LEVELS OF COGNITIVE ACTIVITY REQUIRED TO ANSWER POM TEST BANK MULTIPLE CHOICE QUESTIONS

William R. Sherrard*
David R. Hampton**

The ability to think critically is crucial in today's production and operations management (POM) competitive environment. To promote critical thinking POM instructors should ask questions which will require students to sharpen their thinking skills. One strategy is for instructors to push students to move beyond the rote memorization of facts to correctly answer examination questions. This research evaluates how well the author supplied multiple choice test bank questions that accompany introductory textbooks in POM to foster critical thinking. The study classifies a sample of author- supplied POM test bank questions according to the cognitive level (memorization vs. thinking) required to answer the questions correctly. The more these questions are used by POM instructors the more they determine the standards required of today's POM students.

Textbooks for the introductory production and operations management (POM) course come with a package of supplements including a book of examination questions called a test file or test bank. The typical test file includes hundreds of multiple choice questions that make it convenient for instructors to construct tests. The questions are widely used, and the temptation of instructors to use them seems to grow as class sizes and the labor of grading increase. The more the questions are used the more they determine the standards required of today's POM students.

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*William R. Sherrard is a Professor of Operations Management at the San Diego State University, San Diego, CA

**David R. Hampton is a Professor of Management at the San Diego State University, San Diego, CA

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The purpose of this paper is twofold: to illustrate how it is possible to measure the cognitive activity required to answer multiple choice questions, and to report the results of the cognitive level-classification for a sample of them from the test banks of three leading textbooks in POM. Showing how to recognize the cognitive activity required to answer questions can help instructors begin the continuous improvement process they may judge necessary to rework publisher-supplied questions. Reporting measurement of the cognitive requirements of existing questions can provide a baseline for undertaking continuous improvement in the construction of examinations.

BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES

The systems for assessing questions is the long-established "Taxonomy of Educational Objectives" (Bloom, 1956). Bloom's taxonomy identifies two basic levels of cognitive activity: knowledge (memorization) and intellectual ability and skill (thinking).

Knowledge (Memorization)

Knowledge "....involves little more than bringing to mind the appropriate material." (Bloom, 1956, p. 201). This level of cognitive activity requires memory of simple rules, facts, terms, sequences, and principles. Knowledge questions require the exam taker to recognize or recall information (rules, facts, etc.) from the referenced material. This may involve the recall of a wide range of material from specific facts to complete theories, but fundamentally all that is required is the bringing to mind of the appropriate information. For example, here is a textbook passage cited from a leading POM textbook and a multiple choice question drawn textbook's test bank file.

From the Text

In a net-change system, the basic production plan is modified to reflect changes as they occur. (Stevenson, 1993, p. 666)

From the Test File

Which is true of a net-change system?

a. It is a batch-type system which is updated periodically.
b. It generates exception reports.
c. The basic production plan is modified to reflect changes as they occur.
d. It is used to authorize the execution of planned orders.
e. It indicates the amount and timing of future charges. (Booth, 1993, p. 315)

To answer correctly the student need only remember the definition of a net-change MRP system.

Intellectual Ability and Skill Thinking

This category has five levels of cognitive activity: comprehension, application, analysis, synthesis, and evaluation, all techniques dealing with, organizing or reorganizing materials or problems. *Comprehension* is "…..the lowest level of understanding." "…..the individual knows what is being communicated and can make use of the material or idea...." (Bloom, 1956, p. 204). The purpose of comprehension questions is to determine if the student understands and can begin to use the information. It goes beyond the simple recall of information. *Application* shows the student "will" use the theory. Application is the next cognitive level in which the student is not given the theory but is expected to identify and select the theory and apply it to the best suited concept. *Analysis* requires breaking down the factual elements and drawing inferences as to the interrelationships of those elements. Using analysis, students determine underlying issues and evaluate both relevant and irrelevant issues. *Synthesis* requires development and support of solutions, using creativity, organizing things together into a new pattern or structure, and proposing solutions in situations where all things are not obvious or inherent. *Evaluation* is defined as judgment, opposed to opinion, and concerns the value of an idea or concept based upon knowledge of the terms, comprehension and application of the concepts and determination of how they interrelate and synthesize. Evaluation is the highest level of cognitive ability. The text passage and question below, drawn from a POM textbook, illustrate a "thinking" type question in production and operations management.

