How Do Practitioners Use Conceptual Modelling in Practice?

Islay Davies[1]
Peter Green[2]
Michael Rosemann[1]
Marta Indulska[2]
Stan Gallo[2]

[1]Centre for Information Technology Innovation
Queensland University of Technology
Brisbane, Australia
{ig.davies|m.rosemann}@qut.edu.au
[2]UQ Business School
University of Queensland
Ipswich, Australia
{p.green|m.indulska|s.gallo@uq.edu.au}

Abstract. Much research has been devoted over the years to investigating and advancing the techniques and tools used by analysts when they model. As opposed to what academics, software providers and their resellers promote as should be happening, the aim of this research was to determine whether practitioners still embraced conceptual modelling seriously. In addition, what are the most popular techniques and tools used for conceptual modelling? What are the major purposes for which conceptual modelling is used? The study found that the top six most frequently used modelling techniques and methods were ER diagramming, data flow diagramming, systems flowcharting, workflow modelling, RAD, and UML. Smaller organizations and more experienced modellers appear to employ greater use of the well-established structured techniques. By contrast, larger organizations seem to make greater use proportionately of the more recent object-oriented techniques such as workflow modelling and UML. However, an important contribution of this study was the identification of the factors that uniquely influence the continued-use decision of analysts, *viz.*, communication (using diagrams) to/from stakeholders, internal knowledge (lack of) of techniques, user expectations management, understanding models integration into the business, and tool/software deficiencies. The specific factor of communication (diagrams) to/from stakeholders appears to be important across organizations irrespective of size while the specific factor of internal knowledge (lack of) of techniques seems to be more important in larger organizations than in small organizations. By contrast, communication (diagrams) to/from stakeholders and internal knowledge (lack) of techniques appear to be much more critical to novice modellers (0-3 years) than to more experienced modellers.

1 Introduction

The areas of business systems analysis, requirements analysis, and conceptual modelling are well-established research directions in academic circles. Comprehensive analytical work has been conducted on topics such as data modelling, process modelling, meta modelling, model quality, and the like. A range of frameworks and categorisations of modelling techniques have been proposed (*e.g.* [7,10,15]). However, they mostly lack an empirical foundation. Thus, it is difficult to provide solid statements on the importance and potential impact of related research on the actual practice of conceptual modelling.

More recently, Wand and Weber [19, p. 364] assume "the importance of conceptual modelling" and they state "Practitioners report that conceptual modelling is difficult and that it often falls into disuse within their organizations." Unfortunately, anecdotal feedback to us from information systems (IS) practitioners confirmed largely the assertion of Wand and Weber [19]. Accordingly, as researchers involved in attempting to advance the theory of conceptual modelling in organisations, we were concerned to determine that practitioners still found conceptual modelling useful and that they were indeed still performing conceptual modelling as part of their business systems analysis processes. Moreover, if practitioners still found modelling useful, why did they find it useful and what were the major factors that inhibited the wider use of modelling in their projects. In this way, the research that we were performing would be relevant for the practice of information systems development (See the IS Relevance debate on ISWorld, February 2001).

Hence, the research in this paper is motivated in several ways. First, we want to obtain empirical data that conceptual modelling is indeed being performed in IS practice in Australia. Such data will give overall assurance to the practical relevance of the research that we perform in conceptual modelling. Second, we want to find out what are the principal tools, techniques, and purposes for which conceptual modelling is performed currently in Australia. In this way, researchers can obtain valuable information to help them direct their research towards aspects of conceptual modelling that contribute most to practice. In particular, in line with this motivation, we are keen to examine the impact, if any, on the principal tools, techniques, and purposes of modellers due to the size of the organization and the years of experience of the modeler(s). We were particularly interested in the impact of these two factors. Organisation size often proxies for sophistication of use and budgetary capability to experiment with relatively expensive tools and techniques [*e.g.,* 1, 4, 12]. Moreover, years of experience in modelling is a proxy for the novice-expert dichotomy. Hence, it is reported commonly in the literature as being a significant driver in the choice and use of techniques and tools in modelling [*e.g.,* 5, 11, 12]. Finally, we were motivated to perform this study so that we could gather and analyse data on major problems and benefits *specific* to the task of conceptual modelling in practice. Again, we were interested to examine the impact of organization size and years of modeling experience on these perceived problems and benefits [11].

So, this research aims to provide current insights into actual modelling practice. The underlying research question is "Do practitioners actually use conceptual modelling in practice?" The derived and more detailed sub-questions are:

1. What are the popular tools and techniques used for conceptual modelling in Australia? Is the selection and use of these tools and techniques markedly different because of the size of the organization using them or the years of experience in modeling of the people using them?
2. What are the purposes of modelling? Does the size of the organization or the years of modelling experience influence the purposes for which the conceptual modeling is done?
3. What are major problems and benefits *specific* to modelling? Are these "drivers" different for organizations of varying sizes and modellers of different levels of experience?

In order to provide answers for these questions, an empirical study using a web-based questionnaire has been designed. The goal was to determine what modelling practices are being used in business, as opposed to what academics, software providers and their resellers believe should be used. In summary, we found that the current state of usage of business systems/conceptual modelling in Australia is: ER diagramming, data flow diagramming, systems flowcharting, and workflow modelling being most frequently used for database design and management, software development, documenting and improving business processes. Smaller organizations and more experienced modellers appear to employ greater use of these well-established structured techniques. By contrast, the larger organizations seem to make greater use proportionately of the more recent object-oriented techniques such as workflow modelling and UML. Smaller organizations and novice modellers make more use of modelling for technical design issues while larger organizations and more experienced modellers generally use modelling for documenting and improving business processes.

A contribution of this study is the analysis of textual data concerning critical success factors and problems/issues in the continued use of conceptual modelling. Clearly, relative advantage (disadvantage)/usefulness from the perspective of the analyst was the major driving factor influencing the decision to continue (discontinue) modelling, irrespective of organization size and years of modelling experience. The specific factor of communication (diagrams) to/from stakeholders appears to be important across organizations irrespective of size while the specific factor of internal knowledge (lack of) of techniques seems to be more important in larger organizations than in small organizations. By contrast, communication (diagrams) to/from stakeholders and internal knowledge (lack) of techniques appear to be much more critical to novice modellers (0-3 years) than to more experienced modellers.

Furthermore, the modelling work of respondents is supported in most cases by the use of Visio (in some version) as an automated tool. Visio is more heavily used proportionately by respondents in larger organizations than those in smaller organizations. Those respondents with 4-10 and 11-20 years of systems analysis and modelling experience seem to make greater use of the tools proportionately than those modellers who are complete novices (0-3 years), and indeed, those modellers who are highly experienced (greater than 20 years), even when the tool is a relatively simple tool like Visio. Furthermore, planned use of modelling techniques and tools into the short-term future appears to be expected to reduce significantly compared to current usage levels.

