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DO YOU KNOW WHAT YOU DON'T KNOW? CRITICAL REFLECTION AND CONCEPT MAPPING IN AN INFORMATION SYSTEMS STRATEGY COURSE

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ABSTRACT

Mental models are personal tools developed by students to help them apply ideas they have learned to solve problems. If students are not required to reflect on the adequacy of their current mental models, they risk arriving at suboptimal solutions due to knowledge gaps or misapplication of theory. After critically reflecting on the capstone project reports from students in an undergraduate information systems strategy and planning course, we argue that our students require a deeper and broader understanding of alternative management theories in order to become more effective and creative problem solvers. Furthermore, students must be made explicitly aware of the existence of (and adequacy of) their mental models using techniques such as concept mapping and critical reflection. Our solution to the problem of knowledge gaps is not to "push" more content to students, but to enable students to "pull" new ideas into their mental models once they recognize their existing mental models are inadequate. An action learning approach that combines problem-based learning, student-centered inquiry, concept mapping, and critical reflection can help students self-diagnose and treat their knowledge gaps. This in turn helps students develop into more effective, creative, and motivated critical thinkers and problem solvers.

Keywords: information systems education, management education, knowledge gaps, mental models, action learning, critical reflection

I. INTRODUCTION

A little Learning is a dang'rous Thing;
Drink deep, or taste not the Pierian Spring:
There shallow Draughts intoxicate the Brain,
And drinking largely sobers us again.
-Alexander Pope, An Essay on Criticism, 1709

Mental models are personal tools, developed within the minds of students, that help them apply ideas they have learned to solve practical or theoretical problems [Senge and Sterman 1992]. A primary role of management educators is to help students develop detailed yet flexible mental models for framing and solving complex problems. However, if students are not required to reflect on the adequacy of their existing mental models, they risk arriving at poor solutions based on distorted theoretical concepts [Ghoshal 2005].

As outlined in Figure 1, the premise of this paper is simple. Students develop mental models by combining new ideas with prior knowledge filtered through their unique experiences and perspectives [Johnson-Laird 1983]. Students who skip straight to solving problems or writing reports without reflecting on the adequacy of their mental models risk arriving at inferior solutions. Similarly, students who are not aware that they possess a malleable mental model and instead believe their brain is full of “facts and truths” also risk arriving at inferior solutions. We argue that teaching critical reflection and concept mapping along with problem solving skills will enable students to assess the adequacy of their mental models and determine when they need to seek out alternative theories or perspectives to solve a specific problem.

The problem we address in this paper is that improperly developed mental models can overly constrain or distort solutions to managerial problems [Jih and Reeves 1992]. We analyze the outputs of students in an undergraduate information systems (IS) strategy and planning course to shed light on the problem and draw implications for educators. Concept maps created from a content analysis of student reports are used to highlight the differences between apparently well-formed and inadequate mental models. Our experiences suggest the techniques of concept mapping, critical reflection, and action learning exercises can help students build a better awareness of their emerging mental models and biases and take steps to address knowledge gaps. This in turn helps students develop into more effective, creative, and motivated critical thinkers and problem solvers.

