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ASSESSING ACADEMIC CHALLENGES FOR THEIR CONTRIBUTION TO COGNITIVE DEVELOPMENT

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Abstract

The continual improvement of higher education is a concern for anyone who believes that students should be completing their higher education experience with a well-developed ability to think critically at higher levels of cognition. While research has been conducted that assesses the role of teacher behaviors and characteristics and instructional methods in the development of students' cognitive ability, little has been done regarding the types and the cognitive design of the academic challenges, written work assigned as an extension of lecture, provided to students.

The focus of this study was to use Bloom's Taxonomy to examine the academic challenges provided to students. Specifically the researchers sought to assess how students were being cognitively challenged and how students were being rewarded in the grading scheme for higher cognitive academic challenges.

The results of the cognitive analyses varied by course and by type of academic challenge. The observed variation provides examples of the range of possibilities for using academic challenges. Because of differences in the content and structure of the courses, comparisons between the courses should not be made except to provide examples of the different ways to structure academic challenges and the different types of academic challenges that can be provided

Introduction and Theoretical Framework

One of the goals established by The National Education Goals Panel was that, "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively and solve problems will increase substantially" (1991, p. 5). To meet this goal, professors must place greater emphasis on the development of students' permanent thinking skills and go beyond the learning of facts, theories, and information. Undergraduate instruction should focus not only on providing students the content knowledge of their chosen discipline, but also on facilitating the development of students' critical thinking skills.

How students learn (i.e., how they are challenged to learn) is a key component of the education process. The National Center for Postsecondary Teaching, Learning and Assessment reported that "students' classroom experiences have the most impact on creating intellectual curiosity" (Ratcliff, 1995 p. 8). These "classroom experiences" include both the professors' teaching and modeling and the academic challenges provided as a part of their course. If undergraduate students are to develop their ability to think at higher levels of cognition, they must be challenged to do so by both professors' in-class instructional techniques, and by the academic challenges provided throughout the course.

Studies have examined faculty teaching characteristics and instructional methods with respect to critical thinking skills and opportunities

provided by professors for students to engage in higher order thinking (Bowman & Whittington, 1994; Pickford & Newcomb, 1989; Whittington, 1995; Whittington & Newcomb, 1993). Additional studies have shown that effective use of academic challenges can increase student achievement (Foyle & Baily, 1985; Ziegler, 1986) and can contribute to challenging both students' progression through the thought processes and their development of thinking skills (Cooper, 1989; Meyers, 1986; Terenzini, Springer, Pascarella & Nora, 1995). However, there are few studies which have examined the cognitive level of academic challenges or which provide a system for assessing academic challenges (e.g. Newcomb & Trefz, 1987; Pickford & Newcomb, 1989; Ratcliff, Jones, Guthrie & Oehler, 1991). Because academic challenges represent additional opportunities for learning and the development of thinking skills, it is important that they are included in the search for ways to improve undergraduate education.

One of the most frequently cited and applied systems for categorizing cognitive processes has been the classification system proposed by Bloom et al. in the Taxonomy of Educational Objectives, Handbook I: Cognitive Domain (1956). This taxonomy identifies six hierarchical levels of thinking based on the type of cognitive processes required to complete the objective or answer the question. It is important to note that the cognitive levels are cumulative in structure as each level integrates and builds upon the cognitive activities of the levels below it, implying a type of sequence, or a hierarchy, to the levels of thinking. The six levels are:

Knowledge - Involves the recall of specific facts and theories, methods and processes. This level emphasizes remembering learned material (Bloom, 1956). Common action terms include: list, define, label, match, and designate who, what and when.

Comprehension - Represents the lowest level of understanding. The individual knows the information which is being communicated and can make use of the material without relating it to other information or seeing its fullest implications (Bloom, 1956). Common action terms include: explain, paraphrase, summarize, rewrite, and give examples.

Application - Focuses on having students apply what has been learned to different situations and learning tasks, requiring students to use information that they know and understand (Bloom, 1956). Common action terms include: compute, demonstrate, use, predict, discover, and solve.

Analysis - Involves breaking down the information or situations and separating them into their component parts, focusing on the relationships of these parts with each other and with the whole structure (Bloom, 1956). Common action terms include: differentiate, discriminate, relate, diagram, and distinguish.

Synthesis - Focuses on the combination of learned elements and parts to form a new whole. This includes working with pieces and elements and arranging them so as to create a new form, pattern or structure of the information (Bloom, 1956). Common action terms include: create, compose, produce, and develop.

Evaluation - Involves making judgments about the value of material and methods for given purposes. Judgments are made based on standards or criteria, either established by and provided for the student or those determined by the student (Bloom, 1956). Common action terms include: justify, compare, contrast, evaluate, and interpret.