The remainder of the paper unfolds in the following manner. The next section reviews the related work in terms of empirical data in relation to conceptual modelling practice. The third section explains briefly the instrument and methodology used. Then, major quantitative results of the survey are reviewed with particular emphasis to differences driven by organization size and years of modeling experience. The fifth section presents the dominant results of the analysis of the textual data on the problems and benefits of modelling. These issues are examined also interestingly form the perspective of differences according to organization size and years of modeling experience. The last section concludes and gives an indication of further work planned.

2 Related Work

Over the years, much work has been done on how to do modelling – the quality, correctness, completeness, goodness of representation, understandability, differences between novice and expert modellers, and many other aspects (*e.g.,* [13]). Comparatively little empirical work however has been undertaken on modelling in practice. Floyd [6] and Necco *et al.* [14] conducted comprehensive empirical work into the use of modelling techniques in practice but that work is now considerably dated. Batra and Marakas [2] attempted to address this problem of a lack of current empirical evidence however their work focused on comparing the perspectives of the academic and practitioner communities regarding the applications of conceptual data modelling. Indeed, these authors simply reviewed the academic and practitioner literatures without actually collecting primary data on the issue. Moreover, their work is now dated. However, it is interesting that they (p. 189) observe "there is a general lack of any substantive evidence, anecdotal or empirical, to suggest that the concepts are being widely used in the applied design environment." Batra and Marakas [2, p. 190] state that "Researchers have not attempted to conduct case or field studies to gauge the cost-benefits of enterprise-wide conceptual data modelling (CDM)." This research has attempted to address the problems alluded to by Batra and Marakas [2].

Iivari [8] provided some data on these questions in a Finnish study of the perceptions of effectiveness of CASE tools. However, he found the adoption rate of CASE tools by developers in organisations very low (and presumably the extent of conceptual modelling to be low as well). Gorla *et* al [7] empirically investigated the area of systems analysis practice but their study was limited to tools and in particular process tools. Curtis et al. [4] found that the productivity of the developers and quality of developed systems were affected by limited domain knowledge, fluctuating requirements and communication breakdowns. The focus of their work was developers' productivity and resultant system quality. They were not concerned with what techniques and tools were used, nor for what purposes they were used. Fitzgerald [5] also investigated empirically the adoption of various methodologies and techniques for systems development. However, his work was more concerned with how these methodologies and techniques were used to develop the systems. In particular, he found that different methods are used in a pragmatic way resulting in a unique instantiation of the method for each development project.

More recently, Persson and Stirna [16] noted the problem of lack of empirical investigation, however, their work was limited in that it was only an exploratory study into practice. Most recently, Chang *et al*. [3] conducted 11 interviews with experienced consultants in order to explore the perceived advantages and disadvantages of business process modelling. This descriptive study did not, however, investigate the critical success factors of process modelling. Sedera *et al.* [17] have conducted three case studies to determine a process modeling success model, however they have not yet reported on a planned empirical study to test this model. Furthermore, the studies by Chang *et al*. [3] and Sedera *et al.* [17] are limited to the area of process modeling.

Large organizations are involved typically with large systems and large system developments. Prior studies have alluded to the differences encountered in such developments in terms of complexity and sophisticated interfaces [1, 4, 12]. On this basis, we expect differences therefore between respondents from organizations of different size particularly in regard to the tools used for modelling and the purposes for which the modelling is done. For example, we might expect larger organizations to utilize more sophisticated tools for their modelling because of their larger technical capability and budgetary capacity. Moreover, larger organizations might be using the conceptual modelling more for systems development purposes than smaller organizations.

With regard to years of modelling experience, Kautz *et al.* [12], for example, find that the developers' experience with regard to the development process and the application domain influences method utilization. Indeed, experienced developers use their domain knowledge in many situations instead of the prescribed methods and they develop systems without going through formal step by step guides. On this basis, we might expect that more experienced (expert) modellers will use relatively simple tools and techniques (or indeed no tools at all), while inexperienced (novice) modellers might be prepared to master and utilize the features of more involved tools and techniques.

3 Methodology

This study was conducted in the form of a web-based survey issued with the assistance of the Australian Computer Society (ACS) to its members. The survey consisted of seven pages.[1] The *first page* explained the objectives of our study. It also highlighted the available incentive, *i.e.,* free participation in one of five workshops on business process modelling. The *second page* asked for the purpose of the modelling activities. In total, 17 purposes (*e.g.,* database design and management, software development) were made available. The respondents were asked to evaluate the relevance of each of these purposes using a five-point Likert scale ranging from 1 (not relevant) to 5 (highly relevant). The *third page* asked for the modelling techniques[2] used by the respondent. It provided a list of 18 different modelling techniques ranging from data flow diagram and ER diagrams, to the various IDEF standards, up to UML. For each modelling technique, the participants had to provide information about the past, current and future use of the modelling technique. It was possible to differentiate between infrequent and frequent use. Furthermore, participants could indicate whether they knew the technique or did not use it at all. It was possible also to add further modelling techniques that they used. The *fourth page* was related to the modelling tools. Following the same structure as for the modelling technique, a list of 24 modelling tools was provided. A hyperlink provided a reference to the homepage of each tool provided. It was clarified also if a tool had been known under a different name (*e.g.,* Designer2000 for the Oracle9i Developer Suite). The *fifth page* explored qualitative issues. Participants were asked to list major problems and issues they had experienced with modelling as well as perceived key success factors. On the *sixth page*, demographic data was collected. In particular, years of experience in business systems analysis and modelling and the size of the organization in which the respondent works were collected on this page. The *seventh page* allowed contact details for the summarised results of the study and the free workshop to be entered. The instrument was piloted with 25 members of two research centres as well as with a selected group of practitioners. Minor changes were made based on the experiences within this pilot.

A contribution of this paper is an examination of the data gathered through the *fifth* page of the survey. This section of the survey asked respondents to list critical success factors for them in the use of conceptual modelling and problems or issues they encountered in successfully undertaking modelling in their organisations. The phenomena that responses to these questions allowed us to investigate were why do we continue/discontinue to use a technical method (implemented using a technological tool) – conceptual modelling. To analyse these phenomena, we used the following procedure:

1. What responses confirm the factors we already know about in regard to these phenomena; and
2. What responses are identifying new factors that are specific to the domain of conceptual modelling?

To achieve step 1, we performed a review of the current thinking and literature in the areas of adoption and continued use of a technology. Then, using Nvivo 2, one researcher classified the textual comments, where relevant, according to these known factors. This researcher's classification was then reviewed and confirmed with a second researcher. The factors identified from the literature and used in this first phase of the process are summarised and defined in Table 1.

