Measuring Student Learning: An Empirical Solution with Implications for IS Education and Beyond

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Measuring Student Learning

An Empirical Solution with Implications for IS Education and Beyond*

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ABSTRACT

As we enter the twenty-first century, the organizational role of IS continues to expand and evolve at a dizzying pace. An understanding of and appreciation for that role is becoming mandatory for all managers and executives, not just IS professionals. This paper first determines a generally agreed upon high-level conceptualization of the strategic role IS plays in organizations. It then proceeds to develop and empirically test an instrument designed to measure college students' normative perception of that role. The contributions are twofold. First, the instrument can be used as an indicator of educational quality by assessing the extent to which a concept has crystallized within students (deep learning), as opposed to short-term retention and recall (surface learning). This has immediately applicable implications for designing MIS curricula and learning materials and, more widely, in e-Learning in general, where feedback loops allow interaction to be adjusted and refocused in process based on progress toward established goals like, in this case, the recognition of underlying principles. Second, the instrument can be used to help evaluate how well future business managers and executives truly understand and recognize the value of IS to the organization. This has long-term implications for organizational productivity.

Key Words: *IS Education, IS Research Methodology, Learning Models, Strategic Role of IS, Confirmatory Factor Analysis*

INTRODUCTION

The rapid rate of change in information technology, coupled with the equally rapid diffusion of information systems, has lead to fundamental changes in the role IS plays within

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organizations. The IS function has evolved from a provider of automated transaction processing and record-keeping services to an essential contributor towards not just organizational success, but its very survival. As we enter the twenty-first century, this evolution is accelerating and expanding. IS is becoming more and more pervasive, presaging a change in core perceptions of the organizational role IS will play in the new millennium.

Related to the expanded role of IS in organizations, researchers, educators, and practitioners have reached a general agreement that some base level knowledge and understanding of IS concepts is mandatory for all future business professionals. This is reflected in recent remarks by Robert Zmud in the Call For Papers for a themed issue of *MIS Quarterly* devoted to the redefined role of IS (Zmud, 1999), and earlier calls for revamping business school curricula (e.g., Couger et al., 1995; Lee et al., 1995; Ramakrishna et al., 1995). But merely changing the curriculum content is not enough. Colleges and universities must ensure that their students not only learn key IS concepts at the surface level, but embrace them at a deeper level as well (Martin and Saljo, 1976; Ramakrishna et al., 1995; Evans and Honour, 1997). That is, students should move beyond rote memorization to truly understanding, appreciating, and applying the concepts.

Based on the preceding, our research objectives are twofold. First, we seek to determine a generally agreed upon high-level conceptualization of the strategic role IS will play in organizations as they move into the twenty-first century. Second, we endeavor to develop and validate an instrument to measure an individual's *normative perception* of the strategic role of IT. The purpose of this second objective is not to measure how well a student can parrot back what he or she has been taught. That can be, and usually is, done as part of the grading process. We argue that, given the criticality of IS in today's world, it is crucial that the student's deep-rooted perception of the role of IS be explored to help ensure that future business managers and executives truly understand one of the core concepts of IS.

To achieve these objectives, the remainder of the paper is laid out as follows. In the next section, we establish a framework for evaluating how well a student has learned the currently espoused concept of IS as a means of competitive advantage. After that we examine several notions of the strategic organizational role of IS, and present a generally agreed upon conceptualization of the strategic role IS plays in the current and future business environment. Then we discuss our research methodology and results. Finally, we close with a discussion of the contributions and implications of this research.

A LEARNING FRAMEWORK

In order to effectively appraise whether or not a student has "learned", a framework for defining and evaluating learning must first be put in place. In this study, we use the notion of surface and deep learning, which in turn is based on Bloom's Taxonomy of learning (Bloom, 1956).

In the 1950's a group of educators and psychologists collaborated to develop a theoretical framework for classifying educational objectives, which became known as Bloom's Taxonomy. The taxonomy consists of three overlapping domains; cognitive, affective, and psychomotor. The cognitive domain addresses the acquisition and use of knowledge. The affective domain deals with internalization of interest, attitude, and values. The psychomotor domain emphasizes physical skills, and is clearly outside the scope of this study. There is some overlap between the cognitive and affective domains, particularly as they relate to the individual placing a value on some phenomenon (Krathwohl et al., 1956). However, since the cognitive domain is primarily concerned with intellectual issues, while the affective domain is more inclined towards feelings and emotions (Reeves, 1990), we will focus on the cognitive domain.

