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Reflection and Representation: An Experimental Examination of Computer-Based Representation to Support Reflective Thinking

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REFLECTION AND REPRESENTATION: AN EXPERIMENTAL EXAMINATION OF COMPUTER-BASED REPRESENTATION TO SUPPORT REFLECTIVE THINKING

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Abstract

Effective management requires executives to reflect upon their own beliefs and practices. Self-reflection is a highly subjective process that one engages in either alone or in conversation with others. To self-reflect is to become aware of one's tacit beliefs and practices, and to then critically explore them. This study examines the role of information technology in enhancing the process of reflection. Information representation technologies can help in capturing and organizing surfaced beliefs and practices, which in turn can enhance the process of critically exploring them. Cause mapping in particular has been proposed as an application of information technology that can enhance the process of self-reflection.

In a laboratory experiment comparing the effect of using cause maps against written text and speaking aloud, subjects found the process of reflection more satisfying with the use of cause maps. However, they produced more differentiatively complex representations in the speaking out loud condition. The preference for technology was also mediated by a person's work experience. The less experienced subjects preferred the use of cause maps while the more experienced subjects preferred written text. This study suggests that information technology can enhance the experience of self-reflection, but cautions that speaking out loud without technological support is an effective mode of self-reflection.

1. INTRODUCTION

Organizational renewal requires individual managers to reflect upon their tacit knowledge and to renew their implicit theories and beliefs (Argyris and Schon 1978). Reflective thinking is especially important when managers face novel situations for which they do not already have mental models or formulations (Schon 1983). Most executives are not trained for learning from their experiences and renewing their theoretical base. Anticipating this need, information systems researchers have long expressed the need for designing "systems to think with" (Weber 1986). The research question in this study is whether reflection can be gainfully supported through the use of information technologies.

We recognize that self-reflection always involves a silent thinking to one's self and we are interested in how this thinking to one's self is mediated by modes of representation which make silent thinking visible. When thoughts become visible they are available for further reflection and for sharing with others (Boland, Tenkasi and Te'eni 1994). Reflection can thus be modeled as a two-phase process (Boud, Keogh and Walker 1985). In the first phase, one surfaces and represents one's tacit knowledge. In the second phase, one critically explores the represented knowledge.

We designed an experiment to compare the differential impact of two technologies of representation to support reflection (written text and cause mapping) with speaking aloud and found some surprising results. Contrary to assertions that cause maps produce more complicated perspectives, we found that speaking aloud produced the most differentiatively complex representations. However, subjects using cause maps reported higher levels of learning and satisfaction. Below, we will describe the research model, development of hypotheses, a brief overview of the design of the experiment and the conclusions from this study.

2. RESEARCH MODEL

Adapting the model of decision aids proposed by DeSanctis (1984), the outcome of self-reflection (R) can be considered to be a function of individual characteristics (I), task characteristics (T), and the information representation technology (M).

$$R = f(M,T,I)$$

By standardizing the task situation to be that of reflecting upon one's career planning, we can control for the (T) factor with an open-ended, personally-relevant task. The information representation technology (M) is the primary independent variable of interest. We will compare the use of cause mapping, written text and speaking out loud. Some elements of individual characteristics are expected to mediate the reflective impact of information technologies. An individual's reflective judgment capacity (I) is expected to grow with experience (King and Kitchener 1994) and is also included in our model.

The dependent variable of reflection (R) consists of four measures. Three of those measures are outcome measures while one is a process measure. Two of the outcome measures (differentiative and integrative complexity) (Schroeder, Driver and Streufert 1967) correspond to the surfacing/representing phase of the model of reflection, and one outcome measure (self-reported level of learning) corresponds to the critical exploring phase of the model. The process measure is a self-report measure of process facilitation and it corresponds to the entire experience of reflection.