Table 1. Summary of Factors identified for initial analysis

Factor	Definition	Source(s)
Relative Advantage	The degree to which adopting/using the technique is perceived as being better than using the practise it supersedes.	Karahanna *et al,* [9]
Image	The degree to which adoption/usage of the technique is perceived to enhance ones image or status.	Karahanna *et al,* [9]
Compatibility	The degree to which adopting the technique is compatible with the individual's job responsibilities and value system.	Tan and Teo, [18]
Complexity	The degree to which using a particular technique is free from effort.	Karahanna *et al,* [9]
Trialability	The degree to which one can experiment with the technique on a limited basis before making an adoption or rejection decision.	Karahanna *et al,* [9]
Risk	The degree of perceived risk that accompanies the adoption of the technique.	Tan and Teo, [18]
Visibility	The degree to which the technique is visible within the organisation.	Karahanna *et al,* [9]

[1] A copy of the survey pages is available from the authors on request.

[2] 'Technique' here is used as an umbrella term referring to the constructs of the technique, their rules of construction, and the heuristics and guidelines for refinement.

Results Demonstrability	The degree to which results of adopting/using the technique are observable and communicable to others.	Karahanna *et al,* [9]
Subjective Norms	Generated by the normative beliefs that a respondent attributes to what relevant others (colleagues/peers/respected management) expect them to do with respect to adopting the technique as well as their motivation to comply with those beliefs.	Karahanna *et al,* [9]
Self Efficacy	Self-confidence in a participant's own ability to perform a behaviour.	Tan and Teo, [18]
Facilitating Conditions	Availability of and ease of access to, technological infrastructure and support.	Tan and Teo, [18]
Internalisations	Degree to which decisions are motivated by accepting information from expert sources and integrating it into ones cognitive system.	Karahanna *et al,* [9]
Identification	Decisions resulting from feeling some bond with a likeable source.	Karahanna *et al,* [9]
Compliance	Degree of influence that is produced by a powerful source having control over the respondent in the forms of rewards and punishments.	Karahanna *et al,* [9]
Top management support	Degree of support for the project from middle and upper management of the organisation.	Tan and Teo, [18]
Communication Issues	Degree to which the decisions or attitudes were affected by communications problems between the respondents and key stakeholders within the organisation.	Karahanna *et al,* [9]

After step 1, there remained factors that did not readily fit into one or other of the known factor categories. These unclassified responses had the potential to provide us with insight on factors unique and important to the domain of conceptual modelling. However, the question was how to derive this information in a relatively objective and unbiased manner from the textual data. We used a new state-of-the-art textual content analysis tool called Leximancer[3]. Using this tool, we identified from the unclassified text five new factors specific to conceptual modelling. Subsequently, one researcher again classified the remaining responses using these newly identified factors. His classification was reviewed and confirmed by a second researcher. Finally, the relative importance of each of the new factors was determined.

3.1 Why use Leximancer?

The Leximancer system allows its users to analyse large amounts of text quickly. The tool performs this analysis both systematically and graphically by creating a map of the constructs – the document map - that are displayed in such a manner that links to related subtext may be subsequently explored. Each of the words on the document map represents a concept that was identified. The concept is placed on the map in proximity of other concepts in the map through a derived combination of the direct and indirect relationships between those concepts. Essentially, the Leximancer system is a machine-learning technique based on the Bayesian approach to prediction. The procedure used for this is a self-ordering optimisation technique and does not use neural networks. Once the optimal weighted set of words is found for each concept, it is used to predict the concepts present in fragments of related text. In other words, each concept has other concepts that it attracts (or is highly associated with contextually) as well as concepts that it repels (or is highly disassociated with contextually). The relationships are measured by the weighted sum of the number of times two concepts are found in the same 'chunk'. An algorithm is used to weight them and determine the confidence and relevancy of the terms to others in a specific chunk and across chunks.

Leximancer was selected for this qualitative data analysis for several reasons:

- Its ability to derive the main concepts within text and their relative importance using a scientific, objective algorithm;
- Its ability to identify the strengths between concepts (how often they co-occur) – centrality of concepts;
- Its ability to assist the researcher in applying grounded theory analysis to a textual dataset;
- Its ability to assist in visually exploring textual information for related themes to create new ideas or theories; and
- Its ability to assist in identifying similarities in the context in which the concepts occur – contextual similarity.

[3] For more information on Leximancer, see www.leximancer.com .

4 Survey Results and Discussion

From 645 individuals who started to fill out the survey, 312 actually completed the entire survey, which leads to a completion rate of 48.4%. Moreover, of the 12,000 members of the ACS, 1,567 indicated in their most recent membership profiles that they were interested in conceptual modelling/business systems analysis. Accordingly, our 312 responses indicate a relevant response rate of19.9%, which is acceptable for a survey. Moreover, we offered participation in one of five seminars on business process modelling free of charge as an inducement for members to participate. This offer was accepted by 176 of the 312 respondents. Corresponding with the nature of the ACS as a professional organisation, 87% of the participants were practitioners. The remaining respondents were academics (6%) and students (6.7%). It is also not a surprise that 85% of the participants characterised themselves as an IT service person while only 15% referred to themselves as a businessperson or end user.

Fifty-three percent of the respondents indicated that they gained their knowledge in Business Systems Analysis from University. Further answers were TAFE (Technical and Further Education) (4.5%), ACS (2.3%). Sixteen percent indicated that they did not have any formal training in Business Systems Analysis. Thirty-five percent of the respondents indicated that they have less than four years experience with modelling. Twenty-one percent have between 4 and 10 years of experience. A significant proportion, 44%, has more than 15 years of experience with modelling. These figures indicate that the average expertise of the respondents is supposedly quite high. Twenty-eight percent of respondents indicated that they worked in firms employing less than 50 people, most likely small software consulting firms. However, a quarter of the respondents worked in organisations with 1000 or less employees. So, by Australian standards, they would be involved in software projects of reasonable size.

We were concerned to obtain information in three principle areas of conceptual modelling in Australia *viz*., what techniques are used currently in practice, what tools are used for modelling in practice, and what are the purposes for which conceptual modelling is used. In particular, for the techniques, tools, and purposes identified, we were interested in examining the impact of organization size and years of modelling experience on the results. Indeed, while the largest proportion of respondents came from organizations with less than 50 employees (28%), there was significant representation from respondents in the other categories of organization size, *viz.,* 50-100, 8%; 100-1000, 25%; 1000-5000, 12%; and, greater than 5000, 16% (unknown, 11%). Also too, we were pleased with the reasonably even spread of responses with regard to years of modelling experience. Whil;e the largest proportion came from the novice category (less than four years), a significant proportion of respondents (44%) indicated that they had more than 15 years experience in systems analysis and modelling (experts).