The first two levels, knowledge and comprehension are typically referred to as lower order thinking and the four highest levels (application, analysis, synthesis, and evaluation)

represent higher order thinking as they involve more complex cognitive processing. Although Bloom's Taxonomy is recognized as not being perfect (Furst, 1980), it has been widely accepted and used by many educators and researchers.

Purpose and Objectives

The purpose of this study was to use Bloom's Taxonomy to assess the cognitive level of academic challenges that were incorporated into selected courses offered within the College of Agricultural Sciences at the Pennsylvania State University. The following objectives guided the study:

1. To describe the various types of academic challenges and the frequency with which each type was used in College of Agricultural Sciences courses.

2. To determine the cognitive level at which the students were challenged to think for each academic challenge.

3. To examine the cognitive levels of academic challenges, and assess their value to the students' final grade.

Procedure

Eleven faculty members from nine departments/schools within the College of Agricultural Sciences (agricultural economics, agricultural education, agronomy, animal and veterinary science, dairy science, entomology, forestry, horticulture, and plant pathology) participated in this project. Each participant provided copies of every academic challenge used in their course. The participating professors were consulted when necessary, to provide background/content information and to clarify any questions raised during the analysis.

The collected academic challenges for each course were examined and categorized by type of challenge. The resulting categories were: activities, problem sets, written reports (individual and group), presentations (individual and group), laboratory tests, quizzes, midterms, and finals.

Each individual task, question, problem, or action within all of the academic challenges was analyzed to determine the cognitive challenge it provided to students. A data collection worksheet was designed to assist the researchers in the analysis. In addition to space for recording data, the worksheet contained descriptions for each of the levels and a list of action terms common to that level, compiled from the related literature (Bloom, et al., 1956; Newcomb, & Trefz, 1987; Bowman & Whittington, 1995). A number corresponding to one of the six levels of Bloom's Taxonomy (i.e., 1 = Knowledge, 2 = Comprehension, 3 = Application, 4 = Analysis, 5 = Synthesis, and 6 = Evaluation) was assigned. The analysis was based on the highest level that students would be cognitively challenged in order to answer the item.

In addition to the assessing the cognitive level provided by each academic challenge, the researchers also calculated the degree to which the challenge related to the students' course grade. This calculation was based on the grade-weighting information provided in each course syllabus (which detailed the value of all the academic challenges provided to the students' final grades).

The resulting cognitive analysis describes the portion of each cognitive level included in the academic challenge. For example, a problem set may have a cognitive distribution of 0% knowledge, 7.1% comprehension, 71.4% application, 7.1% analysis, 0% synthesis, and 14.4% evaluation. In other words, 7.1% of this example was written to challenge students at the lower cognitive levels while 92.9% challenged the students at the higher cognitive levels. To obtain the grade-weighted cognitive distribution, the

initial cognitive distribution for each academic challenge was multiplied by its value to the students' final grade.

Results

Types of Academic Challenges Provided

As can be seen in Table 1, there was a wide range of both the total number of academic challenges and the number of different types of academic challenges provided to students. The total number of academic challenges ranged from 6 to 29 with a mean of 13.

The number of different types of challenges provided also varied (i.e., 3 activities, 2 midterms, and 1 final exam). On the low end, two professors utilized 3 different types of challenges. The greatest number of different academic challenges (6) was provided by four professors (i.e., 2 written group reports, 1 group presentation, and 1 final exam). The mean number of different types of academic challenges provided by professors was 4.6.

Cognitive Distribution

The mean cognitive distribution for all of the courses by academic challenge category was: 10.7% at the knowledge level, 17.7% comprehension, 22.3% application, 15.8% analysis, 16.7% synthesis and 16.4% evaluation. Overall, the academic challenges were written 28.4% at the lower cognitive levels while 71.6% of the items challenged students at the higher cognitive levels.

The grade-weighted cognitive distribution was also calculated by academic challenge category. Activities and problem sets were worth 4.8% of student's final grade; written reports, and presentations were worth 34.5% of the final grade; and quizzes, laboratory tests, midterms and finals were worth 60.7% of the final grade.

Conclusions

Types of Academic Challenges

Research has shown that providing a variety of learning challenges is a positive step toward addressing the needs of students with different learning styles (Raven, 1993). Overall, the professors involved in this study provided a variety of both type and number of academic challenges (Table 1).

