Problem Structuring For Research Students: Evaluating a Visual Semantic Scaffold

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Abstract

Problem structuring for research students in virtual tutorials requires a visual semantic integrating conceptual model, architecture, or 'scaffold'. Heterogeneous communities require a scaffold that is customizable for use in different subject areas, and extensible for use in research that proceeds from multiple theoretical perspectives. This report describes such a scaffold and empirically tests its usefulness in graduate research and health knowledge management learning communities. Subjects exposed to the scaffold placed randomized paragraphs in the correct location with an error 44% less than that associated with random placement. Scaffolding exercises for the very first, and subsequent, tutorial sessions of a practice-oriented health knowledge class are described.

Keywords

Sensemaking, constructivism, research, virtual tutorials

1. INTRODUCTION

'How do I know what I think until I see what I say.' Karl Weick [1].

A variety of problem structuring methods exist. SODA [2] and related manual and electronically-assisted cognitive mapping techniques, Soft Systems Methodology [3, 4], and Strategic Choice [5], are but a few of the problem structuring methods on offer. In practice, multiple problem structuring methods may be applied to the same practical problem [6]. Schemes that employ three research paradigms, or three knowledge domains described by Habermas, may be employed to compare methods [7], and to ground them in concepts of enquiry [8, 9, 10, 11, 12]. This paper describes an application of a three-level scheme that was originally developed as a multi-step, electronically-assisted cognitive mapping technique for groups [13]. The steps constitute a problem structuring process-oriented model to guide facilitators of electronic meetings. The purpose of this paper is to describe how this model is employed as a problem structuring device for research students.

Research students in different faculties experience common opportunities and problems. Each may experience authenticity and creativity, yet have problems applying to their own work the generic guidelines in the research literature. Commitment to one's own ideas may clash with the requirement to adopt more formal research strategies, processes and structures. This is an issue that must be managed not only by the student but the student's teachers and research supervisor, and the individual members of the student's thesis and dissertation committee.

Research is a domain characterised by individual and collective exploration of a large spectrum of disparate concepts. Each student must embark on their own journey of discovery. Students structure the research problem by drawing on their own motivation, subject-specific interests and skills, and the guidance they receive from others. While some aspects of the research process may be prescribed, students need assistance in visualizing how these merge to form an interrelated whole.

The end of the journey is marked by the production of a research report deemed acceptable to the target audience. This is a complex and lengthy document marked by careful consideration of how the aspects and perspectives form a coherent whole. Yet the construction process may be marked by failure. The student may exhaust all external resources and inner resourcefulness before the journey is complete. A visual semantic integrating conceptual model, or 'scaffold' is useful to guide the student on this journey so that they may more easily and coherently 'see' (visualize) what they currently believe that they want to 'say' (articulate).

1.1 Theoretical Perspectives

The teaching and learning of graduate researchers can be described from various perspectives. This section reviews three perspectives of relevance to research students – pedogogy, research paradigm, and learning in online communities.

Pedagogy

Graduate students may confuse the aspects of research that are creative with the aspects that are formally prescribed. Their research proposals and completed research report may suffer from a less than coherent mixing of disparate elements. In general, they may be unsure about the degree to which the nature of instruction and learning (pedagogy), and the research report reflects, or should reflect, the characteristics of objectivist and constructivist models of learning and practice. [14] (Table 1).

Table 1. Objectivist and constructivist learning models.

Learning Model	Objectivist	Constructivist
Basic premise	Learning is the uncritical absorption of objective knowledge	Learning is a process of constructing knowledge by an individual
Goals	Transfer of knowledge from instructor to student. Recall of knowledge.	Formation of abstract concepts to represent reality. Assigning meaning to events and information.
Major assumptions	Instructor houses all necessary knowledge. Students learn best in isolated and intensive subject matter.	Individuals learn better when they discover things for themselves, and when they control the pace of learning.
Implication for instruction	Instructor is in control of material and pace. Instructor provides stimulus.	Learner-centered active learning. Instructor for support rather than direction.

Research Paradigm

Graduate research is informed, tacitly or explicitly, by research paradigms. Objectivist and constructivist ontologies are aligned with positivist and interpretivist research paradigms, respectively. Student's claims for the quality and validity of the research report have a status that reflects the research paradigm adopted. Each stakeholder may have a prior commitment to a research paradigm. The student's research supervisor, and individual members of the committee, may not agree on the evaluation of the research report. Power relations, and the critical pluralist paradigm, may explain why the student who recognizes unresolved conflict may feel obliged to wait to 'see what they say' [15] (Table 2).

Table 2. Research paradigms.