Table 2 presents from the data the top six most frequently used modelling techniques. It describes the usage of techniques as *frequently used, infrequently used* (which in the survey instrument was defined as used less than five times per week), and, *not known or not used*. The table clearly demonstrates that the top six most frequently used (used 5 or more times a week) *techniques* are ER diagramming, data flow diagramming, systems flowcharting, RAD, workflow modelling (range of workflow modelling techniques),and UML. It is significant to note that even though object-oriented analysis, design, and programming has been the predominant paradigm for systems development over the last decade, 63 percent of respondents either did not know or did not use UML. While not every conceptual modelling technique available was named in the survey, the eighteen techniques used were selected based on their popularity reported in prior literature. It is interesting again to note that approximately 40 percent of respondents (at least) do either not know or use any of the 18 techniques named in the survey.

Table 2. Top six modelling techniques most frequently used

Technique	Frequently Used	%	Infrequently Used	%	Not Used/Known	%
ER diagram	132	42%	60	19%	120	38%
Data flow diagram	105	34%	82	26%	125	40%
System flowcharts	90	29%	82	26%	140	45%
RAD (rapid application development)	72	23%	44	14%	196	63%
Workflow modelling	69	22%	75	24%	168	54%
UML (unified modelling language)	66	21%	49	16%	197	63%

Moreover, while not explicitly reported in Table 2, this current situation of non-usage appears to be set to increase into the short-term future (next 12 months) as the planned frequent use of the top four techniques is expected to drop to less than half its current usage, *viz*., ER diagramming (19 percent), data flow diagramming (15 percent), systems flowcharting (9 percent), and workflow modelling (13 percent). Furthermore, no increase in the intention to use any of the other techniques was reported, to balance this out. Perhaps, this short-term trend reflects the perception that the current general downturn in the IT industry will persist into the future. Accordingly, respondents perceive a significant reduction of new developmental work requiring business systems modelling in the short-term future. It may also just reflect the lack of planning of future modelling activities.

Table 3 now presents those top six modelling techniques most frequently used broken down according to the size of the organization of the respondent. Each percentage column in the table represents the ratio of the number of respondents in that row to the total of respondents for that size category.

Table 3. Top six most frequently used techniques by size of organization

Technique	< 50	%	< 100	%	< 1000	%	< 5000	%	≥ 5000	%
ER diagram	29	38%	41	46%	7	27%	21	53%	20	40%
Data flow diagram	20	26%	35	39%	4	15%	20	50%	16	32%
System flowcharts	20	26%	22	25%	10	38%	17	43%	17	34%
RAD (rapid application development)	19	25%	24	27%	2	8%	10	25%	12	24%
Workflow modelling	18	23%	16	18%	9	35%	11	28%	13	26%
UML (unified modelling language)	15	19%	16	18%	10	38%	11	28%	10	20%

We can see from this table that the respondents from the smaller organizations (less than 50, and less than 100) appear to employ marginally greater use of the well-established structured techniques of ER diagramming, data flow diagramming, and systems flowcharts. By contrast, the respondents from larger organizations (less than 1000, less than 5000, and greater than 5000) seem to make greater use proportionately of the more recent object-oriented techniques such as workflow modelling and UML.

Table 4 demonstrates the top six modelling techniques most frequently used stratified according to the years of modelling experience of the respondent.

Table 4. Top six most frequently used techniques by years of modelling experience

Technique	0-3 yrs	%	4-10 yrs	%	11-20 yrs	%	>20 yrs	%
ER diagram	30	39%	47	40%	38	50%	17	40%
Data flow diagram	26	34%	31	26%	27	36%	21	49%
System flowcharts	14	18%	41	35%	23	30%	12	28%
RAD (rapid application development)	14	18%	33	28%	19	25%	6	14%
Workflow modelling	17	22%	30	26%	15	20%	7	16%
UML (unified modelling language)	11	14%	31	26%	15	20%	9	21%

Here we can see that generally the use of the more traditional techniques such as ER diagramming, data flow diagramming, and systems flowcharts is higher in the more experienced modellers (11-20 years, and greater than 20 years). While not markedly so, the use of the more recent object-oriented techniques, *viz*., workflow modelling and UML, appears to be higher in the less experienced modellers (0-3 and 4-10 years).

Our work was also interested in what tools were used to perform the conceptual modelling work that was currently being undertaken. Table 3 presents the top six most frequently used tools when performing business systems analysis and design. The data is reported using the same legend as that used for Table 2.

Table 5. Top six most frequently used tools

Tool	Frequent Use	%	Infrequent Use	%	Not Used/Known	%
Visio	137	44%	52	17%	123	39%
Rational Rose	34	11%	31	10%	247	79%
Oracle9i Developer Suite	20	6%	28	9%	264	85%
iGrafx FlowCharter	17	5%	42	13%	253	81%
AllFusion ERwin Data Modeler	10	3%	12	4%	290	93%
WorkFlow Modeler	5	2%	2	1%	305	98%

Again, while not every conceptual modelling tool available was named in the survey, the twenty-four tools were selected based on their popularity reported in prior literature. Table 5 clearly indicates that Visio (61 percent – both infrequent and frequent use) is the preferred tool of choice for business systems modelling currently. This result is not surprising as the top four most frequently used techniques are well supported by Visio (in its various versions). A long way second in frequent use is Rational Rose (21 percent – both infrequent and frequent use) reflecting the current level of use of object-oriented analysis and design techniques. Again, at least 40 percent of respondents (approximately) do either not know or use any of the 24 tools named in the survey – even a relatively simple tool like Flowcharter or Visio.

Moreover, while not explicitly reported in Table 3, into the short-term future (next 12 months), the planned frequent use of the top two tools is expected to drop significantly from their current usage levels, *viz*., Visio (23 percent) and Rational Rose (9 percent) with no real increase reported for planned use of other tools to compensate for this drop. Again, this trend in planned tool usage appears to reflect the fact that respondents expect a significant reduction in new developmental work requiring business systems modelling in the short-term future.

Table 6 shows how the top 6 most frequently used tools are employed by respondents in organizations of different sizes. Again, the percentage columns in the table represent the ratio of the number of respondents in that row to the total of respondents for that size category.