From the Text	From the Test File
A JIT customer-supplier partnership is intended to be a stable relationship. The customer gets a steady, reliable source of supply, and the supplier gets a solid customer base upon which the rest of the business can be built. . . . If the supplier is producing in small lots and responding to pull signals, those changes will not cause any difficulties. (Wantuck, 1989, p. 309) (APICS, 1992, p. 7)	In a JIT environment, marketing may discuss with customers all of the following benefits EXCEPT a. incentives for large-lot deliveries b. improved on-time delivery c. improved quality d. reduced customer hedge inventory

The question requires more than the simple recall of information. It requires comprehension because the student must use the concept in a different situation. However, because the question states the abstraction or concept (JIT) to be used in the new set of facts, the question tests no higher level of cognitive activity than comprehension. "Application" and higher levels such as analysis, synthesis and evaluation require that the abstraction not be stated.

METHOD

Participants

The classification of questions according to Bloom's taxonomy requires persons knowledgeable in the subject matter being considered. Recent studies on the use of management and marketing textbook multiple-choice questions used professors in the two disciplines as the experts to classify questions as either knowledge or thinking. (Hampton, 1993a; Hampton, Krentler & Martin, 1993b; Martin, 1992; Viss, 1990). Karns, Burton and Martin (1983), employing Bloom's taxonomy, used "judges" knowledgeable in economics to evaluate six texts and their accompanying test banks.

The participants in this study were four certified practitioner/educators of the American Production and Inventory Control Society (APICS). On average the raters have taught in the San Diego State University Extension Program in Materials Management for 7.5 years, all have passed the required examinations to become APICS certified in Production and Inventory Management (CPIM) and all have worked in the materials management field for several years.

The participants were instructed in the use of Bloom's taxonomy for classifying questions according to the cognitive level required to correctly answer the question. In addition, the following definitions were placed on the rating forms as a reminder of what constituted a memory and a higher level question.

> **Memory Question:** Requires memory of rules, facts, terms, sequences, and principles. Memory questions ask the reader to recall information (rules, facts, etc.) encountered in the text.
>
> **Higher Level Question:** Requires higher level cognitive activities: Comprehension, application, analysis, synthesis, or evaluation. The purpose of higher level questions is to determine whether the reader understands and can begin to use text information, in addition to being able to recall it as a memory question.

Materials and Procedures

Sixty test bank questions were chosen from three of the most widely adopted introductory textbooks in production and operations management (Heizer and Render, 1993; Krajewski and Ritzman, 1993; Stevenson, 1993). The sixty questions comprised twenty questions drawn from each author -- ten in each subject area. To eliminate any chance for bias in the selection process, every third question in a test bank subject was used for evaluation until ten questions were chosen. To further prevent bias, the starting point in a test bank for selecting every third question was randomly chosen.

Two of the leading subject areas in production and operations management (material requirements planning and just-in-time) were chosen for evaluation. The subjects represent two of the six examination areas for certification from the American Production and Inventory Control Society, a professional society with over sixty-five thousand members (Fogarty, Blackstone & Hoffmann, 1991, Page iii). Also, these two subjects appear in virtually all introductory production/operations management textbooks.

Time considerations prevented the inclusion of more questions or more topical areas in the study. For each question raters must move back and forth between text and question in the classification process. Similar studies in the other areas of production and operations management is a subject for further research.

The raters were asked to classify, according to Bloom's taxonomy, the sixty test bank questions into either of the basic categories: memorization (knowledge level) or thinking (one of the five higher levels). The questions consisted of 10 material requirements planning (MRP) and 10 just-in-time (JIT) questions from each author. The classification process consisted of reading each question, noting the correct answer, and reading the textbook reference for the question. The raters then used Bloom's taxonomy to classify each question according to the cognitive activity required of the test taker to answer the question.

Raters were told to make only the binary decision of whether the question could be correctly answered by memorizing or thinking; they were not required to decide into which of the five levels of cognitive activity a "thinking" question should be classified

Interrater Reliability

To determine the reliability of the cognitive categories (i.e., the rating instrument) and the raters in ranking textbook examination questions, the "percent agreement" index of interrater agreement was used. "In its simplest form, this coefficient is just what the name implies: the percent of time units during which the records of two [or more] observers are in agreement about the record of behavior" (Mitchell, 1979, p. 377). According to Jones, Johnson, Butler and Main (1983), the "simple, uncorrected percent of raters that assign an

individual or object to the same group (i.e., percent agreement)" provides the most accurate estimate of interrater agreement when analyzing categorical data assigned to a small number of similar categories. For this type of data, an average level of 77% agreement or higher is considered sufficient to establish the reliability of the rating instrument (Jones, et. al., 1983).