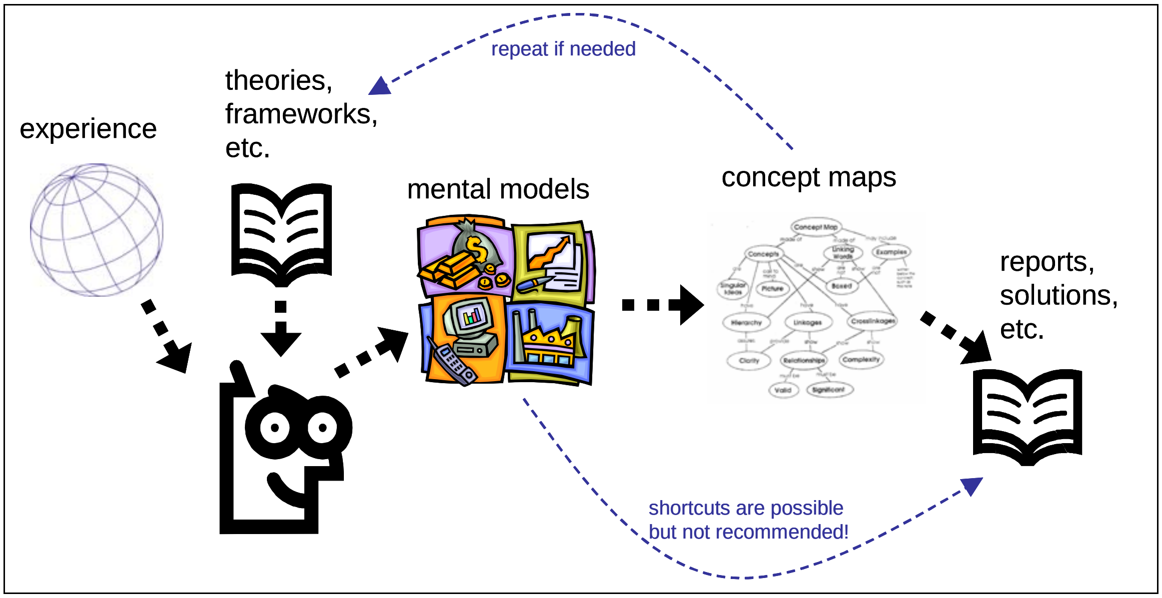

Figure 1. Concept Maps as a Tool for Representing Mental Models

In this paper, we view mental models as a representation of the world formed by individuals to allow them to understand the world and make appropriate decisions [Collins and Gentner 1987]. As systems thinker Peter Senge explains, "Mental models are deeply ingrained assumptions, generalizations, or images that influence how we understand the world and how we take action" [Senge 1990, p. 8]. Mental models are distinguished from conceptual models or theoretical frameworks in that they exist solely in the mind of an individual. Two students may be exposed to the same theoretical framework and may form very different mental models based on how they interpret and understand the theory in light of their existing knowledge, experience, and learning processes. In the cognitive information processing view of learning, developing mental models consists of accretion (understanding new information), restructuring (forming new models), and tuning (modifying existing models) [Leidner and Jarvenpaa 1995; Rumelhart and Norman 1978].

We also distinguish between mental models and concept maps, with the latter being a graphical representation of the former. Concept maps, when properly created by students, can help students and instructors visualize the concepts and connections the students feel are relevant to understanding a topic or solving a problem [Croasdell et al. 2003]. We note a concept map is an idealized representation of a mental model and its accuracy is constrained by the ability of a student to recognize and document their current understanding of a topic.

This paper explores the problem of students possessing poorly developed mental models that are inadequately developed for solving a specific problem. Deficiencies in a student's mental model may arise from one or more of the following problems: (1) lack of appropriate theoretical basis; (2) incomplete learning or comprehension of the theory; or (3) lack of critical reflection on the adequacy of the mental model. In Section II, we provide an overview of mental models and how they can affect the problem solving process. In Section III, we reflect on an illustrative example based on our experience with an undergraduate IS strategy and planning course to shed light on the problem and draw implications for educators. In Section IV, we discuss evidence from a content analysis of student reports from the course to examine the relationship between mental models and student performance. In the final section, we make recommendations for developing more comprehensive mental models and discuss the implications of enabling students to become better critical thinkers and innovative problem solvers.

II. THE ROLE OF MENTAL MODELS IN MANAGERIAL PROBLEM SOLVING

The concept of mental models continues to play an important role in research on human cognition and learning [e.g., Goodwin and Johnson-Laird 2006; Verschueren et al. 2004]. IS researchers have also highlighted the importance of understanding the role of mental models in designing and using information systems [Lim et al. 1997; Majchrzak et al. 2005; Whitworth and Zaic 2003; Zhang et al. 2005]. Although the concept of mental models is likely familiar to most IS educators, we argue that in the rush to deliver constantly evolving content to students, we often forget to educate our students on the importance of reflecting on the adequacy of their evolving mental models. While most would agree that IS students need to be taught how to be better critical thinkers [McBride and Hackney 2003], there is limited guidance on how to embed the concept of mental models into a student's decision-making process.

Johnson-Laird [1983] describes the nature of mental models as "Craikian automation" [presumably after Craik 1943]. As shown in Figure 2, the essential part of this "automation" is the representation of the world external to the individual. An individual receives information in the form of a stimulus that he or she interprets in order to decide what to do about the information and bring about a course of action. Suppose that this stimulus is a colleague vocalizing an assertion. The individual listens to the information presented by the colleague and compares it against his/her own mental model of the phenomenon being discussed. Suppose that this information conflicts with the mental model. The individual could then decide, based on this comparison, to vocalize a rebuttal. Of course, the colleague could then refute the rebuttal which acts as feedback against which the individual compares his/her mental model (illustrated as a dashed arrow in the diagram). Thus, in this conceptualization of thought, mental models play a central role.

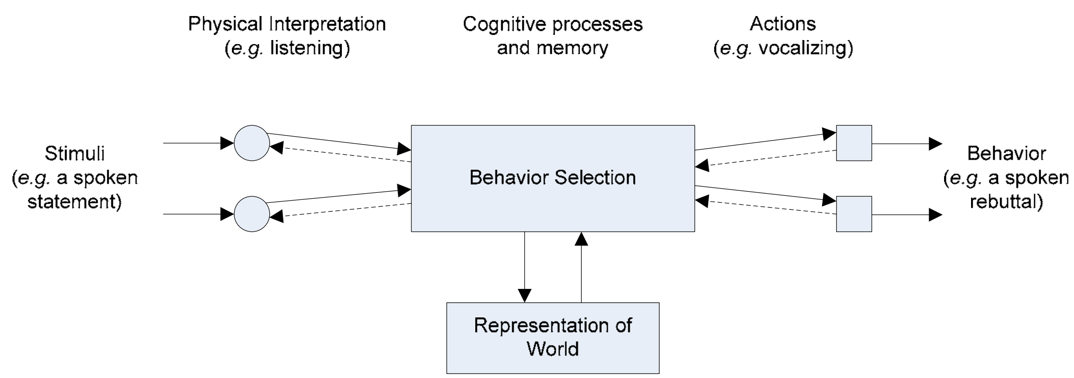

Figure 2. Mental Models and Craikian Automation
(adapted from Johnson-Laird, 1983)

Since mental models shape the approach that students take in problem solving, educators must ensure these models are sufficiently prescriptive to enable convergence on a satisfactory solution, without constraining innovation or arriving at inferior solutions. This is supported by the argument presented by Jih and Reeves [1992] and the evidence provided by Ma et al. [2007] that students who possess adequate mental models are more likely to learn and perform better than those who do not. Aspects such as performance in creative tasks, number and types of errors, and comprehension can be used as measures of the correctness of a mental model [Bostrom et al. 1990]. Satzinger and Olfman [1998] also demonstrated how the ability to effectively use computer-assisted decision tools depends on the adequacy of the individual's mental models.