Research Paradigm	Positivist	Interpretivist	Critical Pluralist
Perspective of researcher	Stands aloof and apart from stakeholders and subject matter so that decisions can be made objectively	Becomes more fully involved with stakeholders and subject matter to achieve a good understanding of the stakeholders' world	Active involvement with stakeholders to surface illusions and to implement alternatives that will improve their world
Goodness or quality criteria.	Conventional bench-marks of 'rigor'; internal & external validity; reliability.	Trustworthiness and authenticity; Fit with social norms and values.	Historical situatedness; erosion of ignorance and misapprehensions; sincerity of beliefs; action stimulus.
Validity claim	Objective truth	Rightness	Truthfulness

Learning in Online Communities

Graduate and undergraduate students typically practice knowledge construction with the aid of Web-based documents and instructional software [16]. At a minimum this environment enables a learning community to access shared documents. Typically the documents serve as exemplars of relevant strategies, processes and structures. They may be organised - by degree of difficulty, and by phase in the development of the project so as to provide conceptual guidance ('scaffolding') for the next step of the research journey [17]. Face-to-face and online tutorials within a particular learning community may be supported by an integrated series of exercises based on a common road map or scaffold. This scaffold constitutes the integrating conceptual model or knowledge map of central importance in knowledge exchange, instruction, discussion, and other aspects of online knowledge construction. (Figure 1).

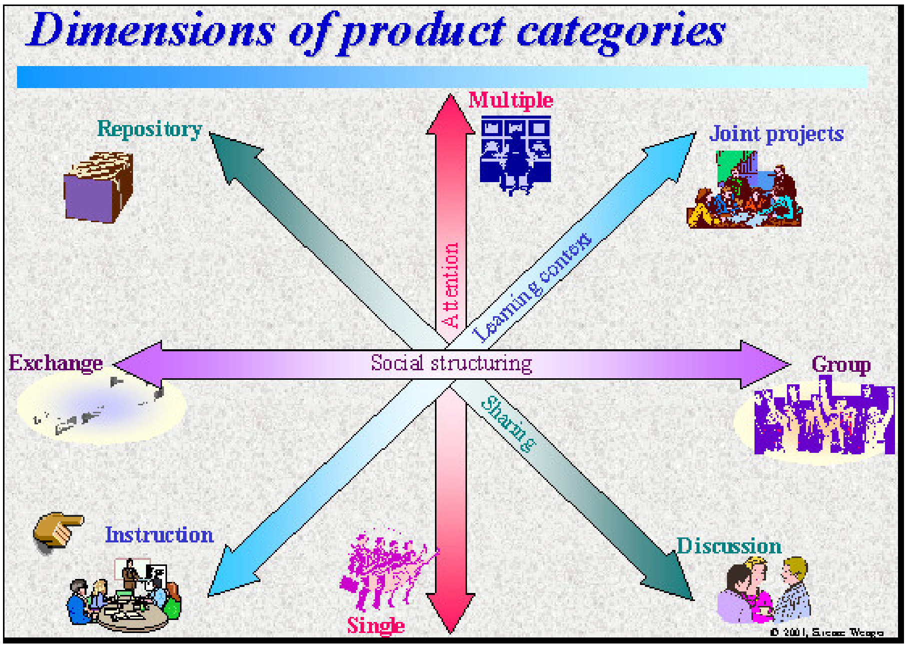

Figure 1. Knowledge Construction in Online Communities.

1.2 Research Objectives

Graduate students may experience difficulties in writing project reports. The journey has to start somewhere. Student's initial attempts at a project proposal often contain basic flaws. The use of a suitable scaffold may assist knowledge construction, articulation and evaluation.

A recurring theme in the journey is the need to triangulate three perspectives: personal commitments, technical requirements, and community norms. Members of learning communities must negotiate how these perspectives should be reflected in both the research process and the content and organisation of the project report. The degree of structure in the scaffold reflects the research paradigm, type of the research undertaken, and the communicative practices in the research community. Scaffolds in online learning communities may emphasise one or more of the following:

- Style sheets that prescribe the detailed design of the research report. (Positivist paradigm)
- Compositional principles that describe the mid-level architecture of the research report and the research process. (Interpretivist paradigm)
- Visual models that provide an initial indication of the value-laden choices associated with the language, purpose and theoretical perspectives of the research undertaken in a heterogeneous community. (Critical pluralist paradigm)

This paper focuses on a scaffold or architecture for knowledge management and research. It evaluates a visual semantic integrating conceptual model for knowledge construction in heterogeneous Web-based learning communities. Section two investigates the characteristics of research scaffolds. Section three evaluates the concepts in the visual semantic scaffold. Section four describes an empirical evaluation. Section five describes applications in health knowledge management. Section six concludes the paper.

2. CHARACTERISTICS OF RESEARCH SCAFFOLDS

'Intelligence organizes the world by organizing itself.' Jean Piaget.

