Higher-order Thinking in a College Course: A Case Study

Josué López, Graduate Student
Department of Agriculture and Extension Education
The Pennsylvania State University
University Park, PA 16802

and

M. Susie Whittington, Associate Professor
Department of Human and Community Resource Development
The Ohio State University
Columbus, OH 43210-1067

Abstract

The Florida Taxonomy of Cognitive Behavior (FTCB), created by Webb (1968) and based upon Bloom et al. (1956), Taxonomy of Educational Objectives in the Cognitive Domain, was used to measure the level of cognition of professors evoked using various classroom behaviors. Students were randomly selected from a lower level agricultural engineering course to engage in a think-aloud protocol to determine their cognitive level of thought during class, given the professor's classroom behaviors. The professor's cognitive level of classroom discourse and students' cognitive level of thoughts during class were assessed and compared.

The professor taught 47% of the time at the knowledge level of cognition, while the most common type of thought displayed by students in class was "random or nonsense thoughts" (27%). The least frequently utilized cognitive levels by professors were application (5.2%), analysis (9.5%), synthesis (.5%), and evaluation (2.2%), and by students were analysis (4.2%), synthesis (3.4%), and evaluation (<1%).

Agricultural educators need to challenge students to develop cognitive abilities and critical thinking at higher levels via the instruction they provide. Thinking at higher levels of cognition is an indispensable skill in the learning process and in everyday life.

Introduction

Educators are being asked to develop more than basic skills in their classrooms. An information base is only of benefit when a person can combine information memory with new information—that is interrelate or rearrange the information (Underbakke et al., 1993). Higher-order thinking is a name given to the type of cognitive activity where thinkers solve a problem, analyze an argument, negotiate issues, or make a prediction.

The public is becoming increasingly aware of the need for student to develop the higher-order thinking abilities needed to cope with the exigencies of living in modern society (National Science Board, 1984). In this case study, Bloom et al. (1956) Taxonomy is used as a basis for examining the cognitive levels of thought of a college professor and students in a classroom setting. The objective was to determine whether or not students in colleges and universities are learning to their full potential. In addition, the Florida Taxonomy of Cognitive Behavior (FTCB) created by Webb (1968), and based upon Bloom et al. (1956), Taxonomy of Educational Objectives in the Cognitive Domain was used as the framework to measure the level of cognition evoked by the professor using various classroom behaviors.

Higher-order thinking

A clear and comprehensive definition of higher-order thinking has the potential to help educators transcend the split between the sciences' "problem solving" and the humanities' "critical thinking" (Lewis & Smith, 1993). To this end higher-order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. A variety of purposes can be achieved through higher-order thinking as defined above. These would include: deciding what to believe, deciding what to do, creating a new idea, a new object, or an artistic expression, making a prediction, and solving a nonroutine problem.

Higher-order thinking accordingly consists of ways of handling content; to learn to think more effectively is to learn more effective ways of dealing with information (Halpern, 1984).

According to Swartz and Perkins (1990) content provides something to think about, but cognitive instruction provides ways to engage students in dealing with that content in thoughtful manner (or to meaningfully use content knowledge). Methods of interrelating information such as selecting and organizing are not simply added to content but rather constitute procedures that are internalized and used as novel ways of responding successfully to situations or information (Underbakke et al., 1993). Fogarty and McTighe (1993) suggested cooperative learning and graphic organizers are two approaches that provide powerful, interactive and organizational mind tools for helping students think more effectively about content. Through cooperative learning, students articulate their thoughts to each other and thus engage in an interactive approach to processing information. Similarly, graphic organizers serve to make the invisible become visible by assisting students in generating and organizing ideas and information.

Too often students do not link what they are learning to their lives. Students need ample experiences in organizing and applying what they are learning as well as frequent opportunities to assess what they have accomplished (Ogle, 1989). Applying learned principles to real life situations and allowing students to actively participate in an understanding-based activity will engage them in higher levels of cognitive thinking (Perkins & Blythe, 1994).

Think-aloud Protocols

At the midpoint of this century, the cognitive revolution initiated a new era of thinking about thinking by addressing fundamental questions about the human mind and by creating perspectives and tools to pursue the answers to those questions (Kucan & Beck, 1997). These tools consisted of think-aloud protocols or verbal reports used as data for psychological research because they provided information as to "what is going on in the mind" (Bowen, 1994). Psychologists and intelligence researchers have legitimized the successful use of think-aloud protocols for verbal reports to collect and analyze human thoughts (Simon & Kaplan, 1989).