In IS education, we often introduce theoretical frameworks to help students address complex socio-technical problems such as performing a systems analysis or analyzing and improving IS-business strategy alignment. Students will implicitly develop mental models based on the concepts they become exposed to. Many students will not explicitly evaluate the adequacy of their mental models unless they are required to evaluate alternative models. For example, students studying IS-business strategy alignment are often exposed to the dominant rational view of business strategy [e.g., Porter 1985] but not more emergent views of strategy [e.g., Eisenhardt and Sull 2001; Mintzberg 1978]. Furthermore, when theories are presented in an abstract summary form, students may lack an understanding of the complexities and limitations of the theories. Thus, the students may apply the theories inappropriately and generate inferior solutions.

Given the breadth and complexity of IS and general management theories, traditional IS management courses can only provide students with a high-level understanding of theories used in managerial problem solving. Educators often omit underlying details, such as how the theories were developed or the extent of their limitations, due to lack of time for the required lectures or readings [Hui et al. 2001]. Many students seem to prefer this approach as it quickly exposes them to a range of "problem-solving tools," without being needlessly bogged down in theory. To facilitate communication, complex theories are simplified and removed from their original context, which obscures the limitations of the theories. This approach can also lead to knowledge gaps that allow students to form mental models without realizing the limitations of those models. Hence, Alexander Pope's quote, "a little learning is a dangerous thing," rings true.

While something may be better than nothing when it comes to exercising [Lorig et al. 2000] or marketing [Harding 1994], it is not the case when it comes to knowledge and education. For example, a superficial awareness of a culture without a deeper understanding can lead to inaccurate stereotypes informing poor decision-making. McFate [2005] illustrates that military operations based on partial cultural awareness are usually worse than no action at all. Similarly, an incomplete understanding of the numerous perspectives and approaches to achieving strategic alignment of IS may lead to suboptimal results. Students are often taught that a firm's IS should fit their business strategies, but may not appreciate that this is but one of many possible paths to strategic fit such as the technology-driven or co-evolutionary approaches [Henderson et al. 1996; Peppard and Breu 2003; Yetton et al. 1995]. McLaren et al. [2004] suggest that many IS planners possess an inadequate mental model of strategic alignment (informed by an incomplete understanding of prior research), which results in difficulties in trying to keep their firm's IS aligned with ever-changing business strategies.

When attempting to apply theory with insufficient knowledge, students are faced with the choice of dismissing the theory, employing potentially improper assumptions, or inquiring further—usually through a literature review. Since the third option requires the most effort, students will likely opt for one of the first two options. Only when the students are required to apply theories to problem situations and then critically reflect on their application (action learning) do they become aware of the limitations (and sometimes the existence) of their mental models [McGill and Brockbank 2004]. Action learning and critical reflection may entice a student to learn more about specific theories and their limitations. While naïve students may not distinguish between theory and fact, reflection focuses attention on evaluation of the validity and applicability of theories for a specific problem-solving context.

Lack of exposure to alternative models may be due to a perceived lack of time to incorporate further materials into a course [Hui et al. 2001]. The educator needs time to prepare and communicate materials and the student needs time to absorb them. However, another reason why alternative models are not presented to students may be the tendency for theorists to over-promote their frameworks as 'one size fits all' solutions. This problem is especially noticeable in the teaching and application of business strategy theories and models. Jones [1998] discusses the intrinsically dynamic nature of strategy that resists a static and finite definition for all scenarios. He notes that although this is a widely recognized attribute of strategy, academics often publish manuscripts that suggest their strategic analysis methods are capable of being brought to bear on any strategic management issue [Jones 1998].

It is important to recognize that models and theories often evolve over time as further studies extend or refine the existing theories. For example, several studies have helped resolve some inconsistencies in Miles and Snow's [1978] competitive strategy typology (Defenders, Prospectors, Analyzers, and Reactors). Although these empirically supported modifications have led to a more refined and better supported model [e.g., Conant et al. 1990; Doty et al. 1993], many educators still teach only the original (and somewhat flawed) Miles and Snow [1978] model. If students and educators are not required to seek out critiques of the prior research, they will not be made aware of their potential shortcomings.

Requiring critical reflection forces students to examine how well the new theory complements their existing mental models (which were developed through a combination of prior life experience and exposure to other theories). Students lacking relevant experience or exposure to alternative theories require more exposure to counter-examples to think critically about new ideas [Verschueren et al. 2004]. On the other extreme, very highly experienced students often have firmly entrenched mental models and may need extra coaching to think critically about their experiences, assumptions, and biases [Johnson-Laird 1983].

A student may have developed a mental model that is inadequate for solving a specific problem due to one or two major problems: (1) the model is based on incomplete or inaccurate theories; or (2) an imperfect learning process resulted in an incomplete or distorted mental model. We argue these problems can be mitigated by: (1) ensuring students are exposed to a variety of theories and perspectives which help frame the problem; (2) requiring students to create concept maps to help identify problems in their learning of the concepts and relationships; and (3) requiring students to critically reflect on their concept maps and proposed solutions to determine whether their mental models are sufficiently developed.

