mental function in the new taxonomy (Anderson and Krathwohl, 2001.)

The related learning verbs are: create, hypothesize, design, construct, invent, imagine, discover, present, deduce, induce, bring together, compose, pretend, predict, organize, plan, modify, improve, suppose, produce, set up, what if, propose, formulate, solve (more than one answer), arrange, assemble, categorize, collect, combine, devise, explain, generate, manage, perform, prepare, rearrange, reconstruct, relate, reorganize, revise, argue for.
Classroom roles for creating:

- Students – generate, hypothesize, plan, design, produce, construct, argue.
- A teacher – reflects, extends, analyzes, evaluates.

The taxonomy is actually a representation of the learning process. Students *remember* a concept as they demostrate *understanding, understand* a concept before they can *apply* it, *analyze* a concept as they *evaluate* it and *remember, understand, apply, analyze, evaluate* in some form in any demonstration of *creating.*

Although many students think that the first two levels (knowledge and understanding) are enough, the third level (application) is where real learning begins. In other words application is a use of a concept in a new situation or what was learned in the classroom in novel situations. It is not enough to simply "to know" something. If the student cannot transfer the knowledge to a new situation, it nothing has really been learned.

Learning outcomes

Learning outcomes describe what students are expected to be able to do upon completion of a unit. They provide a link between expectations, teaching/learning and assessment. They begin with a strong action verb and describe specific tasks, preferably requiring students to develop higher order thinking skills. Unit learning outcomes can be assessed at various levels of thinking.

Bloom's Taxonomy is a way of organizing the students thinking and learning, with the emphasis on reaching the highest level of thinking possible, i.e. learning. In far too many learning environments the learning never goes beyond the very beginning levels of learning and the explanation is very simple – the lower levels are easy to quantify and evaluate. The lower levels are important as they are steps to higher level learning. According to Bloom (1956) and Anderson and Krathwohl (2001) the higher level learning is very significant because it is the higher levels of thinking that students begin to have a real relationship with learning and the world around them. It is the higher levels of thinking that create resourceful lifelong learnig.

Bloom's Revised Taxonomy against Daggett's Application model

Building on the work of Bloom, Anderson, and Krathwohl, the International Center for Leadership in Education, under the leadership of Dr. Bill Daggett, created a Rigor/ Relevance Framework model for learning and student achievement based on two dimensions.

On the one hand, there are some similarities in both approaches: Daggett's Knowledge Taxonomy is described as a continuum based on the six levels of Bloom's Taxonomy, which shows the increasingly complex ways in which people think. The lowest level according to Bloom involves acquiring knowledge and being able to recall or locate that knowledge. The highest level labels the more complex ways in which individuals use knowledge, such as taking several pieces of knowledge and combining them in both logical and creative ways.

On the other hand, Daggett offers the Application Model - is that of action. Its five levels describe putting knowledgein to use. While the lowest level is knowledge acquired for its own sake, the highest level signifies its use to solve complex real-world problems and to create unique projects, designs, and other works for use in real-world situations.

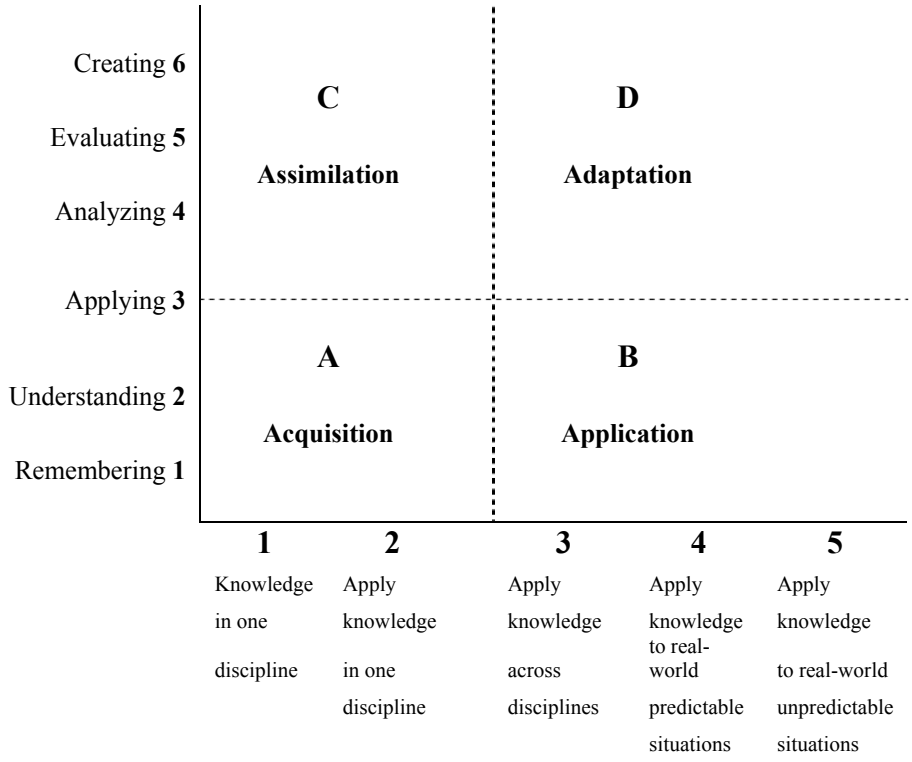
Daggett further specifies his Application Model a five level continuum:

- Level 1—Knowledge in one discipline.
- Level 2—Applying knowledge in one discipline.
- Level 3—Applying knowledge across multiple disciplines.
- Level 4—Applying knowledge to predictable real-world situations.
- Level 5—Applying knowledge to unpredictable real-world situations.