Purpose and Objectives

The purpose of this study was to assess and compare the cognitive levels of instruction among a professor in the College of Agricultural Sciences and the cognitive levels of thought among seven students in his class. Specifically, the research questions that guided this study were:

- At what level of cognition was the professor actually teaching?
- At what level of cognition were students actually operating?
- What is the comparison between the cognitive level of the professor's classroom discourse and the cognitive level reached by the students in his classroom?

Methodology

Population and Sample

This case study research focused on one professor from the College of Agricultural Sciences at The Pennsylvania State University, and 101 students enrolled in a lower level agricultural engineering course during the fall of 1998. At the beginning of the fall semester, seven students were randomly selected from the class. Letters were mailed to the students describing the study and soliciting their participation. All seven agreed to be interviewed.

Instrumentation

In 1968, Webb used Bloom et al. (1956) Taxonomy to create the FTCB to assess the cognitive level of classroom discourse (the formal speech or conversation delivered during class) professors use when they teach. The FTCB utilizes 55 observable behaviors indicative of the various cognitive levels identified by Bloom et al. (1956) Taxonomy. In the "knowledge" category, 17 observable behaviors are listed on the instrument; for "comprehension," 12 observable behaviors are listed; for "application," four observable behaviors are listed; for "analysis," 11 observable behaviors are listed; for "synthesis," nine observable behaviors are listed; and for "evaluation," two observable behaviors are listed. The FTCB was used to assess the cognitive level of the professor in this case study.

Validity for this instrument was based upon its direct development from Bloom et al. (1956) Taxonomy and the support generally given to this hierarchy of cognitive behaviors. Reliability for this instrument was established by coding audiotapes of lectures and establishing Spearman Rho reliability coefficients. Inter-rater reliability was approximately $r = .97$. Intra-rater reliability between previous researchers and the researchers in this study was approximately $r = .96$.

A questionnaire designed by the researchers provided insight into potential reactions of students to being interviewed, classes previously taken that would give background in the material being taught, and information about the students' interests and reasons for enrolling in the course. Students completed the questionnaire prior to the interview.

Data Collection

While attending the professor's class seven times during the semester, researchers recorded the frequency of observable teacher behaviors in six-minute intervals. Examples of observable behaviors at each level of Bloom et al. (1956) hierarchy include: "defines meaning of a term" (knowledge level); "shows cause and effect relationship" (comprehension level); "applies previous learning to new situations" (application level); "shows interaction or relation of elements" (analysis level) "formulates hypothesis" (synthesis level); and "evaluates something from evidence" (evaluation level).

In order to collect data on the professor's background, teaching skills, and knowledge of cognitive levels of teaching, the professor completed a questionnaire. The professor was also videotaped during the lecture for consequent analysis.

To understand how students are thinking during class, researchers used think-aloud protocols (verbaliza-

Table 1. A Synopsis of Bloom's Hierarchy of Thought.

Cognitive Level	Definition	Activity
Knowledge	Recall subject matter	List, define, label, and match
Comprehension	Know information that has been communicated, but cannot apply in other situations	Explain, rewrite, paraphrase, summarize, and give examples
Application	Apply information to different situations and learning tasks	Compute, demonstrate, use, predict, discover, and solve
Analysis	Separate data into its component parts; these parts are differentiated and related based on their relationship	Differentiate, discriminate, relate, diagram, and distinguish
Synthesis	Combines learned elements to create a new whole; working into pieces and elements, arranging so as to create new forms, patterns, or structures	Create, compose, produce, and develop
Evaluation	Make judgments on the value of materials and methods for given purposes	Justify, compare, contrast, evaluate, and interpret

Note: Adapted from Bloom et al. (1956).

tion of thought processes). Students were told the objectives of the study and knew prior to class that they would be interviewed about their thoughts during class. Immediately following class, students were given a hand-held tape recorder and asked to watch the videotaped lecture, listen, and audibly recall and describe their thoughts during class.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Frequency of behaviors observed across all cognitive levels was totaled. Then the frequency within each cognitive level was divided by the overall total to acquire percentages of classroom discourse at each cognitive level. Cross-tabulations, frequencies, and means were calculated. Only descriptive statistics were used.

A staff assistant transcribed the audiotapes of cognitive processes. Thoughts of students were sorted into six research-generated categories and then classified into Bloom's cognitive levels. The researchers categorized the thoughts as:

- Thoughts or observations about professor, people, and objects in classroom
- Nonsense or unrelated thoughts
- Thoughts connected to previous learning
- Thoughts about past experiences prompted by class subject matter
- Deeper learning/questioning thoughts
- Thoughts about behavior that got/maintained attention

Results and Discussion

Professor

After seven sessions, the professor's cognitive level of instruction was at the knowledge (compilation of the first three categories) level of cognition 47% of the time, 36% at the comprehension (translation and interpretation) level, 5.2% at the application level, 9.5% at the analysis level, .5% at the synthesis level, and 2.2% at the evaluation level (see Table 2). The most frequently utilized classroom discourse was at the "knowledge of specifics level." The least frequently utilized levels during classroom discourse were at synthesis and evaluation.