Table 6. Top six most frequently used tools by size of organization

Tool	< 50	%	< 100	%	< 1000	%	< 5000	%	≥ 5000	%
Visio	34	38%	11	42%	36	47%	25	50%	27	54%
Rational Rose	8	9%	4	15%	9	12%	7	14%	3	6%
Oracle9i Developer Suite	6	7%	3	12%	5	6%	2	4%	4	8%
iGrafx FlowCharter	2	2%	2	8%	7	9%	3	6%	3	6%
AllFusion ERwin Data Modeler	3	3%	0	0%	4	5%	3	6%	0	0%
WorkFlow Modeler	3	3%	0	0%	0	0%	2	4%	0	0%

While the data on the use of tools is swamped by the prevalence of the use of Visio (in some form), Table 6 does show that Visio is more heavily used proportionately by respondents in larger organizations (less than 1000, less than 5000, and greater than 5000) than those respondents in smaller organizations. By contrast, and contrary to *a priori* expectations, it appears that more modern, more complex tools like Rational rose and Oracle Developer are used proportionately more by modellers in smaller organizations than those in larger organizations.

Table 7 shows how the use of most frequently used tools is distributed across the experience groups.

Table 7. Top six most frequently used tools by years of modelling experience

Tool	0-3 yrs	%	4-10 yrs	%	11-20 yrs	%	>20 yrs	%
Visio	28	37%	60	51%	36	47%	13	30%
Rational Rose	6	8%	13	11%	10	13%	5	12%
Oracle9i Developer Suite	4	5%	8	7%	6	8%	2	5%
iGrafx FlowCharter	3	4%	7	6%	5	7%	2	5%
AllFusion ERwin Data Modeler	2	3%	4	3%	3	4%	1	2%
WorkFlow Modeler	1	1%	1	1%	3	4%	0	0%

Table 7 appears to tell a similar story of use across all of the top 6 most frequently used tools. That is, those respondents with 4-10 and 11-20 years of systems analysis and modelling experience seem to make greater use of the tools proportionately than those modellers who are complete novices (0-3 years), and indeed, those modellers who are highly experienced (greater than 20 years), even when the tool is a relatively simple tool like Visio. The reasons for this apparent distribution could be many, however, those respondents in the novice category could be too early in their analysis career to be involved with significant modelling that might require the use of computer-based support while those highly experienced modellers may be able to bring so much domain knowledge to bear that they do not require a computer-based tool to support their understanding and conception of the problem. This explanation would be in line with that provided by Kautz *et al.* [12].

Business systems modelling (conceptual modelling) must be performed for some purpose. Accordingly, we were interested in obtaining data on the various purposes for which people might be undertaking modelling. Using a five-point Likert scale (where 5 indicates Very Frequent Use), Table 8 presents (in rank order from the highest to the lowest score) the average score for purpose of use from the respondents.

Table 8. Average use score for modelling purpose (in rank order)

Purpose	Average Score
Database design and management	3.9
Business process documentation	3.8
Improvement of internal business processes	3.8
Software development	3.8
Improvement of collaborative business processes	3.5
Workflow management	3.4
Design of Enterprise Architecture	3.4
Change management	3.4
Knowledge management	3.2
End user training	3.1
Software configuration	3.1
Software selection	2.9
Certification / quality management	2.8
Human resource management	2.6
Activity-based costing	2.6
Auditing	2.5
Simulation	2.5

Table 8 indicates that database design and management remains the highest average *purpose* for use of modelling techniques. This fact links to the earlier result of ER diagramming being the most frequently used modelling technique. Moreover, software development as a purpose would support the high usage of data flow diagramming and ER diagramming noted earlier. Indeed, the relatively highly regarded purposes of documenting and improving business processes, and managing workflows, would support further the relatively high usage of workflow modelling and flowcharting indicated earlier. The more specialised tasks like identifying activities for activity-based costing and internal control purposes in auditing appear to be relatively infrequently used purposes for modelling. This fact however may derive from the type of population that was used for the survey, *viz*., members of the Australian Computer Society.

Table 9 demonstrates the impact of the size of the respondents' organization on the purpose for which the modelling is undertaken.

Table 9. Average use score for modelling purpose by size of organisation (in rank order of organizations less than 50)

Purpose	< 50	< 100	< 1000	< 5000	≥ 5000
Database design and management	4.1	3.7	3.9	4.1	3.8
Software development	3.8	3.4	3.8	4.2	3.6
Business process documentation	3.6	4.0	3.8	3.9	4.0
Improvement of internal business processes	3.6	3.9	3.9	3.7	3.9
Improvement of collaborative business processes	3.3	3.4	3.5	3.5	3.6
Change management	3.3	3.6	3.7	3.1	3.3
Workflow management	3.2	3.8	3.4	3.6	3.3
Design of Enterprise Architecture	3.2	3.8	3.3	3.6	3.8
Knowledge management	3.2	3.0	3.2	3.5	3.0
Software configuration	3.0	3.1	3.0	3.2	3.1
End user training	2.9	3.0	3.2	3.1	3.1
Software selection	2.8	2.9	2.9	2.8	2.8
Certification / quality management	2.8	3.3	2.9	2.7	2.8
Simulation	2.7	2.4	2.3	2.2	2.3
Activity-based costing	2.7	2.7	2.5	2.4	2.5
Human resource management	2.5	2.9	2.5	2.7	2.5
Auditing	2.3	2.6	2.7	2.4	2.5

In small organizations, database design and management and software development are primary purposes for modelling. In larger organizations (greater than 50 employees), business process documentation and business process improvement are more critical purposes for modelling. In line with this dichotomy, in larger organizations, change management, designing enterprise architectures, and workflow management are more important purposes for modelling than in small organizations. Certification and quality management require modelling to an equal level of importance across organisations of all size.

Table 10 explains the breakdown of modelling purposes by years of modelling experience.

Table 10. Average use score for modelling purpose by years of modelling experience (in rank order of organizations less than 50)

Purpose	0-3 yrs	4-10 yrs	11-20 yrs	>20 yrs
Database design and management	3.8	4.1	3.4	3.9
Software development	3.7	4.0	4.0	3.6
Improvement of internal business processes	3.6	4.0	3.8	3.9
Business process documentation	3.5	4.2	3.5	4.0
Improvement of collaborative business processes	3.4	3.8	3.6	3.6
Workflow management	3.4	3.7	3.2	3.5
Design of Enterprise Architecture	3.4	3.8	3.4	3.0
Change management	3.3	3.6	3.5	3.9
Software configuration	3.3	3.3	2.9	3.0

Knowledge management	3.2	3.4	3.2	3.6
End user training	3.1	3.2	3.2	3.8
Software selection	3.1	3.0	2.9	2.8
Certification / quality management	3.0	2.8	2.6	3.2
Simulation	2.8	2.4	2.3	2.7
Human resource management	2.8	2.7	3.0	2.4
Activity-based costing	2.7	2.8	2.1	2.8
Auditing	2.5	2.7	2.5	2.7

Again, database design and management and software development are the most important purposes for modelling with novice (0-3 years) modellers. Business process documentation and process improvement are not so significant for this group. In the 4-10 years range of experience, respondents are involved obviously across the entire range of database design and software development to business process documentation, improvement, and automation through workflow management. Respondents in the 11-20 years range of experience see the importance of modelling in software development but also in business process improvement. The highly experienced (expert) modellers recognize the importance of modelling for database design but their major purposes for modelling appear to be in business process documentation, improvement, change management, and end-user training. In summary then, it appears that as modellers move from novice to expert the focus of their modelling activities moves from technical design issues to business process improvement to change management and communicating effectively the work processes of the business to the end-users.