The average agreement of interrater observations should exceed 77% to establish the reliability of the rating instrument (Jones, Johnson, Butler & Main, 1983). The average percent agreement among the four subjects in this study was 91.7 percent. The subjects concurred in their ratings on 55 of the 60 test bank questions.

If more than one rater disagreed on the categorization of a question, it was removed (discarded) from consideration. Per Table 1, only 5 questions were discarded. Of the remaining 55 questions 69.1 percent were classified knowledge (memorization) questions and 30.9 percent were classified higher level (thinking) type questions.

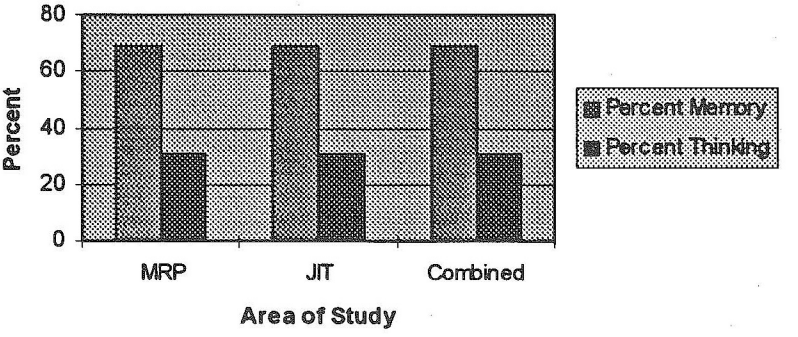
FINDINGS

Per Table 1 and Figure 1 the rater categorization between the two areas of study, MRP and JIT, reflected the overall percentages in the study. For MRP, the respective percentages were 69 percent memory and 31 percent thinking and for JIT the percentages were 69.2 percent memory and 30.8 percent thinking.

Table 1
Summary Statistics Rating by Experts

	Testbank Questions		
	MRP	JIT	Combined
Number of questions	30	30	60
Number discarded	1	4	5
Number of questions remaining	29	26	55
Number memory	20	18	38
Percentage memory	69.0	69.2	69.1
Number thinking	9	8	17
Percentage thinking	31.0	30.8	30.9

Figure 1
Summary Statistics Rating by Experts



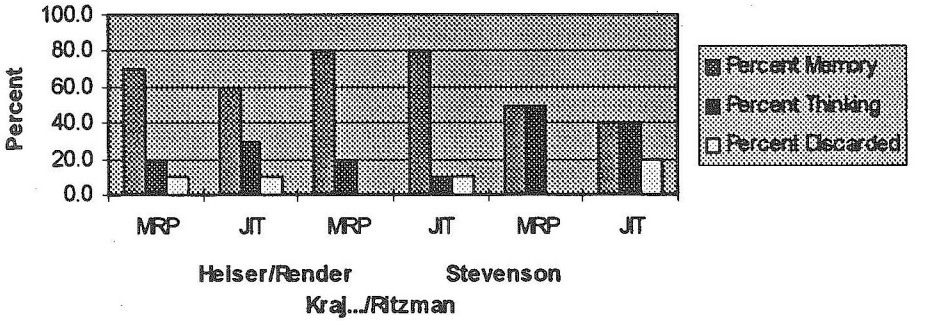
The memory classification percentages between authors ranged from 40 percent to 80 percent (see Table 2 and Figure 2). Krajewski and Ritzman (1993) had an even mix between memory and thinking type questions in both MRP and JIT. Stevenson (1993) at 80 percent in both MRP and JIT had the highest percentage of memory type questions. The categorizations for Heizer and Render (1993) were in between those of the other two authors, 70 percent memory for MRP and 60 percent memory for JIT. The Chi-square goodness-of-fit results for Table 2 indicate that the distribution of cognitive levels was not uniform, meaning that the test files do not provide an equal chance to select a knowledge question or a question requiring intellectual ability and skill.