Within the cognitive domain, there are six hierarchical levels, beginning with *knowledge*, or rote memory, and progressing through to *evaluation.* See Table 1 for a fuller description.

Table 1. Bloom's Taxonomy—Cognitive Domain

Level	Description
1. Knowledge	Recall of information, ranging from specific facts to more general patterns and theories.
2. Comprehension	A low level of understanding what has been taught.
3. Application	The use of abstractions such as general ideas or methods in particular and concrete situations.
4. Analysis	Breakdown of the material into its constituent elements, relationships and interactions, then relating them to a structure which binds them together.
5. Synthesis	Combining elements into an integrated whole.
6. Evaluation	Making a judgement about the value or worth of ideas, solutions, or methods.

Bloom's Taxonomy is widely used in general educational settings (Kottke and Schuster, 1990). It has also been used in the study of business ethics (Reeves, 1990) and IS education (Hosseini, 1993). However, there is some discussion concerning the precise delineation between the various levels (e.g., Kottke and Schuster, 1990; Seddon, 1978). In order to sidestep some of the debate about exact specification of the levels, other researchers have grouped Bloom's six levels into two. The RECAP model (Imrie, 1984; 1995) divides the cognitive domain into two tiers. Tier 1 is composed of the first three levels of Bloom's taxonomy, while Tier 2 combines levels four through six. The two tiers correspond to what has been described as surface and deep learning (Martin and Saljo, 1976). The concept of surface and deep learning has also been applied to IS education (Cox and Clark, 1998). Both of these simplified taxonomies differentiate between rote

memorization of specific pieces of information and the application *and appreciation* of more abstract concepts. It is this appreciation that will be used to evaluate the individual's normative perception of the strategic role of IS.

THE ROLE OF INFORMATION SYSTEMS

Notwithstanding the voluminous body of scholarly research on how the organizational role of IS has evolved, we chose to focus on a different, although closely related, academic medium—the textbooks used in foundation IS courses in business schools. This approach was selected for three reasons. First, the presentation of material in textbooks usually draws on scholarly research. For example, Zwass' (1998) presentation of the evolution of the role of IS is "based in part on the work of Lynda Applegate . . . and her colleagues" (p. 84). Similarly, Schultheis and Sumner (1998) adapt the work of Nolan (1979; 1984) to discuss the evolution of IS, and Laudon and Laudon (1998) tie their discussion of the changing conceptions of IS to Porter's (1985) work on competitive advantage. The second reason for focusing on textbooks is that they are the direct and immediate source of information for students.[1] Finally, our focus is on the evolving role of IS today and in the future, not so much its historical progression.

Five foundation-level business school textbooks, designed for both IS and non-IS majors, were examined. Selection of the textbooks was based on informal conversations with various instructors at several different universities, and review of an ISWorld Listserv discussion related to introductory MIS books (Flatto, 1999). While no pretense is made that this is a "scientific sample," we argue this selection is representative of the information contained in the vast majority of such texts. See Table 2 for a summary of the textbooks' presentation of the changing role of IS.

A common theme running through these books is the premise that some knowledge and understanding of IS concepts is mandatory for future business professionals. There is also general agreement among the textbooks concerning the crucial role IS plays in contributing to the organization's success, both today and in the future (see Table 3). We have distilled these two general notions into a series of questions designed to evaluate an individual's normative perception of the strategic role of IS. The questions are based on Laudon and Laudon's (1998) depiction of the changing conception of the role of information systems. This was not done because we consider Laudon and Laudon's treatment of the subject superior to the other texts: we consider all the textbooks to be high quality works. The choice of Laudon and Laudon is based on both an abstract and a pragmatic basis. Abstractly, they approach the subject as a change in the *conception* of IS, rather than the historical evolution perspective of several of the other books. This is more in line with our desire to assess the normative perception of IS. Pragmatically, this was the text our subjects used in their classes.