This section surveys constructivist learning and teaching and reviews the use of the American Psychological Association (APA) style sheet as a scaffold. Compositional principles are surfaced and research objectives refined.

2.1 Constructivist Learning and Teaching

Knowledge construction in research reflects the application of the constructivist learning model. Constructivists argue that humans construct meaning from current knowledge structures and these are a product of background and culture [14]. Scaffolds must achieve the right balance between the degree of structure and flexibility that is built into the learning process.

Some disciplines are heterogeneous. A scaffold that supports multiple disciplines, subject areas and topics is said to be customizable. Complexity may arise from the application of multiple theoretical perspectives within a single topic area, such as knowledge management [15]. A scaffold that supports multiple theoretical perspectives is said to be extensible. A customizable and extensible scaffold enables the same organising concepts to be practiced across a wide variety of research activities and exercises.

Knowledge construction includes a variety of constructivist learning and teaching activities. The production of research and knowledge management project proposals and the critical evaluation of relevant reports are but two examples of activities that share many of the characteristics listed above. Both exercises involve the organisation of research fragments into a formal structure acceptable to a particular learning community. The research fragments may be supplied by the instructor or may constitute the student's own creative work. The exercises may be completed by individuals, or by groups, or some combination of both. Brief tutorials are based on a small number of fragments and a simple organising structure. More lengthy tutorials may involve more and/or more complex fragments. Students proficient with the use of the scaffold may engage in cooperative learning with those that are less proficient [18, 19].

2.2 The American Psychological Association (APA) Style Sheet

The use of scaffolds may be observed in different areas of research. Templates suitable as scaffolds are employed as core organizing devices in many disciplines, academic associations, journals and conferences. In an article entitled 'What goes where? An activity to teach the organization of journal articles' Ault (1991) [20] describes the use of the APA style to scaffold psychology research students. Ault states that 'Although they have access to numerous examples of correctly written articles, the instructions from their textbook, the Publication Manual of the American Psychological Association (American Psychological Association, 1983), and in-class lectures on how to write journal articles, their research reports usually contain fundamental mistakes.' (ibid, p. 45)

Ault describes an exercise requiring 1 to 2 hours based on the placement of randomized fragments of a research report into the APA template. Subjects were given 20 paragraphs taken from a complete brief journal article totalling 23 paragraphs. Before being presented to the subjects the paragraphs were randomized then identified with a letter from A-T. 'Subjects turn in a single sheet of paper numbered 1 to 20 with their choices of a paragraph letter beside each number; they also indicate the placement of headings (Abstract, Method, Subjects, etc.)…By diagnosing the errors students make, instructors can determine where additional teaching is needed.' (ibid., p. 45).

2.3 Compositional Principles

In disciplines such as business, research reports differ in structure and only some features are common [21]. Knowledge construction in heterogeneous Web-based research communities may embrace positivist, interpretivist and critical pluralist paradigms. Prescriptive style sheets must be supplemented with compositional principles and visual models. The scaffold for the research report should follow the general pattern found in the APA and other templates, but eschew details that are specific to each. The compositional principle behind the APA template is that the body of the research report should proceed in a double funnel sequence. The two initial sections (Introduction and Method) and their constituent elements are organised from the broad to the detailed. The two final sections (Results and Discussion) and their constituent elements are organised from the detailed to the broad. Trochim (2006) [22] provides a visual model of this general organising principle. The visual model is shaped like an hourglass (Figure 2).

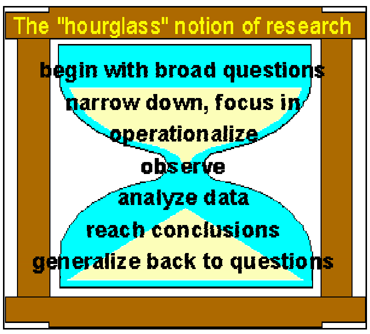

Figure 2. The double funnel sequence.

3. CONCEPTUAL EVALUATION OF THE VISUAL SEMANTIC SCAFFOLD

3.1 The V-Model

'Research methods courses have had to adjust to accommodate the emergence of scientific relativism in which truth is contextual. The incorporation of different perspectives in individual pieces of research has been problematic because of the lack of a framework that could integrate knowledge generated from different paradigms.' Ken Wilber [23].

A scaffold expressible as a visual semantic model consistent with the requirements developed in the previous section should provide separate visual spaces for each half of the double funnel sequence. The essential logic or compositional principle underlying the model should be expressed with a minimum of technical jargon so as to constitute a minimal specification useful in heterogeneous disciplinary areas. One such visual semantic scaffold is The V-Model [13]. The model draws on systems theory, sensemaking and Habermas's theory of communicative action. The underlying theoretical perspective is critical pragmatism [24]. It serves as a performance framework for evaluating business activities [25], action science, and research. It employs the constructs of 'structure' and 'intentionality' to define two dimensions in a semantic space containing narrative fragments and the compositional principle that links them.