Table 2. Professor's Assessed Cognitive Level of Instruction During Class.

Level of Cognition	Mean of frequencies	Range (%)	Total (%)
1.0 Knowledge of specifics	21.2	13 - 30	23.4
1.2 knowledge of ways and means of dealing with specifics	16.1	11.7 - 25	17.5
1.3 Knowledge of universal and abstracts	5.6	3.0 - 9.2	5.7
2.0 Translation	18.1	18.2 - 27.3	21.8
3.0 Interpretation	12.7	10.3 - 16.7	14.0
4.0 Application	5	1.1 - 7.7	5.2
5.0 Analysis	8.8	5.5 - 15	9.5
6.0 Synthesis (Creativity)	.43	0 - 2.4	.5
7.0 Evaluation	2	0 - 3.8	2.2

Note. 1.0 + 1.2 + 1.3 = Bloom et al. (1956), "Knowledge" level; 2.0 + 3.0 = Bloom et al. (1956), "Comprehension" level.

Table 3. Assessment of Students' Cognitive Levels of Thoughts During Class.

Categories of Thoughts	Range of frequencies	% of time
Thoughts or observations about professor, people, and objects in classroom	2 - 21	27.0
Nonsense or unrelated thoughts	4 -24	29.0
Thoughts connected to previous learning	1 - 26	20.1
Thoughts about past experiences prompted by class subject matter	0 - 8	5.8
Deeper learning/questioning thoughts	0 - 5	5.3
Thoughts about behavior that got/maintained attention	2 - 8	12.0

Table 4. Students' Cognitive Level of Thought During Class.

Cognitive Level	Frequencies	(%)
Knowledge	28	23.7
Comprehension	15	12.7
Application	7	5.7
Analysis	5	4.2
Synthesis	4	3.4
Evaluation	1	<1
Other	58	49.1
Total	118	100

Students

The most common type of thought expressed by students (29%, see Table 3) was "nonsense or unrelated thoughts" (metacognitive processes unrelated to class subject matter). An example was, "I'm just praying nobody asks any more questions so we can keep moving." The second most common category of thought (27%) was "thoughts or observations about professor, people, and objects in classroom." An example was, "He really likes to use different colors of chalk." The least used category of thought (5.3%) was, "deeper learning/questioning thoughts," and one example was, "I don't understand how you can make something with that little of a depth. It doesn't seem to make sense, but that's what it says in the book, so I guess it's the right answer."

The following categories, "thoughts connected to previous learning, thoughts about past experiences prompted by class subject matter, and deeper learning/ questioning thoughts" were collapsed into one category called "thinking." This "thinking" category was then

assessed for its cognitive level content. As can be seen in Table 4, approximately 24% of students' thoughts were at the knowledge level. The second most common cognitive level was comprehension (12.7%). The least common students' cognitive level of thought was at evaluation level (approximately 1%). However, approximately 50% of the students' thoughts during class were not classified as a part of the cognitive assessment since they were "nonsense or unrelated thoughts."

Students' Cognitive Level of Thoughts

As mentioned previously, the most common cognitive level of students' thoughts was "knowledge level" (23.7%, see Table 5). Knowledge was considered in two different forms: (a) searching for, and (b) expressing the recognition of basic knowledge. For instance, when the professor was explaining sediment traps in class, one student thought, "What are they trying to do with this filter fence?" This example is a search for knowledge. However, when the professor was further discussing sediment traps, one student thought, "I do remember the part of sediment traps from Friday class," the student was demonstrating an expression of basic knowledge.

The next most used level of cognitive thinking was comprehension (12.7%). Comprehension involves two forms; to understand information and to question the information given. For instance, with regard to understanding information, when the professor was talking about the advantages of wetlands, one student thought, "In South Carolina, they have taken so much fresh water out of the ground that the sea water is starting to come in and cause problems." The questioning form of comprehension is shown in the following situation: when the professor discussed ecological problems with the Penn State living filter, one student thought, "I'm wondering why Penn State's filter system keeps going on if it's not really functioning properly."

The application level of cognitive thinking involved an average of 5.7% of the students' thoughts in class. For example, while the professor was discussing a homework problem in class from the book, one student thought, "Now, this makes sense to me because I know how to place the sprinklers in the field."