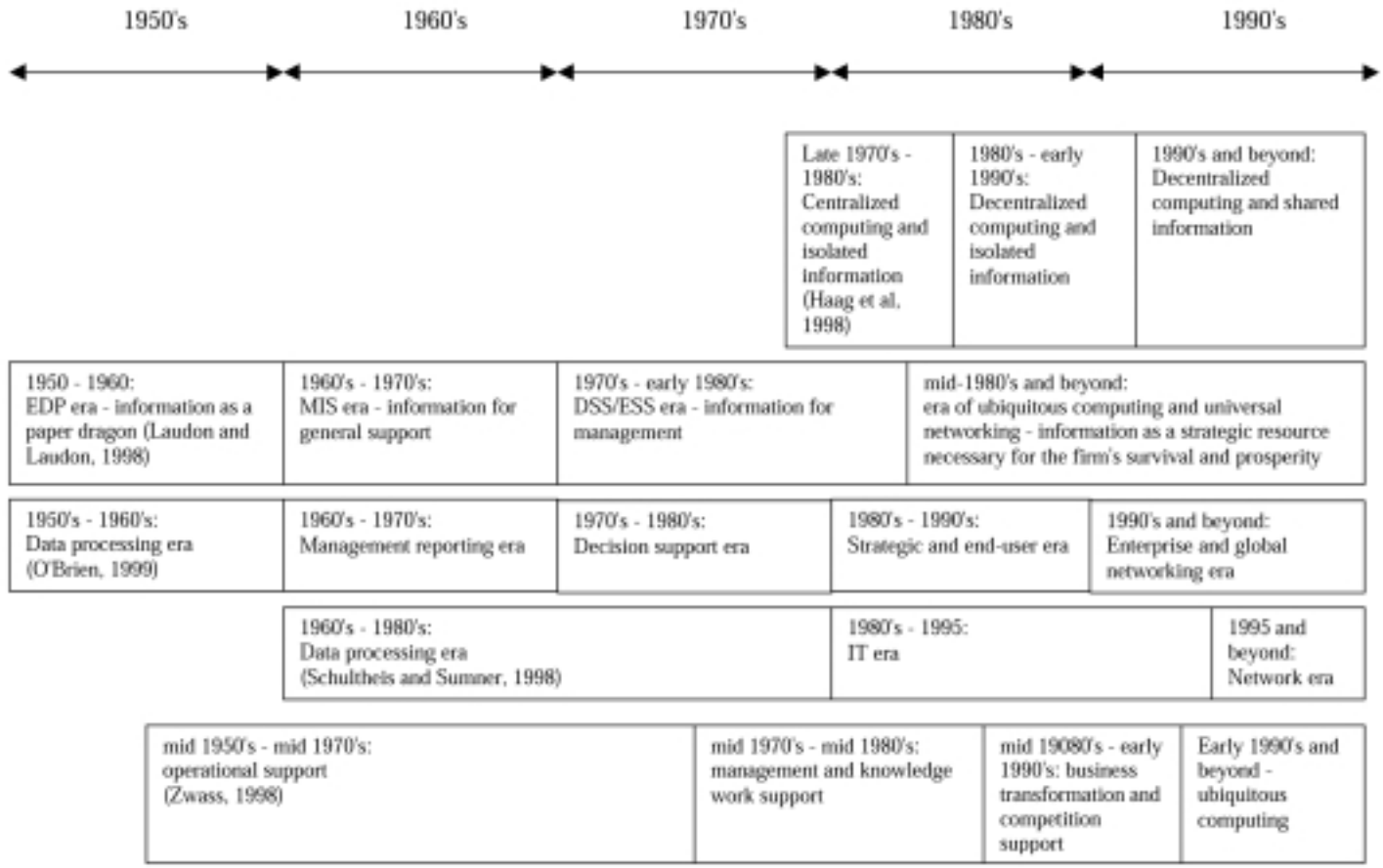

Table 2. Changing Roles of Information Systems

Table 3. Curremt Role of IS

Source	Current Role of IS
Haag et al. (1998)	IS is essential for doing any kind of business. IS is an essential enabler of innovation. (pp. 431–432)
Laudon and Laudon (1998)	IS promotes the survival and prosperity of the firm. (p. 50)
Schultheis and Sumner (1998)	IS is used to leverage business results. (p. 22)
O'Brien (1999)	IS is revolutionizing how the business opportunities and management of successful global enterprises are supported. (p. 55)
Zwass (1998)	IS enhances the firm's competitive position.

METHODOLOGY

The study sample consisted of all sections of a core IS course required of all students enrolled in the MBA program at a large southwestern urban university. Participation was voluntary. There were three sections taught by two different instructors. All sections were included; therefore any bias related to selection of a particular section was minimal. All sections used the same text—Laudon and Laudon, 1998.

The instructors allowed us to conduct this study, but were intentionally not informed of our actual hypotheses, questionnaires, and variables being studied. This was done to eliminate any bias and to prevent instructors from changing their teaching styles to influence the outcomes. Both of the instructors are qualified researchers and understand the value of controls in an experiment.