3. HYPOTHESES DEVELOPMENT

Word Processing: Written text is a long established technology of representation with clear syntactical and semantical rules. Skilled use of text can extract the full rhetorical power of a language and thus help express the cause-effect relationships among abstract factors in great detail (Vygotsky 1962; Goody 1986; Bruner 1990). Its sequential mode of presentation provides its author with a high degree of control over the flow of logic and argument (Kaufer and Carley 1993).

Cause Mapping: Cause maps are based upon the assumption that cause-effect relationships are the dominant way in which understanding about the world is organized (Huff 1990). They are a quasi-graphical tool for representing a person's understanding of a situation, including the causal factors, their inter-relationships, and other attributes. They assist in knowledge management in many different ways, some of which can be argued to be unique to cause maps, such as:

(1) They help evoke tacit knowledge: Weick (1979) argues that cause maps add a visual component to written text, to form a simplified and convenient short-hand technique for representing cause-effect relationships. The visual directness of the cause maps (Arnheim 1992) simplifies and facilitates the representation of mental models and thus acts as a trigger in surfacing one's tacit knowledge (Polanyi 1966).

(2) They help organize knowledge: Weick suggests that cause maps help in organizing the newly surfaced knowledge in the context of that which is already structured and organized. Further, the concepts can be easily moved around, as in playing anagrams, leading to an experimentation with different patterns and organization of concepts and knowledge.

(3) They help create new knowledge: Cause maps can be network-analyzed for their structural characteristics, leading to an understanding of the densities and patterns (such as cycles) of relationships among the causal factors (Eden, Jones and Sims 1979; Weick 1979; Ackerman and Eden 1992).

Cause maps have been implicitly assumed to be superior to written text (Weick 1979; Huff 1990; Eden, Jones and Sims 1979). This assumption, however, needs testing, as written text continues to be popular as a means of expression and impression (Kaufer and Carley 1993). This leads to our first and main hypothesis, which reflects the major premise being tested.

H1: The use of technological support (cause maps) will have a superior effect upon the process and outcome of self-reflection compared with another technological support (written text) and no technological support (speaking out loud) conditions.

Reflective judgment ability is an important individual characteristic that develops with increasing age, work experience and education (King and Kitchener 1994). From a definitive and inflexible view of knowledge at a younger age, a person develops a contingent and flexible view of knowledge with growth in education and experience. A person's level of work experience can serve as a useful proxy for one's level of reflective judgment (King and Kitchener 1994). A higher level of work experience, and thus reflective judgment, may impact a person's view of self-reflection, and his/her preference for certain technologies for the purposes of self-reflection. This leads us to our next two hypotheses:

H2: Individuals with a higher level of work experience will experience superior process and outcome of self-reflection.

H3: The level of work experience will mediate an individual's preference for technological support for reflection.

3. MEASUREMENT AND EXPERIMENT DESIGN

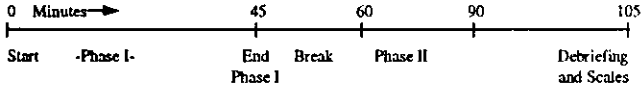
Technological support: Three levels of technological support were used as independent variables in this study: no technological support, written text, and cause maps. We used a DOS-based word processing package for written text support. Cause mapping support was provided through the Spider system developed at Case Western Reserve University (Boland, Maheshwari, Te'eni, Schwartz and Tenkasi 1992). Spider was developed on a UNIX platform using C language, Xwindows and Motif, and currently runs on a VAXstation. The no-technological support was operationalized by letting the subject speak aloud in front of a non-directing interviewer.

Level of Experience: The level of full-time work experience was a self-report measure and was dichotomized around the median value (3.5 years). Those below the median value were classified as having a low level of experience while those above the median level were classified as having a high level of work experience. The average work experience was over five years.