The compositional principle in the V-Model is expressed as follows: 'Employ a consistent framework or system of inquiry that resembles a V. The left half of the V contains process steps associated with intentions (e.g., developing ideas, objectives and activities). The right half of the V contains process steps associated with developing outcomes (e.g., doing thoughtful activities to achieve results that payoff). Phases one to three successively refine and narrow intentions. Phases four through six successively aggregate and expand outcomes. Validate systemic knowledge via testing the coherence among intentions and outcomes at three levels of inclusiveness.' [13] (Figure 3).

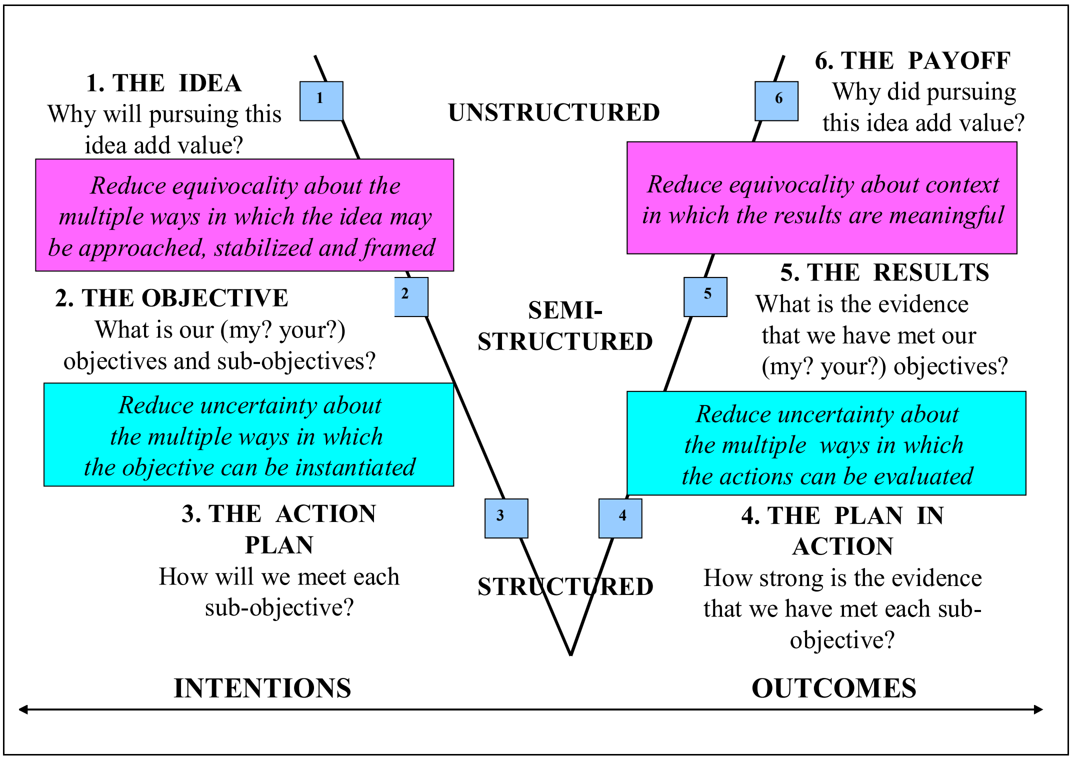

Figure 3. The V-Model

3.2 Scope of Applicationl

The V-Model scaffolds discourse on the research process as well as the research report. The 'unstructured' level deals with authenticity and the personal desires of the multiple stakeholders that motivate research action. The 'semi-structured' level deals with inter-personal agreements that define what constitutes appropriate research objectives and sound conclusions. The 'structured' level deals with the technical procedures that specify the way that clear evidence can be obtained in order to achieve the agreed objectives. The narrative spaces both opened up and framed by the V-Model may be 'customized' to three-level hierarchies in various domains. (Table 4).

Table 4. Some Terms for Three-Level Hierarchies in Selected Domains

Domain Level in Hierarchy	General Systems	Developing IT Systems Intentions	Developing IT Systems Outcomes	Developing Research Intentions	Developing Research Outcomes	Planning and Control
Upper Level	Approach	Idea (System Concept)	Payoff (System Review)	Idea (Introduction)	Payoff (Discussion & Conclusion)	Strategic
Middle Level	Framing	Objectives of System (Business Req'ts)	Results of System (Business Application)	Objectives of Research (Literature Review)	Results of Research (Analysis)	Tactical
Lower Level	Decomp-osition	IT System Design	IT Software Development and Testing	Action Plan (Methodology)	Plan in Action (Data Gathered)	Operational

The V-Model may also be 'extended' to represent the theoretical perspectives and corresponding validity claims, such as those in Habermas's theory of communicative action. Applications include knowledge management [26, 27], critical research, ethical inquiry [28], and scenario planning [29] (Figure 4).