On the first day of class the students in all sections were given a questionnaire primarily designed to capture normative perceptions of the strategic role of IT. In addition, a variety of information, including demographics, the student's baseline knowledge of the subject matter taught in the course, and the student's overall perception of the value of IS were gathered. Following the taxonomies given in the Laudon text we identified three distinct strategic role-types for IS: management control, decision-making, and competitive advantage. There were two measures developed for each of these role-types (see Table 4 for items). There were 147 subjects at this point.

A second questionnaire was administered at the end of the semester. It re-measured the student's knowledge of the subject matter and perception of the role of IS. There were 127 usable responses. All of the scales used were five-point Likert-type scales.

The average age of the students participating in the study was 29 years old. Sixty-seven percent worked full-time and attended the university part-time. Twenty-five percent had Management Information Systems undergraduate degrees, 59% had other business degrees, and 16% were non-business majors (none of which were computer science majors).

RESULTS

The first day (Before) and the last day (After) questionnaire data were matched by the last four digits of the students' social security numbers. After adjusting for students who

Table 4. Measures Used in Research

Management Control Role
VAL60S1. Other than processing routine transactions, information technology should be primarily used to provide reports for better monitoring, controlling, and administering.
VAL60S2. Other than processing routine transactions, information technology's primary role is to provide useful and timely reports for managing.

Decision-making Role
VAL80S1. Other than processing routine transactions, information technology's primary role is to enhance the decision making in the organization.
VAL80S2. Other than processing routine transactions, information technology should be primarily used to improve decision making within the organization.

Competitive Advantage Role
VAL90S1. Other than processing routine transactions, the primary role of information technology is to enable the reengineering of the Company's business processes for competitive advantage.
VAL90S4. Other than processing routine transactions, the primary role of information technology should be to provide a strategic advantage over a Company's competitors.

dropped out or improperly completed their questionnaires, there were 105 matched pairs. It was hypothesized that the students' perception of the role of IS in the organization would move from being oriented towards the earlier role of management control to the more current roles of decision-making and competitive advantage. Using the data, a matched pairs test of means was performed. The results appear in Figure 1. There was little change in perception of the IS role related to management control and decision-making. However, there was a significant change (at the .05 level) in the student's perception of IS as a means of competitive advantage, implying that the student's perception of the role of IS has crystallized around that concept of IS.

To assess the extent to which the various notions of the role of IS crystallized in the minds of the students, we performed a confirmatory factor analysis using AMOS 4.0. This analysis provides an assessment of whether deeper learning actually occurred as a

Figure 1. Change in Perception of the Role of IS (Paired Means Test)

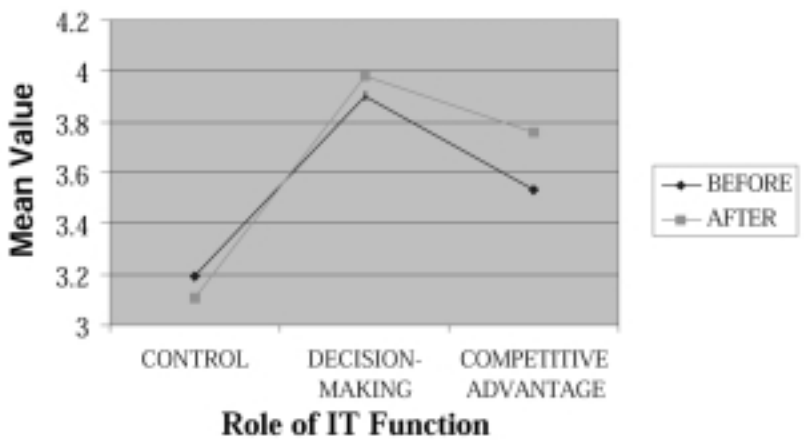

Table 5. Overall Model Fit For the Confirmatory Factor Analysis

Fit Measures	recommended levels	Before taking course (n=147)	After taking course (n=127)
Degrees of freedom		6	6
Number of parameters		15	15
P	> 0.05	0	0.044
Discrepancy	smaller is better	51.26	12.959
Discrepancy / df	< 5.00	8.543	2.16
RMR	< 0.10	0.08	0.058
GFI	> 0.90	0.899	0.965
Adjusted GFI	> 0.85	0.647	0.877
Normed fit index	> 0.90	0.826	0.93
Incremental fit index	> 0.90	0.844	0.961
Tucker-Lewis index	> 0.90	0.596	0.898
Comparative fit index	> 0.90	0.838	0.959

result of taking the course. The resulting overall model fit statistics in Table 5 show that deep learning did occur. Prior to taking the course, the various ways of viewing the strategic role of IS (i.e., management control, decision making, and competitive advantage) did not exist in the minds of the students. The poor fit measures show that the three IS roles were not well formed in the minds of the students. This is further demonstrated by examining the correlations among the constructs (as depicted in Figure 2) where the near perfect correlation of 0.94 suggests there is no differentiation between the constructs of managerial control and competitive advantage. In other words, in the minds of the students, the items used for these two constructs were viewed as interchangeable. This conceptual confusion disappeared after taking the course. The overall model fits are all at or above the recommended levels. More importantly, we see that the managerial control and competitive advantage constructs have crystallized into separate constructs (i.e., changing from a standardized correlation of 0.94 to 0.45).