5 Textual Analysis Results and Discussion

Nine hundred and thirty-five (935) individual comments were received across the questions on critical success factors and problems/issues for modelling. Using the known factors (Table 1) influencing continued use of new technologies in firms, Table 11 shows the classification of the 935 comments after phase 1 of the analysis using Nvivo.

Table 11. Results of classification by key factors influencing continued use (after phase 1)

Key	Percentage	Totals
Relative Advantage/Usefulness	45%	441
Complexity	8%	74
Compatibility	7%	69
Internalisations	6%	54
Top Management Support	5%	48
Facilitating Conditions	4%	42
Image	0%	0
Trialability	0%	4
Risk	1%	11
Visibility	0%	2
Results Demonstrability	1%	5
Subjective Norms	2%	22
Self-Efficacy	1%	14
Identification	0%	2
Compliance	0%	2
Communication Issues	3%	25
Unclassified	***17%***	***165***
Total (All records)	**100.00%**	**980**

Clearly, relative advantage (disadvantage)/usefulness from the perspective of the analyst was the major driving factor influencing the decision to continue (discontinue) modelling. Does conceptual modelling (and/or its supporting technology) take too much time, make my job easier, make my job harder, and make it easier/harder for me to elicit/confirm requirements with users? Such comments typically contributed to this factor. Furthermore, it is not surprising to see that complexity of the method and/or tool, compatibility of the method and/or tool with the responsibilities of my job, the views of "experts", and top management support were other major factors driving analysts' decisions on continued use. Prior literature had told us to expect these results, in particular, the key importance of top management support to the continued successful use of such key business planning and quality assurance mechanisms as conceptual modelling for systems.

However, nearly one-fifth of the comments remained unclassified. Were there any new, important factors unique to the conceptual modelling domain contained in this data? Fig. 1 shows a document (concept) map produced by Leximancer from the unclassified comments.

Five factors were identified from this map using the centrality of concepts and the relatedness of concepts to each other within identifiable 'chunks'. While the resolution of the Leximancer generated concept map (Fig. 1) may be difficult to read on its own here, the concepts (terms) depicted are referred to within the discussion of the relevant factors below.

A. Internal Knowledge (Lack of) of Techniques:

This group centred on such concepts as knowledge, techniques, information, large, easily and lack. Related concepts were work, systems, afraid, UML and leading. Accordingly, we used these concepts to identify this factor as the degree of direct/indirect knowledge (or lack of) in relation to the use of effective modelling techniques. Highlighted inadequacies raise issues of the modeller's skill level and questions of insufficient training.

B. User Expectations Management:

This group centred on such concepts as expectations, stakeholders, audience and review. Understanding, involved, logic and find were related concepts. Consequently, we used these items to identify this factor as issues arising from the need to manage the expectations of users as to what they expect conceptual modelling to do for them and to produce. In other words, the analyst must ensure that the stakeholders/audience for the outputs of conceptual modelling have a realistic understanding of what will be achieved. Continued (discontinued) use of conceptual modelling may be influenced by difficulties experienced (or expected) with users over such issues as acceptance, understanding and communication of the outcomes of the modelling techniques.

C. Understanding the Models Integration into the Business:

This group centred on understanding, enterprise, high, details, architecture, logic, physical, implementation and prior. Accordingly, we identified a factor as the degree to which decisions are affected by stakeholder/modeller's perceived understanding (or lack of) in relation to the models integration into business processes (initial and ongoing). In other words, for the user, to what extent do the current outputs of the modelling process integrate with the existing business processes and physical implementations to support the goals of the overall enterprise architecture?

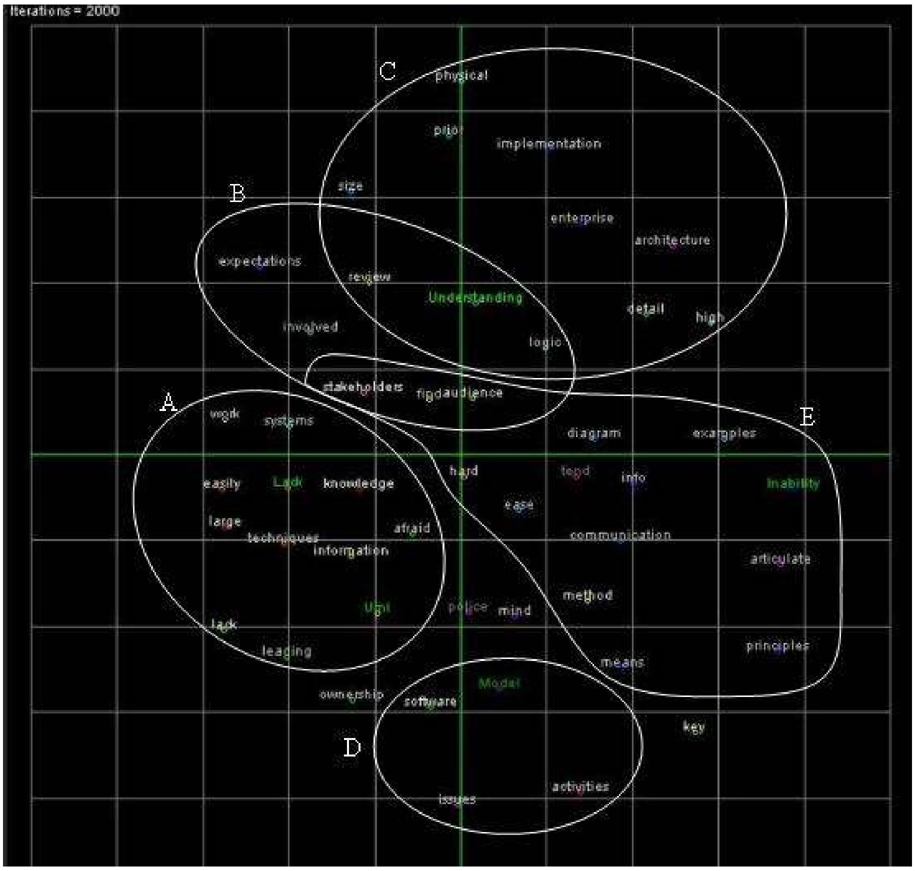

Fig. 1. Concept map produced by Leximancer on the unclassified comments

D. Tool/Software Deficiencies:

This group was focused on such concepts as software, issues, activities, and model. Subsequently, a factor was identified as the degree to which decisions are affected by issues relating directly to the perceived lack of capability of the software and/or the tool design.