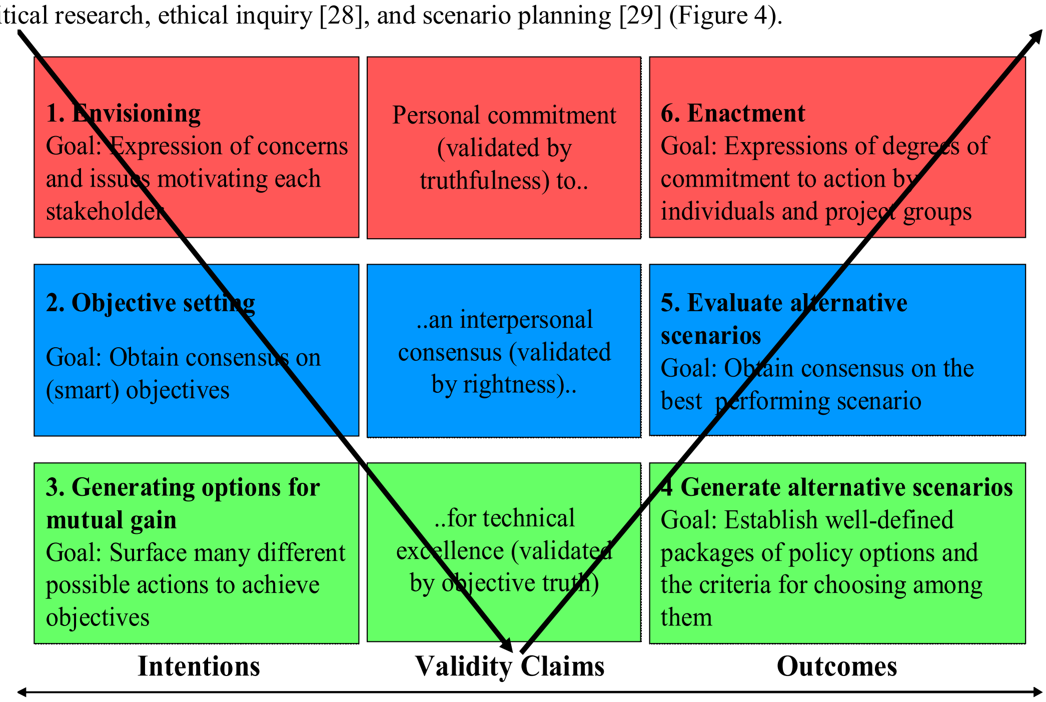

Figure 4. An Extended and Customized V-Model for Scenario Planning.

4. EMPIRICAL EVALUATION

This section describes the procedures for data gathering, measurement of error, and data analysis.

4.1 Data gathered

Empirical data was gathered using a scaffolding technique which has some similarities to that described in [20]. Paragraphs were selected not from a brief report organized in APA style, but from a research methods text [30] hitherto unknown to the students. This 181-page text contains six chapters devoted to case study research that are aligned with the linear-analytic structure.

Each chapter begins with two or three paragraphs that summarize the chapter. Approximately 1,000 words are employed in a total of thirteen summary paragraphs. These 13 paragraphs were typed, randomized, and identified with a letter A-M. Each paragraph was placed on a separate piece of paper 4 inches wide and 3 inches in height. Each student received a package consisting of the 13 paragraphs ordered from A-M, an A5-sized answer sheet, and an A3-sized V-Model graphic. The answer sheet contained a list of the identifying codes A-M (in alphabetical order) and a space alongside each for the correct location in the V-Model (step number and item number within step).

For the purposes of control, data was gathered in a timed exercise in regular face-to-face classes. Subjects - graduate students studying research design at the University of Auckland - were given 30 minutes to read the paragraphs and identify the location of each in the semantic space defined by the V-Model graphic, and to record their answers on the answer sheet. Thirty-nine subjects recorded locations for all 13 paragraphs. Most subjects had finished after 20 minutes. Five answer sheets were incomplete and not included in the subsequent analysis. The item number within each step, included so as to provide for additional precision, proved unnecessary and was not included in the analysis. The placement of a paragraph was judged correct if it was placed in the correct step (1-6) of the V-Model. On this measure the most successful student placed 12 out of 13 paragraphs in the correct locations, and the three least successful subjects placed only one paragraph in its correct location.