The implications of this research go far beyond the IS discipline and extend into any area where learning goals include the recognition of underlying principles in the material. It also opens the door for "smart" eLearning modules to incorporate this assessment methodology to customize the learner's experience and make it more efficient by sensing the level of understanding and adjusting content presentation accordingly.

DISCUSSION

One of the contributions of this research is the development and validation of an instrument for measuring an individual's normative perception of the strategic role of IS. However, the other contributions go beyond that. The instrument can be used as an indicator of educational quality, in the sense that deep learning (implanting a deep-rooted cogni-

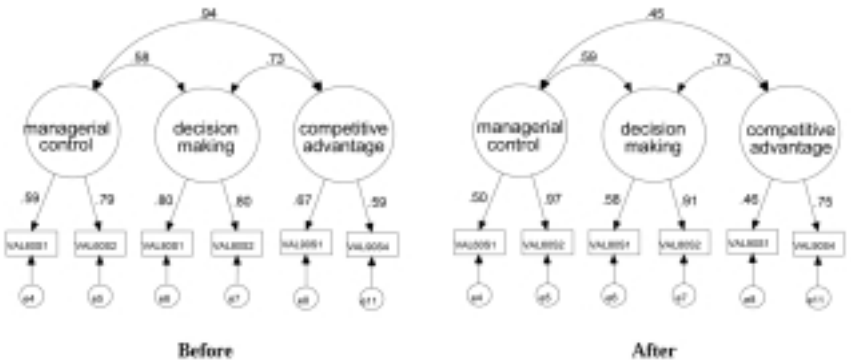

Figure 2. Confirmatory factor analysis of perceptions of the role of IT (standardized estimates before and after taking the MIS course)

tive perspective in students of the current and future value of IS to organizations) is preferable to surface learning (retention and recall of specific material). It is conceivable that a student can still rote recall the various statements of the role of IT as presented in our instrument, but still not make the conceptual differentiation. To assess whether deep learning has taken root, the use of confirmatory factor analysis as applied in this study is required. The results and approach presented here has implications beyond a narrow assessment of students. The students of today are the managers and executives of tomorrow. Their internalized appreciation and evaluation of the organizational role of IS guides their thinking and behavior, which has long-term implications for organizational productivity and the impact of IS on society. The fact that the student sample examined represents graduate students, many of who work under a managerial capacity gives pause for consideration. Is it possible that the normative perceptions of the strategic role of IS that IS academics take for granted may not actually exist in the minds of managers? This study raises this possibility and we argue that future research ought to examine how deep-rooted these roles actually are among current business managers.

Areas for Future Research

The instrument and methodologies used in this study can easily be applied to other areas of research where substantial conflicting results have been obtained. Specifically the area of evaluating the effectiveness of distance learning as compared to the traditional face-to-face method has been fraught with research results that support either one method or the other (Ester, 1995, Wetzel, Radke, and Stern, 1994). "Learning" in these studies has been demonstrated only with measures of perceived learning or with evaluation of content or surface learning. Comparing the two teaching methods with a measure of deep learning, as was done in this study, may produce more meaningful results. It also provides a mechanism for assessing understanding in the eLearning environment and immediately modifying content of "smart" modules.

A second area of future research would measure the relationship between deep learning and surface learning in the same students and in the same environment. By giving the students course content questions both before and after taking a course, a measure of surface learning is obtained. This surface learning could also be extended to measure retention by administering a subsequent test several months after completing the course.

A third area of application involves determining the effectiveness of individual instructors. This would be helpful in identifying deficiencies in teaching skills and/or materials. The implications of this capability go way beyond the universities. American businesses are spending up to $210 billion annually on staff development initiatives (Wexley & Latham, 1991). Businesses are keenly aware of the need to spend these dollars effectively.

Note

1. This is not to minimize the role of the instructor. This statement is based on the twin assumptions that: 1) what instructors teach is, for the most part, tied to the text; and 2) students read the text. Hopefully, these

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