Table 2
Summary Statistics by Author Rating by Experts

	Heiser/Render		Stevenson		Krajewski/Ritzman	
	MRP	JIT	MRP	JIT	MRP	JIT
Number of Questions	10	10	10	10	10	10
Number Discarded	1	1	0	1	0	2
Percentage Discarded	10.0	10.0	0.0	10.0	0.0	20.0
Number Memory	7	6	8	8	5	4
Percentage M	70.0	60.0	80.0	80.0	50.0	40.0
Number HL	2	3	2	1	5	4
Percentage HL	20.0	30.0	20.0	10.0	50.0	40.0

Chi-square results: χ^2 (1,N=55) = 6.635, p<.01

Figure 2
Summary Statistics Rating of Textbooks by Experts



DISCUSSION

The interrater reliability results suggest that the cognitive level of the test bank multiple choice questions can be consistently classified according to a simplified version of Bloom's taxonomy. Our results imply that the knowledge or memory type question is the dominant form of multiple choice questions in the test banks that accompany basic textbooks for production and operations management.

Our findings did not differ from similar studies in other disciplines. Hampton (1993a) found test banks accompanying management textbooks contained more knowledge than thinking type questions. Similar results were obtained in a study using marketing textbooks and test banks (Hampton, Krentler & Martin, 1993b). Karns, Burton and Martin, writing several years earlier, reported a preponderance of memory over thinking type questions in the six economics textbooks they evaluated (Karns, Burton, & Martin, 1983).

One reason for the low level of test file questions may be due to the difficult and time-consuming work of preparing "thinking" type questions. Possibly, authors tired after completing the text often have publishers employ others at very little pay to write questions for the test file that accompanies the text.

Also authors and publishers may not consider the level of cognitive activity of multiple choice questions in test bank files as a critical factor in adoption decisions. If instructors demanded higher level questions in test banks, authors and publishers would respond in order to market their textbooks.

Although test banks may include problems and essay questions to stimulate thinking, instructors of large classes (40 students or more) often resort to testing memory rather than thinking for the determination of grades. To the extent that this occurs instructors will reward a student's ability to memorize text passages rather than the students ability to think. This can result in students becoming ill prepared to respond in situations requiring the application of basic knowledge to the solution of complex problems.

SUMMARY AND CONCLUSIONS

One of the authors on cognitive theory believes that examinations should contain a mixture of memory and thinking type questions (Bransford, 1979). Students must learn key definitions in a subject before they can apply their knowledge in areas requiring higher level thinking. The student should be tested on whether he/she has learned the definitions, then given a "transfer test" to see if he/she can "identify novel examples of the concepts" (Bransford, 1979, p. 225).

This of course raises the issue of what the mix should be between thinking and memory type questions. If the objective is to test thinking, then the proportion of memory type questions should be significantly below the level required to pass an examination, otherwise a student could pass the exam by answering only memory level questions.

One way to create better questions is to convert memory questions to thinking type questions. This is not difficult, as illustrated in the following conversion of a memory type question from the testbank of a management textbook.

From the Text	From the Test File
Forward Integration occurs when a company enters the business of its customers. If Ford decided to acquire some of its 10,500 franchised dealerships and/or open company owned dealerships, Ford would be engaging in forward integration. (Hellriegel & Slocum, 1992, p. 254)	14. If Ford Motor Company decided to acquire some of its 10,500 franchised dealerships, it would be engaging in a. forward integration b. backward integration c. horizontal integration d. concentric diversification (Fischthal & Fischthal, 1992, p. 124)

The following rewrite of the question requires students to comprehend as opposed to remembering in order to correctly answer the question.

From the Text	Question
Forward Integration occurs when a company enters the business of its customers. If Ford decided to acquire some of its 10,500 franchised dealerships and/or open company owned dealerships, Ford would be engaging in forward integration. (Hellriegel & Slocum, 1992, p. 254)	When several country and western music stars built their own theaters and hired their own staffs to run them in Branson, Missouri, they were engaged in: a. forward integration b. backward integration c. horizontal integration d. concentric diversification

Instructors can easily turn the conversion process into a learning experience. Have students, or groups of students working together, convert some of the memory type questions in the test banks to thinking type questions. The thinking type questions, thus created, can then be exchanged between students and/or subsequently used on examinations.

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