In short, IS educators can help students become innovative problem solvers by ensuring that course pedagogies support the development of diverse and flexible mental models that provide multiple problem-solving perspectives. Students must also master critical thinking skills such as knowing which mental models can appropriately frame a problem and which models can distort the situation and lead to unsatisfactory solutions.

The following section provides an illustration of how the development of mental models impacts problem solutions. The insights are drawn from an IS Strategy course in which two of the authors were instructors and one of the authors was a student. Although students must be able to employ flexible and diverse mental models for most managerial problems, the need for such models in analyzing IS strategy issues is especially acute and provides a useful illustrative example.

IV. REFLECTIONS ON MENTAL MODEL DEVELOPMENT IN AN IS STRATEGY COURSE

An illustration of how knowledge gaps can be created from a reductionist understanding of complex theory can be seen in examples from the authors' experience in how competitive strategy typologies are taught in a capstone IS strategy and planning course. Porter's [1985] generic strategies of cost leadership, differentiation, and focus typically receive the most attention due to their sustained popularity (which may be related to their ease of communication and application). As an alternative to the rational Porterian view of competitive strategy, Miles and Snow's [1978] typology of Defenders, Prospectors, Analyzers, and Reactors was also taught to illustrate Mintzberg's [1978] view of strategy as a pattern of emergent (rather than intended) activities. In addition, students were introduced to other views of strategy, including Treacy and Wiersema's [1993] concept of "value leadership" and the "resource-based view of the firm" [Grant 1991]. To address the links between business and IS strategies, concepts of IT portfolio investment management [Weill and Broadbent 1998] and IT strategic alignment maturity [Luftman 2000] are also discussed.

Miles and Snow's defenders, prospectors, analyzers, and reactors organizational archetypes can be used to help classify a firm's emergent strategies based on how they develop products and markets. Miles and Snow created detailed conceptualizations of the four archetypes after analyzing the consistent and recurring patterns that were displayed in numerous companies in several industries.

Although Miles and Snow's typology is one of the most widely used in empirical competitive strategy research [Gimenez 1999; Hambrick 1983], many students and educators appear to favor more simplistic "two-by-two" matrices such as Porter's generic competitive strategies. One reason may be it is easier to quickly distinguish between idealized cost- or differentiation-focused firms than between the multidimensional defender, prospector, analyzer, and reactor configurations. Similarly, the prescriptive actions inherent in the Porter classification (e.g., "cost-focused firms should focus on costs") are much more intuitive than the prescriptions for multidimensional archetypes (e.g., "Defenders should ensure all strategic actions are consistent with those of an archetypical defender").

In contrast to Porter's generic strategies, the Miles and Snow typology enables a richer multidimensional analysis of a firm's competitive strategies, while attempting to reduce the complexity of analysis by grouping the firm's strategic patterns into one of defender, prospector, and analyzer, or reactor archetypes. However, a major criticism of the Miles and Snow [1978] typology is that the simplistic paragraph-type measure used to identify a firm's archetype in research studies does not properly operationalize all 11 dimensions of the competitive strategy typology [Conant et al. 1990]. Thus, there is a risk that a firm will be improperly characterized if only the paragraph measure is used. In other words, proper application of the Miles and Snow typology requires an understanding of the detailed conceptualizations of the archetypes, rather than just selecting the archetype based on a short-paragraph description.

Another issue with blindly applying theoretical frameworks frequently appeared when students performed a strategic analysis for a nonprofit organization. As with for-profit companies, analysis of the competitive strategies of a nonprofit can be used to improve their strategies and improve the support of IS for these strategies. However, the nonprofit strategies have different attributes than for-profit strategies, requiring different models and guidelines for analysis and implementation [Moore 2000; Rojas 2000]. The risk is that if a student does not know how the models were developed or the situations to which they were intended to apply, the students may not recognize the need to adapt the models or seek out other models that are more appropriate to their situation. Indeed, Kilbourne and Marshall [2005] suggest that intrinsic differences in the models can lead to failures when using for-profit models and guidelines in nonprofit settings.

For many students, the solution might have been as easy as locating a study that extends the original model to the new problem domain (nonprofit organizations). However, it would appear the students have been trained to accept anything appearing in a textbook or PowerPoint slide as "the truth." Thus, many do not recognize the need to critically analyze the appropriateness of the frameworks used, no matter how "theoretical." Requiring students to do a critical reflection on the mental models used in their analysis forces students to question both the appropriateness of the solution and the process used to arrive at the solution. The critical reflection process stimulates active learning and tends to produce more creative critical thinkers [Mezirow 1998].

Although many of our students appear to be skilled at generating solutions to problems, the difficulty some have in objectively evaluating their own solutions underscores the need for educators to raise awareness of the role of mental models and reflection in managerial problem solving. In the following section, we discuss techniques for diagnosing deficiencies in mental models using concept maps. We also provide a brief analysis of project reports completed in the previously discussed IS strategy course in order to investigate the linkage between concept maps and student performance.