4.2 Measurement of placement error

Two methods are employed to measure the accuracy of placement of text fragments. The first method employs a one-dimensional ordinal measure based on the sequence of positions or steps in the V-Model. As in [20] sequence error is measured on an ordinal scale by counting the number of steps between the placement of a text fragment and its correct position. The second method employs a two-dimensional semantic measure based on the two dimensions (intentionality and structure) of the V-Model. The procedure for calculating semantic error is described below.

In the second method the semantic error between an actual response and the correct response is based on displacements measured in a 3-row, 2-column tabular presentation of the V-Model. The method of calculation is as follows: count one point for every row error, plus two points for an error in column. Note that the maximum semantic error for the research phases at the top and bottom rows of the V-Model (phases one, three, four and six) is four. These paragraphs are classified as Type I paragraphs (Figure 5). Paragraphs dealing with research corresponding to the middle section of the V-Model (phases two and five) have a maximum semantic error of three and are classified as Type II paragraphs (Figure 6).

D L	C I
J E	H K

Figure 5. Type I paragraphs

B G M	A F

Figure 6. Type II paragraphs

A Chi-square test will be used to evaluate the null hypothesis that the 39 subjects placed paragraphs A to M randomly over all phases in the V-Model. Random placement would result in a placement probability of 1/6 for each phase, and an expected frequency for each phase of the V-Model of 39 x 1/6 = 6.5.

The distribution of semantic errors resulting from random placement depends on whether the paragraph is Type I or Type II. Figure 7 shows the frequency of semantic errors expected from the random placement of paragraphs L and M, examples of Type I and type II paragraphs, respectively. Figure 8 records all possible semantic errors and the frequencies of occurrence. The weighted average placement error for each of the eight Type I paragraphs is 2.0. The weighted average semantic error for each of the five Type II paragraphs is 1.67. The weighted average expected semantic error for the random placement of all Type I and II paragraphs is (8 x 2.0 + 5 x 1.67)/13 = 1.872.

Para. L	
0	2
1	3
2	4

Para. M	
1	3
0	2
1	3

Figure 7. Possible semantic errors for paragraphs L and M

4.3 Analysis

All paragraphs are well behaved and will be included in the analysis. (Table 4). Only the analysis by the second method is examined below.

Table 4. Data Analysis

Para-graph	Correct step number	Mean step number	Mean sequence error	Mean sequence error: Std dev	Mean sequence error: **t**	Mean sem-antic error: Type I para.	Mean sem-antic error: Type II para.	Mean sem-antic error: Std dev	Mean sem-antic error: **t**	Mean sem-antic error: Chi-square
A	5	4.00	1.00	1.03	3.04**		0.95	0.89	6.5**	18.9**
B	2	2.46	0.46	1.05	6.19**		0.9	0.75	8.07**	29.1**
C	6	4.86	1.14	1.43	5.94**	1.03		1.14	4.66**	27.5**
D	1	2.44	1.44	1.7	3.91**	1.15		1.27	3.54**	22.7**
E	3	2.46	0.54	1.12	5.79**	0.97		1.01	5.53**	34.9**
F	5	4.08	0.92	1.61	2.23*		1.1	1.05	4.59**	10.9**
G	2	3.23	1.23	1.16	1.45		1.26	1.04	3.68**	5.4
H	4	3.92	0.08	1.09	2.43*	1.05		1.1	4.66**	28.2**
I	6	5.41	0.59	0.79	15.19**	0.64		0.96	8.01**	64.2**
J	3	2.38	0.62	1.43	4.89**	1.31		1.17	3**	15.6**
K	4	3.77	0.23	1.04	1.62	1.13		1.1	4.2**	25.5**
L	1	2.18	1.18	1.62	5.09**	0.87		1.03	6.06**	35.5**
M	2	3.23	1.23	1.16	1.45		1.36	1.16	2.77**	4.2
Type I						1.02				208.7†
TypeII							1.11			52.7†
All para.		3.42	0.82	1.25		1.05	1.05	1.05		

*: Sig at p=0.05
**: Sig at p=0.01
†: Sig at p=0.00000

Effect size

The calculations based on a two-dimensional analysis (structure and intentionality) indicate that the average expected semantic error when all paragraphs are placed randomly is 1.872. Yet the actual average semantic error is 1.05. That is, the actual error in the placement of a paragraph is 56% of the value expected in random placement. It is concluded that subjects exposed to the V-Model placed randomized text fragments in the correct location in two-dimensional semantic space with an error 44% less than that associated with random placement.