The mean of 4.6 types of academic challenges provided per course, indicates that the professors were providing several different types of challenges for students. The actual number of challenges per course (mean of 13.2) indicates that multiple challenges of the same type were frequently provided. The most frequently utilized types of academic challenges were: activities, individual written reports, midterm exams, and final exams. The types of academic challenges utilized the least were lab tests and individual presentations.

The variety of types of academic challenges used across the different courses may be attributed to differences in course content, curricular demand, teaching methodologies, course educational objectives, and the professors' personal experience in teaching the course. Currently, there are no standards or guides for professors to use when determining the types and number of academic challenges to provide in a course. The courses in this study as a whole though, provide examples of the range of possible combinations of academic challenges.

Value of Academic Challenges to Students' Final Grade

The contribution of an academic challenge to students' final grade depends on how the professor decides to structure the course.

Table 1. Academic Challenges Provided by Course

	Courses										
AC Categories	A	B	C	D	E	F	G	H	I	J	K
Activities		1		2			1	7	6	19	3
Problem sets			5				14		1	1	
Written reports, ind.		4	4	10	1	1	1		4	4	
Written reports, grp.	2					7		1	2	1	
Presentations, ind.						4					
Presentations, grp.	1			1		1		1			
Quizzes	3				3		2			3	
Laboratory test	1										
Midterm exams	1	1	2	3	2	1	2			1	2
Final exam	1	1	1	1	1	1	1				1
# of AC provided mean = 13.2	9	7	12	17	7	15	21	9	13	29	6
# of categories used mean = 4.6	6	4	4	5	4	6	6	3	4	6	3

Traditionally, more weight has been given to midterm and final exams than any other type of academic challenge. Although the courses examined in this study used a variety of grading schemes, final exams and midterms made the largest contribution to students' final grades (means of 24.5% and 17.2%, respectively). This was followed closely by the four courses in which the group presentations were worth a mean of 16.6% of students' final grade.

In addition to the differences in how the categories of academic challenges contributed to students' final grade, there were differences within the academic challenge categories themselves. For example, in course I, students were challenged to write four individual written reports. The values of each of the four reports were 2.7%, 4%, 12.8% and 20.2% (not in the order assigned to the students) for a total of 39.7% of students' final grade. The differences in the value of the reports to the students' final grade were a result of the emphasis the professor placed on the individual assignments. This pattern of different grade values can be seen throughout all of the courses and all of the academic challenge categories.

Examining the value of the academic challenges to students' final grade revealed the different reward structures for the courses, It is a common practice for professors to weight certain academic challenges more than other challenges in determining students' final grades. While the grade values of the academic challenges are interesting and valuable, they become more so when they are combined with the corresponding analysis of the cognitive challenge.

Cognitive Level of Academic Challenges

The cognitive analysis by academic challenge type revealed the differences between the categories in the cognitive level reached. While there were fluctuations within the categories, certain types of challenges tended to be written to challenge students more at the higher cognitive levels than other types.

On average, the individual presentations, quizzes, midterm exams, and final exams tended to

emphasize lower cognitive challenges for students. This emphasis on the lower cognitive levels of knowledge and comprehensionin tests and quizzes is similar to the findings of Newcomb and Trefz (1987). However, within each of these categories, there are examples of challenges that were written to emphasize the higher cognitive levels.

The other academic challenge categories (activities, problem sets, individual and group written reports, group presentations, and laboratory tests) tended to be written to emphasize the higher cognitive levels. Problem sets placed the greatest emphasis on the higher cognitive levels (a mean of 97.2%). Based on the cognitive analysis, it appears that these non-exam types of academic challenges, by their nature, are more conducive to challenging students at the higher cognitive levels of application, analysis, synthesis and evaluation.

The cognitive analysis by course provided information on where the cognitive emphasis was placed within each course. However, because of differences in the content and structure of the courses, comparisons between the courses should not be made except to provide examples of the possible ways to structure academic challenges and the different types of academic challenges that can be provided.

Level of Challenge and Value to Grade

Ideally, the grading structure of a course should place more emphasis on the academic challenges that are written at the higher cognitive levels. The examination of the types of academic challenges did lean toward rewarding students more for completing academic challenges written at the higher cognitive levels and less for lower cognitive work, but not entirely.

Overall, the individual and group written reports, the group presentations and the laboratory tests were written with an emphasis on the higher cognitive levels and when combined, they were worth a total of 45.6% of students' final grades (7%, 7%, 16.6% and 15%, respectively). Quizzes and individual presentations tended to emphasize the lower cognitive levels and were worth a total of 7.9% of students' final grades (4% and 3.9%, respectively).