Operationalizing Self-reflection: We designed multi-item scales for measuring process satisfaction and level of learning from reflection using a rigorous scale-development process of concept definition, item generation, data collection, reliability analysis, and validity testing (Churchill 1979). The two scales are shown in the appendix. The reliability estimate for the 4-item scale for process satisfaction was satisfactory at 0.80. The reliability estimates for the 7-item scale for level of learning was also satisfactory at 0.85 (Nunnally 1978). Differentiative and integrative complexity of the protocol of reflection was judged by two independent coders (Schroeder, Driver and Steufert 1967; Krippendorff 1980). The coders were trained using test cases that were not included in this analysis. The inter-rater reliability was also high: 0.88 and 0.90 for differentiative and integrative complexity respectively.

Subjects: Fifty-eight graduate business students with an average age of twenty-seven years and an average work experience of five years agreed to participate in this study. They were randomly assigned to one of the three technological support conditions.

Time Line: The experiment consisted of two phases separated with a break. The time line for the experiment is shown below:



In Phase I, a sheet of paper with written instructions was provided to each subject. It provided a standardized stimulus for the subject to begin reflecting upon their career and career planning (Table 1). The subject reflected for up to 45 minutes. In the cause-mapping and written text cases, the experimenter left the room returning only when the subject was finished with the task. In the speaking aloud cases, the experimenter sat quietly and uttered only selected neutral phrases such as "Um!", "Anything else?", or "Take a moment" from a standardized list.

At the end of Phase I, the subject went through a ten minute long, standardized, commercially available audio-tape of a body-relaxation program. The objective of this relaxation exercise was to create a cognitive break between the two phases of the experiment, i.e., to simulate a situation where the subject revisits the task after a period of time. In Phase II, subjects received standardized written instructions to continue reflecting upon their career planning for up to thirty minutes. They were allowed to use the instruction sheet provided to them in Phase I. At the end of the experiment, the subjects were administered the measurement scales and were then debriefed for their reactions to the experiment. All subjects successfully completed the experiment.

4. DATA ANALYSIS AND DISCUSSION

We conducted multivariate analysis of variance (MANOVA) on this data to test the three hypotheses developed before. MANOVA takes into account the correlations between the dependent variables and also helps keep the overall alpha under control (Stevens 1986). The results of MANOVA are summarized in Tables 2 and 3.

Two major findings can be observed here. The first and major finding is that technology does not always help create richer and more complex representations. We found that the use of technology, whether written text or cause mapping, reduces the number of factors that are considered by a person ($p=0.000$) as compared with speaking out loud. One obvious reason for the higher level of factors considered in the speaking aloud condition is that it is much faster to talk than it is to write or to draw. Given equal time, they are able to cover more areas and issues. A second reason is that, when using technology, subjects spend more time organizing the cumulative work, whereas in speaking out loud, many subjects appear to devote less time in organizing their talk, and simply follow their stream of consciousness around their career with all its detours, discontinuities, etc. The role of speech, dialogue, and conversation in revealing tacit beliefs and practices, and developing the potential for learning, is thus revealed.

A second finding concerns the impact of technology upon process facilitation and learning. Overall, those in the cause mapping condition reported a higher level of process facilitation and learning as compared with written text and with speaking out loud. In addition, this impact was mediated by the subject's

Table 1. Instructions to Subjects

Instructions to subjects
"Please reflect upon your own career and career planning. You may ask yourself questions such as: What is your career plan? Why is your career plan the way it is? What are the factors that influence, support and inhibit, your career and your career plan? What are the key assumptions that you make? What are the key issues and unresolved questions? How would you go about facing those issues and questions? There are no right or wrong answers to these questions. Career planning is highly subjective. You are the best judge of your own career plan."

Table 2. Descriptive Statistics for TECH Support x EXPerience (Means & s.d.) (N = 58)

Technological Support	No support		Written Text		Cause Maps	
Level of Experience	Low	High	Low	High	Low	High
Subjects in cell	7	12	9	10	13	7
Process Facilitation	4.79 (.56)	4.88 (.90)	4.28 (.76)	5.47 (.88)	5.67 (.57)	4.93 (1.03)
Level of Learning	3.82 (1.31)	4.26 (.52)	3.24 (1.02)	4.57 (1.30)	4.86 (1.10)	3.90 (1.18)
Differentiative Complexity	15.00 (1.68)	15.25 (2.32)	13.61 (1.69)	13.80 (2.80)	9.62 (1.58)	10.79 (2.66)
Integrative Complexity	3.28 (.29)	3.67 (.61)	3.49 (.20)	3.50 (.37)	3.26 (.46)	3.40 (.58)