V. CONCEPT MAPS AS A TOOL FOR VISUALIZING MENTAL MODELS

As educators, we have traditionally focused on delivering content to students in hopes that they will develop robust mental models suitable for solving problems. In the problem-based learning (PBL) approach [e.g., Woods 1995], the passive lecture method is replaced with students learning through solving problems. Thus, with PBL, we no longer just hope students will become effective problem solvers, we actively assess the effectiveness of each student's problem-solving process and outcomes. It is relatively easy to evaluate the efficacy of the process by questioning the steps taken and the logic used to identify the problem and arrive at a solution. It is even easier to evaluate the solution. What is very difficult, however, is diagnosing the flaws in a student's mental models that, if remedied beforehand, would likely lead to a more satisfactory solution. In other words, our challenge is to help students assess the sufficiency of their mental models for solving a specific problem so that they can fix any knowledge gaps or inappropriate assumptions before they suggest a solution.

Concept maps have been shown to be an effective tool for enabling students or instructors to represent and evaluate a student's current mental models [Croasdell et al. 2003; McClure et al. 1999]. While mapping techniques vary, the basic approach described in Croasdell et al. (2003) is to have a student identify a key concept relevant to the problem domain. The student then adds the concept terms that are relevant to the first concept, using lines to show the conceptual connections and distance between concepts to show their relatedness. Additional related terms are added until a network or web diagram emerges containing the most pertinent concepts. Different boxes or colors can be used to distinguish between the perceived importance of concepts. Several iterations of redrawing the maps are often required to arrive at a map the student feels is reflective of their mental model.

Concept mapping can be used in place of notetaking or as an output to be formally graded by an instructor [Freeman and Urbaczewski 2001; Markham et al. 1994]. However, our usage of concept maps has been as an informal diagnostic tool to help students and instructors understand which concepts the student currently feels are relevant to the problem and what connections the student has made between the topics. In this manner, the instructor, student, or peers can determine whether the student is focusing on inappropriate concepts, is missing any relevant concepts, or has drawn incorrect connections between the concepts. The map can serve as an outline for a project report, allowing group members to determine whether they are focusing on the most important concepts to be discussed.

To examine the relationship between mental models, concept maps, and student performance, we reviewed 18 major group project reports completed by the students in a capstone undergraduate IS strategy and planning course in 2005. The students were not asked to create concept maps prior to writing their reports. Instead, we have used text analysis software to generate *post hoc* concept maps and perform a cluster analysis of the concepts identified in the reports. The concept maps and clusters were then examined to determine whether there was a relationship between the key concepts identified and the grade that was awarded for the report. The grades had been awarded based on standard project report criteria such as the sufficiency of the strategic analysis and whether arguments were supported by literature or evidence. The grading was done by the primary author without access to the concept maps, which were generated two years later for this study.

Although we might have used an expert coding panel to create concept maps of the reports, the time required to code and resolve inter-rater agreement issues for the over 1000 pages of text would have been prohibitive. Instead, using Crawdad Text Analysis software, we completed the text file preparation, analysis, concept map generation, and cluster analysis within a number of hours. Crawdad uses Centering Resonance Analysis (CRA) to generate a network or matrix of the most influential terms (noun phrases) in each student report. Prior studies have validated the concept maps produced using Crawdad and have shown the concept maps produced are very similar to what researchers would produce using more intensive hand-coding techniques [Corman et al. 2002; Lee 2007]. Furthermore, unlike hand coding, CRA describes the concepts in statistical terms (the resonance, distance, and betweenness of terms described in Corman et al. 2002) suitable for cluster analysis.

Most prior text analysis software determines word importance from the frequency of the term in the text or across texts. In contrast, CRA uses linguistic centering theory to infer the importance of a term from the amount of influence it has on creating coherence in the text [Corman et al. 2002]. In centering theory, important terms are ones that are not necessarily the most frequently used, but ones that form links between other important terms. Thus, even if a word does not appear frequently in the text, if it connects together other influential concepts, it is deemed an influential word. As a result, the list of most influential terms provided by CRA and the concept maps describing their linkages are very similar to what a researcher would produce if they were interpreting the text. In contrast to frequency analysis, CRA more closely mimics the human linguistic process of determining word value from the structural position of the words and their coherence in communicating ideas [Corman et al. 2002; Lee 2007].

Prior to generating the CRA matrices, the student reports were converted to plain text files and pre-processed to remove tables, appendices, headers, footers, and any text that would identify the students or companies involved. To facilitate clustering by grade received, the percentage grade that had been awarded to the report was used as a filename (followed by a letter if the grade was not unique, e.g., "78b.txt").

Once the CRA matrices were generated, Crawdad was used to generate concept maps containing the most influential terms in each of the 18 reports. The concept maps revealed the terms that had influence values greater than 0.025 as well as the structural connections between the terms in each student report. Following Corman et al. [2002], the cutoff value of 0.025 was chosen to depict the top 10-20 most influential terms.

Although concept maps are useful for showing the most influential terms and their inter-relationships in a report, statistical clustering techniques are better suited for comparing terms between reports. Thus, we used Crawdad used to perform a hierarchical cluster analysis (using Wall's agglomeration method) to statistically analyze the "resonance" (a statistical measure of similarity described in Corman et al. 2002) between the 18 CRA word influence matrices. In Wall's method, the least squares distance between every pair of matrices is calculated, along with the within-cluster resonance of any potential clusters. Where there is similarity (lack of distance) between a matrix and another matrix or cluster, the two entities are clustered together. The stepwise clustering can proceed from the initial state of each matrix is its own cluster, to a maximal end state of all matrices in one cluster. The statistically optimal clustering state is determined by the step that minimizes the combined distance of all clusters, while maximizing the within-cluster resonance. Alternatively, stepwise clustering proceeds until further clustering would fail to differentiate sufficiently between the clusters [Corman et al. 2002].