Statistical significance

A one-tail t-test statistics indicates that 11 out of the 13 paragraphs have a t-test value greater than 1.7, the value significant at p=0.05 [31, p. 274]. The remaining two paragraphs (G, and M) are not significant at p=0.10. Overall, the high level of significance reported on the t-test provides a reliable indication that the placement of each paragraph in semantic space did not occur by chance. Using a one-tail test, 11 out of the 13 paragraphs have a chi-square value greater than that expected in random placement significant at p=0.05. The remaining two paragraphs (G, and M) are not significant at p=0.10. Chi-square tests conducted on placement errors for all Type I, and on all Type II paragraphs, are significant at p=0.00000. It is concluded that the distribution of observed frequencies is not compatible with the frequencies expected in random placement over the semantic space defined by the V-Model. The effect size noted above is statistically significant.

5. APPLICATIONS IN HEALTH KNOWLEDGE MANAGEMENT

Health knowledge management is both heterogeneous and systemically complex. Graduate students and health practitioners may lack unifying concepts [32] and become disoriented. To reverse the Piaget quote at the beginning of section 2, those unable to organise their concepts cannot organise the world of health knowledge management. For some years, the visual semantic scaffold has been employed by students in the School of Population Health Graduate Diploma, in the Faculty of Medical and Health Sciences at the University of Auckland. Students in a Health Knowledge Management employ the scaffold in their first class. The goal is two-fold: firstly, to provide an organising scheme for the student's research project; secondly, to identify knowledge management domains and candidate research paradigms in health knowledge management. Four illustrative examples are described below.

Cut and paste

The visual semantic model provides the organising scheme for randomised fragments 'cut' from a coherent project report, to be 'pasted' so as to restore coherence. Scaffolding exercises for the very first health knowledge management tutorial involves exactly six fragments central to the purpose of the course. Multiple short exercises are completed. In each exercise, the fragments consist of six steps in a research process [21, p. 16], six components in a research report [21, p. 18], or six chapter headings [30]. (Table 4). Subsequent exercises may involve sentences from an abstract, and section and subsections from a research report, including the current report.

Project Chartering

Six questions about chartering the student's knowledge management project are identified in Figure 8. The project almost invariably involves action research based on the work role of the student. In most cases the project has an exploratory purpose and the research process requires support from those who have a stake in the project. Access requires a project sponsor and consideration of the views of stakeholders. The visual model presents a project management scaffold expressed in the language of a personal journey of discovery taken with a supportive group. Because the journey of each student is unique, the language is not task or domain specific. The questions prompt students for prospective (left) and retrospective (right) accounts of their journey. The dimension of structure is conveyed by the use of the words 'why' (unstructured), 'what' (semi-structured), and 'how' (structured). The graphic that is Figure 8 invites a personalised approach that supports team building. Discussions on the questions in the model, and the graphic itself, charter the project.

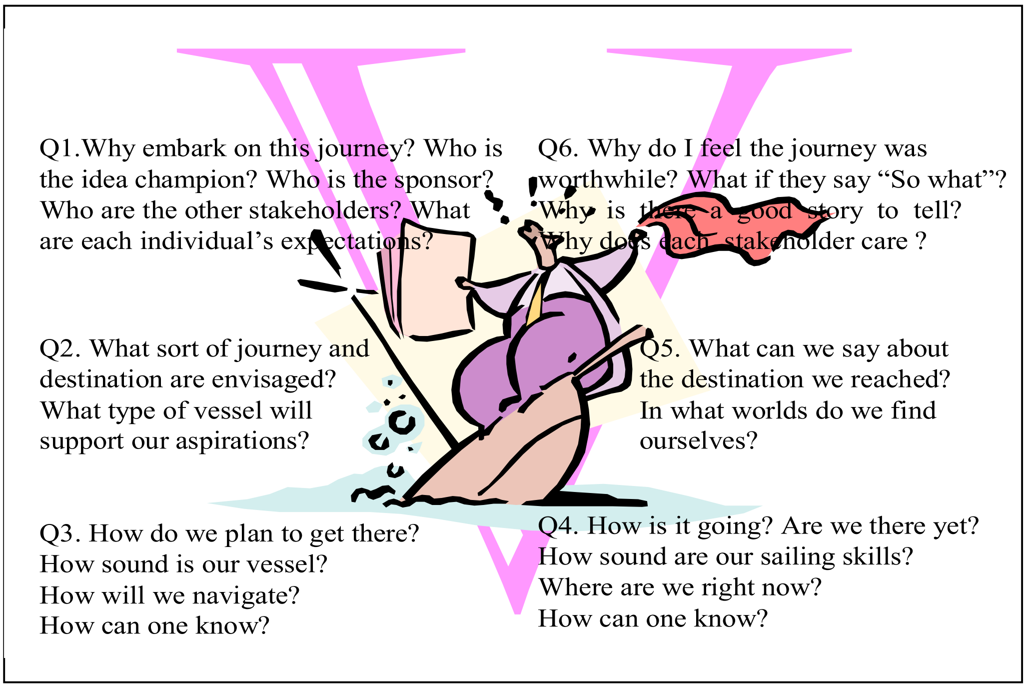

Figure 8. Chartering a Knowledge Management Project: Six Questions

Process Design

Health knowledge management projects include those that design (left), implement (right), and audit (links between left and right) work flow processes. Process ‘engineering’ in a health setting requires the integration of heterogeneous aspects of systemically complex procedures [33]. For more advanced students, an epistemic version of the visual semantic model is provided as an integrating scaffold. (Figure 9).