Table 3. Results of MANOVA by TECH Support x EXPerience (n = 58)

Effect	TECH x EXPerience	EXPerience	TECH
Multivariate Test of significance: Wilk's Lambda	F (8, 98) d.f. =2.35 Sig. of F =0.023 Power=0.85	F (4,49)d.f. =0.71 Sig. of F =0.466 Power=0.27	F (8,98)d.f.=5.56 Sig. of F=0.000 Power=1.00
Univariate F-tests:	(2,52) d.f.	(1,52) d.f.	(2,52) d.f.
Process Facilitation	F=7.01, **p=0.002**	F=0.71, p=0.403	F=1.94, p=0.154
Level of Learning	F=5.11, **p=0.009**	F=0.85, p=0.362	F=0.90, p=0.411
Diff. Complexity	F=0.29, p=0.745	F=0.85, p=0.362	F=24.9, **p=0.000**
Integ. Complexity	F=0.80, p=0.453	F=2.23, p=0.141	F=0.73, p=0.483

level of work experience ($p<0.01$). In other words, subjects preferred different technologies based upon their level of experience. Younger, less experienced subjects found the use of cause maps most satisfying and reported higher levels of learning although subjects with higher levels of experience preferred the use of written text ($p<0.01$). One possible explanation for this finding is that younger people are more enthusiastic about new technology, such as cause maps, and quickly embrace it, while the more experienced subjects are slow to do so. Another possible explanation is that the more experienced subjects are also more skilled at using the full rhetorical power afforded by written text, while they find cause maps constraining in representing their complex cognition. This finding is thus consistent with, and supports the theory of, reflective judgment, which specifies that the level of reflective judgment becomes more flexible, contingent and complex with age, experience and education (King and Kitchener 1994).

5. CONTRIBUTIONS AND FUTURE DIRECTIONS

This research finds statistically significant evidence that the use of cause mapping technology helps reflective thinking by creating higher levels of satisfaction and learning. Contrary to assertions in the literature, however, speaking aloud resulted in the most differentiatively complex representations. Further, the choice of technology depends upon one's background. Younger, less experienced subjects preferred the use of cause mapping while the more experienced subjects preferred the use of written text. This research contributes also by making available models, measures and coding strategies for further research on systems that allow managers to do reflective thinking.

In this research, the two sessions of reflection were contiguous, separated by a short break. Reflective judgment grows over time and experience. It will be interesting to see the results of reflection when subjects revisit the same situation after a longer time, say one week or a month.

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Appendix

Decision-Making Experiment

Name: ____________________

Date: ____________________

Please respond to the following statements relating to the experience you just had, on a seven point scale.

		Strongly Disagree						Strongly Agree
1.	I was fully engaged in the experience.	1	2	3	4	5	6	7
2.	The flow of the experience was smooth and organized.	1	2	3	4	5	6	7
3.	I wanted this experience to continue for a longer period.	1	2	3	4	5	6	7
4.	I was highly satisfied with this experience.	1	2	3	4	5	6	7
5.	I became aware of new elements that affect my career.	1	2	3	4	5	6	7
6.	I became aware of new relationships among the elements that affect my career	1	2	3	4	5	6	7
7.	I obtained new insights about my career plan.	1	2	3	4	5	6	7
8.	I learned a lot from this experience.	1	2	3	4	5	6	7
9.	My perspective on my career significantly changed.	1	2	3	4	5	6	7
10.	My career plan came together nicely for me.	1	2	3	4	5	6	7
11.	My career plan became simpler.	1	2	3	4	5	6	7

Note: Items 1 to 4 relate to process facilitation.
Items 5 to 11 relate to level of learning.