The Application Model describes how knowledge is put to use based on the levels of relevance. The highest level signifies action — using the knowledge to solve complex real-world problems and to create projects, designs, and other works for use in real-world situations. When learning moves to high relevance, it is generally defined as "real-world," meaning the students' work is similar to that done by adults outside of school. The advantage of this is that students are more likely to be motivated to engage in learning since it is easier the see the purpose for learning.

The Knowledge Taxonomy and Application Model are not separate scales but consecutive connected and relational.

Daggett (2000) states that one way to think about the Rigor/Relevance Framework in day-to-day teaching/learning is in terms of the roles that teachers and students take. It is reflected in four quadrants as seen in the picture.



Each quadrant is labeled with a term that characterizes the learning or student performance at that level.

1. Quadrant A - Acquisition - students gather and store bits of knowledge and information. Students are primarily expected to remember or understand this knowledge.
2. Quadrant B -Application - students use acquired knowledge to solve problems, design solutions and complete work. The highest level of application is to apply knowledge to new and unpredictable situations.
3. Quadrant C - Assimilation - students extend and refine their acquired knowledge automatically and routinely to analyze and solve problems and create solutions.
4. Quadrant D - Adaptation - students have the competence to think in complex ways and to apply their knowledge and skills. Even when confronted with perplexing unknowns, students are able to use extensive knowledge and skill to create solutions and take action that further develops their skills and knowledge.

For students to become lifelong learners, problem-solvers, and decision-makers, Quadrant B and D skills are required. Teachers can use this framework to measure their progress in adding rigor and relevance to teaching and learning and to select appropriate learning strategies to meet students needs and higher achievement goals.

When teaching and expected student learning is in Quadrant A, the focus is on "teacher work." Teachers use energy to create and assess learning activities — providing information, creating worksheets, and grading student work. The student is often a passive learner.

When the student expectation moves to Quadrant B, the emphasis is on the student doing realworld work. This student work often is more complicated than Quadrant A work and requires more time. Learning in Quadrant B is best described as "student work" because students are doing extensive real-world tasks.

Learning in Quadrant C is best described as "student think." In this quadrant, students are expected to think in complex ways — to analyze, compare, create, and evaluate. The term that best describes Quadrant D activities is "student think and work." Learning in Quadrant D is more demanding and requires the student to think and work. Roles shift from the teacher-centered instruction in Quadrant A to student-centered instruction in Quadrants B, C, and D. Teachers still work in Quadrants B, C, and D, but their role is more as a coach or facilitator.

Conclusion

The taxonomy of educational objectives is a framework for understanding statements of what students are expected to learn as a result of teaching/learning.

SOLO taxonomy is a hierarchic taxonomy—increasing quantity & quality of thought. It is powerful in creating variety in the difficulty of curriculum and cognitive challenge.

Bloom's Taxonomy of learning domains is a map of learning levels. The revision of the original Bloom's taxonomy is a two-dimensional framework: Knowledge and Cognitive Processes.

Noble (2004) assures that both taxonomies give a clear multi-layered answer on the question why they should be used:

- Objectives (learning goals) are important to be established in a pedagogical interchange so that teachers and students understand the purpose of that interchange in the same way.
- Teachers can benefit from using frameworks to organize objectives because organizing objectives helps to clarify objectives for themselves and for students
- An organized set of objectives helps teachers to:
  - 'plan and deliver appropriate teaching/learning',
  - 'design valid assessment tasks and strategies',
  - 'ensure that teaching and learning and assessment are aligned with the objectives'.

Gaggett's Application Model in its turn with its five levels helps to understand the application of knowledge better.

This work has been supported by the European Social Fund within the project «Support for Doctoral Studies at University of Latvia».

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TAKSONOMIJA UN MĀCĪŠANĀS

Sandra Ozola

S u m m a r y

Taksonomija - zinātne par augsti organizētu hierarhisku dabas un sabiedrības sistēmu klasifikācijas un nomenklatūras principiem no grieķu valodas: 'taxis' – izvietojums noteiktā 'nomus' – likums. Jēdzienu 'taksonomija' lieto kā sinonīmu vārdam 'sistemātika'.

SOLO un Blūma izveidotā mācību mērķu sistēma aptver skolēna izziņas un attieksmju veidošanas jomu dažādus līmeņus un ir saistīta ar augsti attīstītas domāšanas veicināšanu. Izziņas joma ietver mācību satura apguvi piecos (SOLO) un sešos (Blūma) domāšanas līmeņos, sākot ar vienkāršākajiem, piemēram, konkrētu faktu atcerēšanos, un beidzot ar sarežģītākajiem – analizēšanu, sintezēšanu un novērtēšanu - citiem vārdiem sakot - domāšanas līmeņu skala.

Šīs labi zināmās un plaši pielietotās shēmas pedagogiem ir nodrošinājušas domāšanas un mācīšanās procesu sistemātisku un sistēmisku klasifikāciju. Taksonomiju pielieto mācīšanās rezultātu izmērīšanai. Mācīšanās rezultāti ir apgalvojumi par to, ko audzēknis/skolēns/ students zina, prot un kādus uzdevumus tas ir spējīgs veikt programmas (priekšmeta kursa, moduļa, atsevišķas nodarbības) noslēgumā (zināšanas, prasmes, kompetences).