PROCESS **FOCUS**	**Developing Intentions**	**Developing Outcomes**
Establishing validity of *personal*, social and technical concerns (the *hardest* system?) Subjectivist/Critical	Step 1 Knowledge engineering	Step 6 Knowledge engineering
The *social* system that is served (the *soft* system) Constructivist/Interpretive	Step 2 Concept engineering	Step 5 Concept engineering
The *technical* system that serves (the *hard* system) Objectivist/Positivist	Step 3 Information engineering	Step 4 Information engineering

Figure 9. Engineering Integration in Health Knowledge Management

Knowledge Management Architecture

Health knowledge management distinguishes between knowledge creation, knowledge normalization, and knowledge application. This architecture can be represented diagrammatically as three intersecting domains each with a distinctive mode of existence, access and validation [26]. (Figure 10).

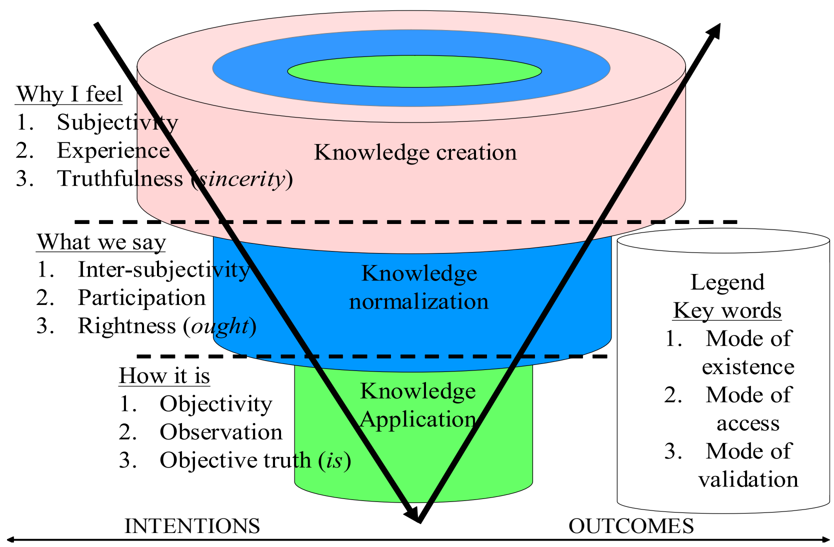

Figure 10. Architecture of Knowledge Management

6. CONCLUSION

'Seeing is believing but feeling's the truth.'
Thomas Fuller

Learning conversations mix creativity and conflict; personal values, community norms, and objective facts. The heterogeneity of learning communities is often experienced when a report is evaluated - and found wanting. The model captures these critical communicative events via a focus on quality criteria and the validity claims that link intentions and outcomes. The model is customizable to meet the requirements of a disparate collection of research, action science, professional, and business projects. The model is extensible to articulate an epistemic commitment. The distinctions in the model may assist individuals to recognize how prior commitment to an epistemic position colours perceptions of what each individual feels is the truth.

A strength of the study is the magnitude of effect size, and related measurement and data collection procedures. The latter employed summary paragraphs from a research methods text. A focus on compositional principles enables evaluation of conceptually rich, heterogeneous projects. This feature, plus the control provided by a classroom setting, allows the findings to be tested in other studies. A major weakness of the study is the lack of a control group. Because the study focuses on constructivist learning and teaching, it is embedded in the context of a learning community that is existentially real for participants. The research findings reflect not only the properties of the visual semantic scaffold, but the context in which it is deployed. This is a study of how knowledge emerges from an intact social ecology. No attempt has been made to perform a controlled experiment. Replication of the study in other intact social groups offers a promising alternative.

The visual semantic model has been customized and extended to support problem structuring of the research and knowledge management activities identified in sections two and five. Students and faculty routinely employ the scaffold in the form of a 3-row, 2-column table to assess the quality of research reports. Masters and post-graduate diploma students, both in individual and group presentations, employ the V-Model graphic to communicate the organization of their theses and project reports. Further research is required to evaluate the performance of the visual semantic scaffold in these and other tasks.

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