E. Communication (using diagrams) to/from Stakeholders:

This final group involved such concepts as diagram, information, ease, communication, method, examples, and articulate. Related concepts were means, principals, inability, hard, audience, find, and stakeholders. From these key concepts, we deduced a factor as the degree to which diagrams can facilitate effective communication between analysts and key stakeholders in the organisation. In other words, to what extent can the use of diagrams enhance (hinder) the explanation to, and understanding by, the stakeholders of the situation being modelled?

Using these five new factors, we revisited the unclassified comments and, using the same dual coder process as before, we confirmed a classification for those outstanding comments easily. Table 12 presents this classification and the relative importance of those newly identified factors.

Table 12. Relative importance of factors specific to conceptual modelling

Key	Percentage	Total
Communication (Diagrams) to/from Stakeholders	28%	46
Internal Knowledge (Lack of) of Techniques	27%	44
User Expectations Management	18%	30
Understanding models integration into the business	17%	28
Tool/Software deficiencies	10%	17
Total:	100%	**165**

As can be seen from Table 12, communication using diagrams and internal knowledge (lack of) of the modelling techniques are major issues specific to the continued use of modelling in organisations. To a lesser degree, properly managing users' expectations of modelling and ensuring users understand how the outcomes of a specific modelling task support the overall enterprise systems architecture are important to the continued use of conceptual modelling. Deficiencies in software tools that support conceptual modelling frustrate the analyst's work occasionally.

Table 13 shows all the factors including those specifically identified for conceptual modelling categorized by size of the organization of the respondent.

Table 13. Results of classification of all key factors influencing continued use/disuse by organization size

Factor	< 50	%	< 100	%	< 1000	%	< 5000	%	≥ 5000	%
Relative Advantage/Usefulness	123	43%	48	50%	98	47%	62	47%	75	48%
Compatibility	23	8%	8	8%	13	6%	6	5%	13	8%
Top Management Support	20	7%	3	3%	10	5%	8	6%	1	1%
Internalisations	19	7%	4	4%	8	4%	3	2%	14	9%
Complexity	15	5%	7	7%	15	7%	15	11%	16	10%
Facilitating Conditions	14	5%	4	4%	7	3%	8	6%	7	4%
Communication (Diagrams) to/from Stakeholders	12	4%	1	1%	9	4%	6	5%	8	5%
Communication Issues	10	4%	3	3%	7	3%	2	2%	1	1%
User Expectations Management	10	4%	2	2%	8	4%	6	5%	1	1%
Internal Knowledge (Lack of) of Techniques	8	3%	5	5%	11	5%	4	3%	10	6%
Subjective Norms	6	2%	2	2%	5	2%	4	3%	2	1%
Tool/Software deficiencies	5	2%	4	4%		0%	4	3%	2	1%
Understanding models integration into the business	5	2%	2	2%	5	2%	4	3%	6	4%
Risk	4	1%	1	1%	3	1%	1	1%	0	0%
Self-Efficacy	4	1%	1	1%	5	2%	0	0%	1	1%
Results Demonstrability	3	1%	0	0%	1	0%	0	0%	0	0%
Identification	2	1%	0	0%	0	0%	0	0%	0	0%
Trialability	2	1%	0	0%	1	0%	0	0%	0	0%
Compliance	0	0%	0	0%	1	0%	0	0%	0	0%
Visibility	0	0%	1	1%	0	0%	0	0%	0	0%
TOTAL	***285***		***96***		***207***		***133***		***157***	

Relative advantage is critical across respondents irrespective of the size of the organization. Compatibility with job responsibilities and value systems is also an important driver across respondents generally irrespective of the organization size. However, top management support and internalizations (references from experts) are far more important in small organizations (less than 50) than in larger organizations. Moreover, the specific factor of communication (diagrams) to/from stakeholders appears to be important across organizations while the specific factor of internal knowledge (lack of) of techniques seems to be more important in larger organizations than in small organizations.

Table 14 allows us to see the key factors grouped by years of modelling experience of the respondent.

Table 14. Results of classification of all key factors influencing continued use/disuse by years of modelling experience

Factor	0-3 yrs	%	4-10 yrs	%	11-20 yrs	%	> 20 yrs	%
Relative Advantage/Usefulness	82	51%	175	50%	119	39%	65	41%
Communication (Diagrams) to/from Stakeholders	14	9%	11	3%	14	5%	7	4%
Complexity	14	9%	32	9%	16	5%	12	8%
Internal Knowledge (Lack of) of Techniques	10	6%	15	4%	15	5%	4	3%
Compatibility	8	5%	18	5%	26	8%	17	11%
Facilitating Conditions	8	5%	8	2%	16	5%	10	6%
Top Management Support	6	4%	16	5%	15	5%	11	7%
User Expectations Management	6	4%	7	2%	15	5%	2	1%
Communication Issues	4	2%	11	3%	7	2%	3	2%
Subjective Norms	2	1%	9	3%	7	2%	4	3%
Tool/Software deficiencies	2	1%	5	1%	8	3%	2	1%
Understanding models integration into the business	2	1%	13	4%	8	3%	5	3%
Compliance	1	1%	0	0%	0	0%	1	1%
Internalisations	1	1%	22	6%	24	8%	7	4%
Self-Efficacy	1	1%	5	1%	6	2%	2	1%
Trialability	1	1%	0	0%	1	0%	2	1%
Identification	0	0%	0	0%	2	1%	0	0%
Results Demonstrability	0	0%	1	0%	2	1%	2	1%
Risk	0	0%	3	1%	5	2%	3	2%
Visibility	0	0%	0	0%	1	0%	1	1%
TOTAL	***162***		***351***		***307***		***160***	

Again, relative advantage of the modelling exercise is the pervasive factor influencing respondents at all levels of experience. For novice modellers though (0-3 years), communication (diagrams) to/from stakeholders, complexity of the technique, and internal knowledge (lack) of techniques are the next three most important drivers. By contrast, for more experienced modellers the next three most factors appear to be generally complexity, compatibility, and top management support.

6 Conclusions and Future Work

This paper has reported the results of a survey conducted nationally in Australia on the status of conceptual modelling. It achieved 312 responses and a relevant response rate of 19.9 percent. The study found that the top six most frequently used modelling techniques were ER diagramming, data flow diagramming, systems flowcharting, workflow modelling, RAD, and UML. Smaller organizations appear to employ marginally greater use of the well-established structured techniques of ER diagramming, data flow diagramming, and systems flowcharts. By contrast, the larger organizations seem to make greater use proportionately of the more recent object-oriented techniques such as workflow modelling and UML. The use of the more traditional techniques such as ER diagramming, data flows diagramming, and systems flowcharts is higher in the more experienced modellers. While not markedly so, the use of the more recent object-oriented techniques, *viz.*, workflow modelling and UML, appears to be higher in the less experienced modellers.