Figure 3 graphically depicts the clustering solution for the 18 student reports. The lowermost horizontal bar indicates the first (most significant) cluster arrived at, while the uppermost horizontal bar indicates the final clustering step (all 18 in one cluster). The optimal clustering step that had the highest within-cluster resonance resulted in a three-cluster solution with an average within-cluster resonance of 0.0581. The four-cluster solutions had a slightly slower average within-cluster resonance of 0.0579, while the two-cluster solution had a much lower average resonance of 0.0391. In non-technical language, the 18 concept maps generated from the student reports were seen to form three clusters of similarity, shown as ovals in Figure 3.

The cluster with the highest within-cluster resonance (0.0979) was Cluster A, which was composed of the two lowest scoring reports, which had received grades of 66 percent and 70 percent. Cluster B had the next highest within-cluster resonance (0.0401) and was composed entirely of reports that had received grades of 80 percent or above. The remaining Cluster C had the least similar concept maps with a within-cluster resonance of 0.0363. With the exception of two reports that received grades of 89 percent and 82 percent, the 10 reports in Cluster C received grades in the 71-80 percent range. The mean scores (and standard deviations) for clusters A, B, and C were 68 percent (2.8 percent), 84.8 percent (4.1 percent), and 77.5 percent (5.6 percent).

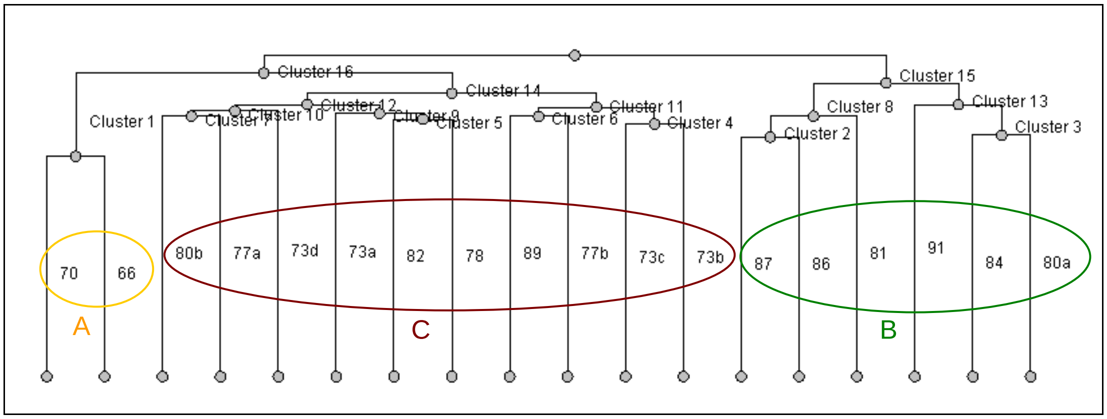

Figure 3. Cluster Analysis of Concept Maps from Graded Student Reports

As shown in the cluster analysis, the two lowest scoring student reports had concept maps very similar to one another. Similarly, with a few exceptions, the highest scoring reports shared similar concept maps, while the lowest scoring reports also shared similar concept maps, although the lowest scoring reports had the least similar concept maps[1].

One explanation for the results of the concept map cluster analysis are that either the mental models used or the process of translating the mental models into text was relatively poor for Cluster A, relatively good for Cluster B, and moderate for Cluster C. While a detailed examination of differences between the concept maps in each of the three clusters is beyond the scope of this paper, we briefly describe some of the differences by comparing the most influential terms from concept maps generated from the most influential terms from a report from Clusters A and a report from Cluster B. As shown in Figure 4, the report from Cluster B focused on key concepts one would expect to be associated with an IS strategy and planning course (for example, “product,” “customer,” “system,” “industry,” “strategy,” “process,” and “firm”). In contrast, the report from Cluster A did not appear to focus on these key concepts (except for the term “industry” and to a lesser extent “service” and “information technology,” the concepts from the course did not found to be influential terms in the Cluster A report.

We note that computer software was used to generate these concept maps well after the reports were submitted and graded. Had the students created these concept maps before writing the report (perhaps as a conceptual outline for the report), we would be inclined to use the concept map from Cluster B as a good example to build upon. Similarly, we would likely instruct the students who created a concept map similar to the Cluster A example to rethink their plan for the report. We might even suspect that the Cluster A students have not yet formed mental models that are adequate for performing the required strategic analysis and planning for the project report.

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[1] We are careful not to overemphasize the significance of these findings as they merely depict statistical similarities in the most influential terms used in the 18 student reports. It could be that high, low, and medium performing student groups each share similar vocabularies that are distinct from each other. We did not use experimental controls in the study to rule out all explanations, nor did we attempt to analyze additional reports beyond what were collected from the course described in this paper during one semester in 2004. However, the instructor did note that after carefully grading the reports, he was surprised that the grade allocation did not necessarily reflect the presumed writing abilities of the student groups, nor their performance in other aspects of the course. In the opinion of the instructor who had assigned the grades, the explanation of the low, medium, and high-scoring clusters reflecting inadequate, satisfactory, and well-developed concept maps seems plausible.