However several types of academic challenges were counter to the ideal. As was noted previously, the midterm exams and final exams tended to emphasize the lower cognitive levels but they were worth 4 1.7% of students' final grades (17.2% and 24.5%, respectively). Activities and problem sets were worth a total of 4.8% (3.5% and 1.3%, respectively) although they were written to emphasize the higher cognitive levels. This parallels Pickford and Newcomb's study (1989) which concluded that activities tended to challenge students more but were rewarded the least.

The analysis by course showed similar fluctuations in the grade values of the academic challenges. Several courses rewarded students more for the portion of academic challenges written at the higher cognitive levels. For example, the academic challenges provided in Course H emphasized the higher cognitive levels (a mean of 82.9% written at the higher cognitive levels) and the course's grading structure was set such that over 94% of the students' grades came from the work at the higher cognitive levels. Similar grading structures were observed in Courses B, E, F, I, and J.

Conversely, in Courses A, C, D, G, and K the opposite occurred; students' work at the lower cognitive levels was worth more than their initial portion of the cognitive distribution. For example, 16% of the academic challenges in Course G was written at the lower cognitive levels, but that 16% was worth 39.5% of the students' final grades. Much of the shift observed in Course G was due to the weight of the quizzes, midterms, and the final exam (these emphasized the lower cognitive

levels but were worth a total of 80% of the students' final grades).

Discussion

The results of the cognitive analyses varied by course and by type of academic challenge as they should, given the variety of course subjects included in the study. The observed variation provides examples of the range of possibilities for using academic challenges. Research has shown that well designed academic challenges can contribute to the development of students' thinking skills (Terenzini, et al., 1995; Cooper, 1989). The question, however, is what makes an academic challenge effective? Creating effective academic challenges involves: 1) consciously selecting the type of academic challenge most appropriate for the lesson and material; 2) deliberately constructing the academic challenge such that it requires students to think at the higher cognitive levels; and 3) creating a grading structure that rewards students for completing work at the higher cognitive levels.

This study examined the academic challenges written by eleven college of agriculture professors. The participating professors were selected by their department heads as "good" teachers. As such, they may not be representative of college of agriculture teaching or higher education. Personal interviews with the participants indicated that the professors spent much time specifically developing their curricula to challenge the students to think and learn. The participants also indicated their desire to improve as teachers.

This assessment process is intended to result in benchmark information which may assist professors in evaluating the cognitive level of their academic challenges, specifically, how they are written, and how they reward students. The study provides an opportunity for professors to question whether or not their academic challenges are accomplishing what they are intending.

Recommendations for Educators

Critically examining the number and type of academic challenges included in each course will assist professors in answering important questions. Do the academic challenges contribute to meeting the course's educational objectives? Is there a combination of academic challenges that would be more effective for facilitating the development of students' thinking ability?

Assessing the level of cognition at which each item and thus each academic challenge is written will aid professors in making decisions about the items included in the academic challenge. Are the academic challenges written at the desired cognitive levels? Can/Should they be re-written to contribute more toward the development of students' thinking ability?

Examining the grading structure of the course can be insightful for thinking about why values are chosen. How are students being rewarded for the work they are doing? Can/Should the grading structure be adjusted to reward students more for completing academic challenges written at the higher cognitive levels?

Recommendations for Additional Research

Is there a specific combination of types and/or number of academic challenges that would be most effective for developing students' thinking ability within a particular course?

Given the recognized importance of developing students' ability to think at the higher cognitive levels and given the hierarchical nature of Bloom's Taxonomy, is there a "best" distribution of the six cognitive levels for writing academic challenges?

Does rewarding students more for work

completed at the higher cognitive levels encourage the development of their thinking ability?

How do student variables (such as attitude, motivation, challenge acceptance) affect the development of students' thinking ability?

What interventions can be used to improve how professors are writing academic challenges to increase the cognitive challenge to students?

Can this cognitive analysis process be used as a tool for detailing professional teaching activities and therefore be used in promotion and tenure reviews?

Final Thoughts

Writing effective academic challenges may be more difficult than it appears. Most professors already have established course curricula and academic challenges and change (if needed) is frequently more difficult than the status quo. The barriers noted by Bowman and Whittington (1994) relative to the cognitive level of professors' discourse in the classroom may also be involved in designing effective academic challenges. These barriers include: professors' lack of knowledge regarding techniques for writing academic challenges at higher cognitive levels; professors' lack of time to write or re-write their academic challenges; and frustration and/or apprehension associated with making changes to established curricula.

To facilitate improvement, this study establishes a framework that educators can use to analyze their academic challenges and to assess whether or not they are challenging students at the cognitive levels to which they aspire. It is hoped that this framework will assist educators to improve their effectiveness at developing students' ability to think at the higher cognitive levels.

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