The analysis level of cognition consumed an average of 4.2% of the thoughts in class. For example, when discussing how to calculate spacing of irrigation sprinklers in class, a student thought, "Why did they not choose 80 feet when you would have to buy less sprinklers per foot?"

The synthesis level of cognition involved an average of 3.4% of the thoughts in class. Less than 1% of

Table 5. Comparison of Professor's and Students' Cognitive Level of Thought During Class.

Cognitive Level	Professor (%)	Students (%)
Knowledge	46.6	23.7
Comprehension	35.8	12.7
Application	5.2	5.7
Analysis	9.5	4.2
Synthesis	<1	3.4
Evaluation	2.2	<1
Other	0	49.1
Total	100	100

students' thoughts could be classified at the evaluation level. However, almost half (49.1%, see Table 4) of thoughts generated by students during class were "random nonsense thoughts;" these were not classified as part of the cognitive assessment.

Summary

Professor

The professor in this study, who was teaching an introductory course, was generally teaching at lower cognitive levels. The most common teaching behaviors recorded in this study were: basic elicitation of facts, verbalizing from and/or creating graphic representations, making generalizations about concepts or ideas, summarizing and concluding from what had been said, and giving reasons for facts. However, when the professor was aware of cognitive levels, teaching was more effective and the most common behaviors were: producing unique communication and/or divergent ideas, showing the interaction and relationship among elements, and applying abstract knowledge in a practical situation (Perkins & Blythe, 1994). This led to improving classroom behaviors and teaching techniques that helped students to think at higher cognitive levels.

This case study showed that the first task professors need to realize is that the subject matter content is not the focus but rather the means to engage students to think at higher-order levels (Swartz & Perkins, 1990). Students deal with content in a thoughtful manner when professors give them the opportunity to reach higher levels of thoughts through the lecture. Since professors' performance is the most powerful predictor of students' learning at higher levels of cognition, they should learn more effective ways to deal with information to produce desirable outcomes (Halpern, 1984).

More importantly, when professors give students the opportunity to interrelate information, students internalize the procedures beyond successfully real-life situations (Underbakke et al., 1993). Further, when professors used inquiry-oriented approaches in class, students reach higher level of cognition. For example, it is desirable for students that professors provide time for peer-and self-assessment throughout the class, helping students to analyze, synthesize, and evaluate knowledge.

Students

Students, primarily thought "random nonsense thoughts" during lectures. They rarely thought at the higher cognitive levels no matter the cognitive level at which the professor taught.

When students find information relevant to their daily lives, the information was interrelate, rearranged, and extended to achieve a purpose or find possible solutions (Lewis & Smith, 1993). Students in this study engaged in higher-order thinking when situations in class were associated to recent circumstances. Therefore, information was more readily absorbed and easily understood.

Students in this case study were stimulated to think at higher levels when inquiry-oriented questions were asked. In some instances, students were motivated when visual aids were used during the lecture. When shown a visual aid from class, students could describe what the professor was discussing and what they were thinking in regard to the subject matter.

Recommendations

Based on the conclusions of this study, the researchersrecommend that professors:

- become more aware of cognitive level of teaching in order to achieve higher outcomes from their teaching,
- participate in seminars, workshop, forums, presentations, and conferences that highlight the use of higher-order thinking in their lectures,
- provide students opportunities to connect their class to real-life situations,
- be aware of various class behaviors and teaching techniques used to engage students in higher-order thinking,
- use inquiry-oriented approaches during class more often and the lecture approach less often,
- and provide students opportunities to peer-and self-evaluate their performance in class.

Based on the conclusions of this study, the researchers recommend that students:

- connect learned information to previous and future life situations,
- be more aware of how to interrelate, rearrange and handle information independently,
- discipline themselves to pay attention and focus on the lesson,
- take advantage of any opportunity to apply, analyze, synthesize and evaluate knowledge.
- and be more independent in their learning process regardless of the professor.

Implications

This case study suggests that there is a need to provide college and university professors with teaching training on critical thinking and higher-order thinking. Moreover, educators should engage students in higher-order thinking activities from elementary school levels. Classes should be less crowded in order to provide more opportunities for professors to use inquiry-oriented approaches

and less lecture-based teaching. In addition, further research in cognitive teaching should be conducted at all educational levels.

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Underbakke, M., J. M. Borg, and D. Peterson, 1993. Researching and developing the knowledge base for teaching higher-order thinking. Theory Into Practice 32(3): 13 -144.Table 1. A Synopsis of Bloom's Hierarchy of Thought.