On reflecting on the concept map from Cluster A shown in Figure 4, we suspect it is typical of the small minority of our students who are particularly excited about generating technical solutions to problems, yet tend to overlook the related managerial, business, or strategic issues that must be attended to for a satisfactory solution. Perhaps if we had some warning that the "Cluster A" students were focusing only on technical or idiosyncratic concepts rather than broader management issues, we might have taken corrective action by having the students refocus on the key course concepts that were missing from their concept map. Fortunately, we can require students to create their own concept maps before writing their reports, which gives both the students and instructors an opportunity to assess the adequacy of their concept maps and underlying mental models[2]. Similarly, we can use critical reflection techniques [e.g., Mezirow 1998] with or without concept mapping to help students determine the adequacy of their mental models prior to solving problems or writing reports.

IV. CONCLUSIONS AND DISCUSSION

It is crucial for both educators and students to be keenly aware of the limitations of theories, the existence of alternative theories, and the importance of reflecting critically on the mental models used to solve problems. As students become managers, those who apply theory inappropriately can propagate misleading or inappropriate assumptions to the point where good practices are adversely affected. For example, Ghoshal [2005] suggests that corporate accounting scandals might be traced to the popularity of agency theory and its implicit assumption that financial managers should not be trusted. It may be easier to justify inappropriate behaviours if one's mental models include the belief that "everyone is doing it." Similarly, Lee et al. [2004] highlight how many earlier information technology (IT) outsourcing decisions that were based on the "best practices" of the time have subsequently failed to meet expectations. Their more recent research suggests earlier outsourcing theories failed to account for the need for fit or congruence among the many lesser decisions made in an IT outsourcing project.

[2] Croasdell et al. [2003] describes how to teach concept mapping skills to students for learning and evaluation purposes. Although some educators advocate formal evaluation of concept maps as a graded component of a course, this requires confidence in ones ability to determine a grade for a concept map. We prefer to use concept maps as a self-diagnostic tool and have only begun to study their impact on student performance.

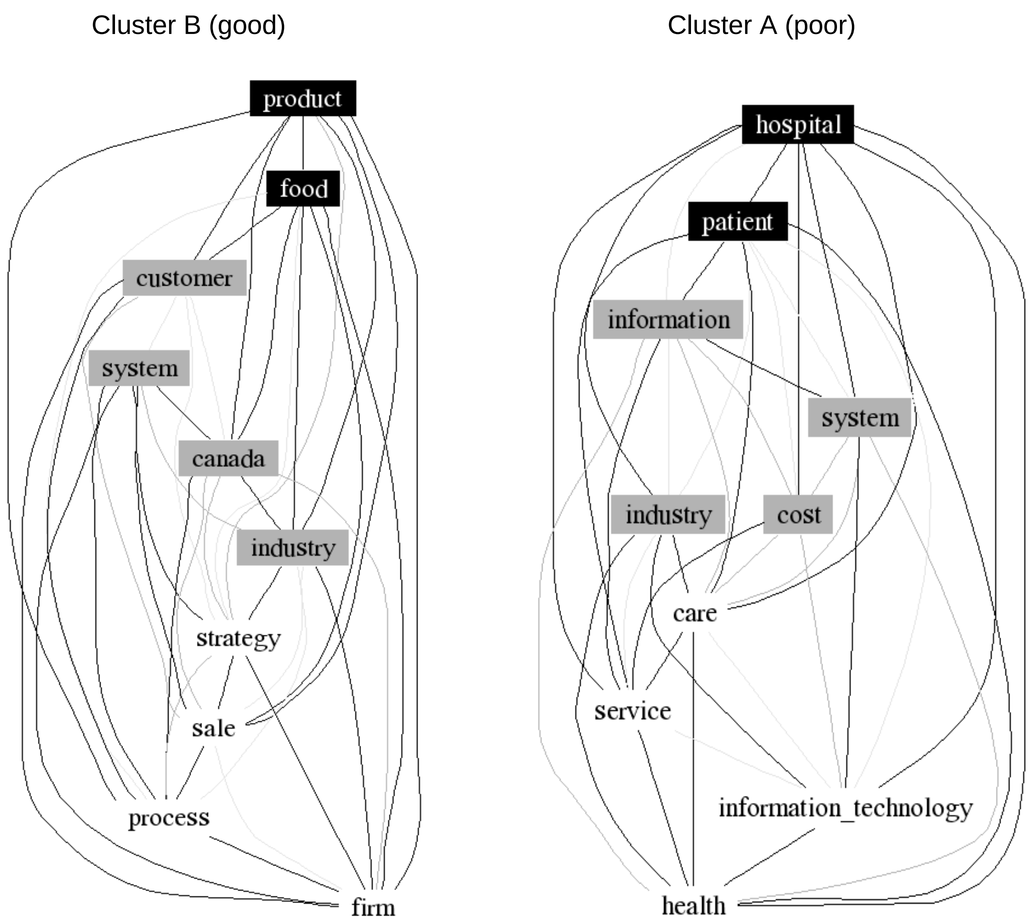

Figure 4. Sample Concept Maps Generated from Student Reports[3]