This study found that clearly Visio is the preferred tool of choice for business systems modelling currently. Rational Rose and Oracle Developer suite were a long way second in frequent use. Visio is more heavily used proportionately by respondents in larger organizations than those respondents in smaller organizations. By contrast, and contrary to *a priori* expectations, it appears that more modern, more complex tools like Rational Rose and Oracle Developer are used proportionately more by modellers in smaller organizations than those in larger organizations. Those respondents with 4-10 and 11-20 years of systems analysis and modelling experience seem to make greater use of the tools proportionately than those modellers who are complete novices

(0-3 years), and indeed, those modellers who are highly experienced (greater than 20 years), even when the tool is a relatively simple tool like Visio.

Database design and management remains the highest average *purpose* for use of modelling techniques. This fact links to the result of ER diagramming being the most frequently used modelling technique. Moreover, software development as a purpose would support the high usage of data flow diagramming and ER diagramming. In small organizations, database design and management and software development are primary purposes for modelling. In larger organizations, business process documentation and business process improvement are more critical purposes for modelling. It appears that as modellers move from novice to expert the focus of their modelling activities moves from technical design issues to business process improvement to change management and communicating effectively the work processes of the business to the end-users. A contribution of this study is the analysis of textual data concerning critical success factors and problems/issues in the continued use of conceptual modelling. Clearly, relative advantage (disadvantage)/usefulness from the perspective of the analyst was the major driving factor influencing the decision to continue (discontinue) modelling. Moreover, using a state-of-the-art textual analysis and machine-learning software package called Leximancer, this study identified five factors that uniquely influence the continued use decision of analysts, *viz.*, communication (using diagrams) to/from stakeholders, internal knowledge (lack of) of techniques, user expectations management, understanding models integration into the business, and tool/software deficiencies. Moreover, the specific factor of communication (diagrams) to/from stakeholders appears to be important across organizations irrespective of size while the specific factor of internal knowledge (lack of) of techniques seems to be more important in larger organizations than in small organizations. By contrast, communication (diagrams) to/from stakeholders and internal knowledge (lack) of techniques appear to be much more critical to novice modellers (0-3 years) than to more experienced modellers.

The results of this work are limited in several ways. Although every effort was taken to mitigate potential limitations, it still suffers from the usual problems with surveys, most notably, potential bias in the responses and lack of generalisability of the results to other people and settings. More specifically, in relation to the qualitative analysis, even though a form of dual coding (with confirmation) was employed, there still remains subjectivity in the classification of comments. Furthermore, while the members of the research team all participated, the identification of the factors using the Leximancer document map and the principles of relatedness and centrality remains arguable.

We intend to extend this work by administering the survey in other countries (England, Sweden and the Netherlands) to address the issues of lack of generalisability in the current results and cultural differences in conceptual modelling.

References

1. Bansler, J., and Bodker K.: A reappraisal of structured analysis: design in an organizational context ACM Transactions on Information Systems. Vol. 11 Nr. 2 (1993) 165-193.
2. Batra, D., Marakas, G. M.: Conceptual data modelling in theory and practice. European Journal of Information Systems, Vol. 4 Nr. 3 (1995) 185-193
3. Chang, S., Kesari, M., Seddon, P.: A content-analytic study of the advantages and disadvantages of process modelling. 14th Australasian Conference on Information Systems. Eds.: J. Burn., C. Standing, P. Love. Perth (2003).
4. Curtis, B., Krasner, H., and Iscoe, N.: A field study of the software design process for large systems Communications of the ACM. Vol 31 Nr 11 (1998).
5. Fitzgerald, B.: An empirical investigation into the adoption of systems development methodologies. Information and Management, Vol.34 (1998) 317-328.
6. Floyd, C.: A comparative evaluation of system development methods. Information Systems Design Methodologies: Improving the Practice. North-Holland, Amsterdam (1986) 19-37.
7. Gorla, N., Pu, H.-C., and Rom, W.; Evaluation of Process tools in Systems Analysis. Information and Software Technology. Vol. 37 Nr. 2 (1995) 119-126.
8. Iivari, J.: Factors affecting perceptions of CASE Effectiveness. IEEE Software. Vol. 4 (1995) 143-158
9. Karahanna, E., Straub, D. W., Chervany, N. L.: Information Technology Adoption Across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs. MIS Quarterly, Vol. 23 Nr. 2 (1999) 183-213
10. Karam, G. M., Casselman, R. S.: A cataloging framework for software development methods. IEEE Computer, Feb., (1993) 34-46
11. Kautz, K., and McMaster, T.: Introducing structured methods: an undelivered promise? – a case study. Scandinavian Journal of Information Systems, Vol 6 Nr 2. (1994) 59-78.
12. Kautz, K., Hansen, B., and Jacobsen, D.: The Utilization of Information Systems Development Methodologies in Practice. Journal of Information Technology, Cases and Applications. Vol 6 Nr 4 (2004)
13. Lindland, O. I., Sindre, G., Solvberg, A.: Understanding Quality in Conceptual Modeling. IEEE Software, March, (1994) 42-49
14. Necco, C. R., Gordon, C. L., Tsai, N. W.: Systems analysis and design: Current practices. MIS Quarterly, Dec., (1987) 461-475
15. Olle, T. W., Hagelstein, J., Macdonald, I. G., Rolland, C., Sol, H. G., M.van Assche, F. J., Verrijn-Stuart, A. A.: Information Systems Methodologies: A Framework for Understanding. Addison-Wesley, Wokingham (1991)
16. Persson, A., Stirna, J.: Why Enterprise Modelling? An Explorative Study Into Current Practice. 13th Conference on Advanced Information Systems Engineering, Switzerland (2001) 465-468
17. Sedera, W., Gable, G., Rosemann, M., Smyth, R.: A success model for business process modeling: findings from a multiple case study. 8th Pacific Asia Conference on Information Systems (PACIS'04). Eds.: Liang T.P., Zheng, Z.: Shanghai (2004)
18. Tan, M., Teo, T. S. H.: Factors Influencing the Adoption of Internet Banking. Journal of the Association for Information Systems, Vol. 1 (2000) 1-43.
19. Wand, Y., Weber, R.: Research Commentary: Information Systems and Conceptual Modeling – A Research Agenda. Information Systems Research. Vol. 13 Nr. 4 (2002) 363-376.