In this paper, we have argued that if a student does not pay attention to the adequacy of their mental models during problem solving and report writing, they risk arriving at an inferior result. In the previous section, we have provided evidence that suggests the adequacy of a student's mental model (as represented by a concept map) is related to the adequacy of their project report outputs (as represented by the grade they received). Although we have not attempted rigorous experimental controls to definitively test this assertion, we do note that the clusters of similar concept maps appeared to also be differentiated by the grade received on the report. Specifically, one cluster of highly similar concept maps had received relatively high grades, another cluster received relatively low grades, while a third cluster received grades in between the two. After examining the concept maps, it appears the high performing reports all had concept maps which highlighted terms directly relevant to the major course topics (e.g. strategic alignment, industry

[3] The darker shaded boxes represent more influential terms, the darker shaded lines represent more frequent occurrences of pairs of terms, and the length of the lines represents how closely or loosely connected are the terms.

analysis, competitive forces, etc.), while the lower performing reports had concept maps that pertained to more idiosyncratic topics such as the type of technology in use at the firm studied.

In reflecting on our experiences with an IS strategy and planning course, we conclude that, as educators, we must help students build an awareness of the existence of mental models and must help students recognize and address the existence of inadequate or overly constraining mental models. Deficiencies can arise from a lack of knowledge required to solve a problem or from a lack of knowledge about the existence of alternative models. In other words, students must not only "know what they know," but they should "know what they don't know." Educators can help diagnose these problems in students and can help address the issues through their choice of course material and pedagogical techniques used to help students learn the material (see Table 1).

Table 1. Troubleshooting Problem-Solving Problems

Symptom	Diagnosis	Suggested Treatments
Student unable to provide satisfactory solution	Mental model is blank	This problem usually responds to most instructional approaches (e.g., lecture, case study, student-centered inquiry, problem-based learning, etc.)
Solution is inferior, overly costly, or unrealistic	Inappropriate mental model for specific problem	Feedback and reflection on problem recognition, models used, and solution (e.g., problem-based learning, critical reflection, action learning)
Solution lacks creativity or is based on assumptions that limit its usefulness in real world applications.	Inadequate diversity and flexibility of mental models	Awareness and analysis of alternative theories and models (e.g., literature search, case study, critical reflection, problem-based learning)

Educators are responsible not only for resolving knowledge gaps in students, but also for raising awareness of the limitations inherent in any mental model. Since it is difficult for educators to distinguish between knowledge gaps and poor problem solving or communication skills, the students must be made responsible for diagnosing and treating their own knowledge gaps. This could involve making students responsible for supplemental literature searches in a problem-based learning approach [e.g., Woods 1994] or making them responsible for the entire learning process in a student-centered inquiry-based learning approach [e.g., Lee 2004].

The recognition of knowledge gaps should be initiated by the student and facilitated by the educator, as is done in the critical reflection phase of an action-learning approach [e.g., McGill and Brockbank 2004; Mezirow 1998]. In this approach, students must reflect on their problem solution as well as the assumptions and mental models used in the problem solving process. By articulating and reflecting upon their problem solving process, students are able to evaluate and refine their mental models for application in various problem domains. This conscious attention to the problem-solving process used allows students to develop more robust mental models. It also enables students to examine alternative solutions using different perspectives [Collins 1991]. Such action learning approaches often increase students' motivation to learn by giving them the responsibility of learning what they need or want to know [McGill and Brockbank 2004]. Students can also become more confident in their problem-solving abilities when they critically reflect upon their assumptions [Mezirow 1998].

We have developed the preceding guidelines based on our experience as educators and students of IS strategy theory and application. These propositions are based more on our experiences than an accumulated body of research evidence, but we believe them to be worthy of further consideration and investigation:

1. Theories and frameworks should be taught in the context of progressively complex real-world problems to highlight the applicability and limitations of theories for diverse problems (which is amenable to problem-based learning or action learning approaches);
2. Educators need to make students responsible for diagnosing their own knowledge gaps (which is amenable to critical reflection or action learning approaches); and
3. Educators need to make students responsible for treating their own knowledge gaps (which is amenable to student-centered inquiry or action learning approaches).

In comparison with other teaching techniques, action learning places a more equal focus on the principles of theoretical diversity, applied problem solving, critical reflection, and student responsibility for learning. For example, most case-based learning techniques require students to apply theory to problems, but do not require students to reflect on the appropriateness of the solution, the mental models employed, or the process used to arrive at the solution. This suggests that adding a critical reflection component to every problem-solving activity may have the greatest impact in imparting an awareness of the adequacy of a student's existing mental models and problem-solving abilities.

Although further research is needed, our propositions are rooted firmly in our experience of teaching information systems strategy and planning techniques to undergraduate business students. Through observing the difficulties some students display when solving complex problems, we have gained an acute awareness of how some may develop inadequate mental models due to knowledge gaps or inadequate critical reflection. We conclude that developing students to become innovative problem solvers requires a deeper and wider understanding of management theory and practice from both the student and educator. Students must be given more experience critically analyzing problems as well as reflecting on the adequacy of the solution, the problem-solving process, and the mental models used to solve the problem. This will help students become better, more creative problem-solvers who are better equipped to self-assess the quality of both their mental models and their proposed solutions.

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