December 2002

Shared Use of Diagrams in Requirements Elicitation: roles, expectations and behaviours

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Abstract

This paper describes the results of an action research study whose focus was requirements elicitation for an e-business system. The study showed that analysts and end-users use the same diagrams for quite different purposes, the former for validation and establishing correctness and the latter as a structuring mechanism for uncovering requirements and gaps and reasoning about a system under consideration. A model of cognition that explains this behaviour is proposed.

Keywords

Information Requirements Determination; IS Research Issues; Action Research

INTRODUCTION

The research described in this paper explored the shared use of diagrams (specifically the business rules diagram developed by McDermid, 1998) by end-users and analysts in requirements elicitation and analysis for an e-business system. Diagrams are a central part of many IS development (ISD) methodologies. However, we believe that the way diagrams are actually used is an area that has not been investigated in sufficient detail. Similarly, Avital and Vandenbosch (2002) gave a brief review of the evolution of the relationship between the IT function and the organisation which it (the IT function) is intended to support and pointed out there is a paucity of research concerning the relationship between IT professionals and business processes (which the information systems are meant to support). It follows therefore that how IT professionals capture business processes and what models they use is central to this issue.

This study attempts to address this issue by exploring how IT professionals and end-users (in partnership) model business processes. With this paper we also hope to build more detailed theory about the use of diagrams and provide some evidence of the validity of the theories espoused.

THE ROLE OF DIAGRAMS – LITERATURE REVIEW

Diagrams serve two main purposes, firstly, to facilitate communication and secondly, to assist in internal problem solving (or reasoning).

As communication tools, diagrams serve to document a set of assertions about some situation that the diagrams model, which are then used for various purposes by the receiver of the diagrammatic information. In ISD, a diagrammatic model can serve to describe to users what an analyst has learned and to seek feedback from the users. This is for example commonly done with data flow diagrams (DFDs) and entity-relationship diagrams (ERDs). The user is then expected to confirm or disconfirm the validity of the diagrams. Further, diagrams are used to communicate the result of work in one area to people who do further work. For example, an ERD may be passed on to a database designer. The different uses

and users of diagrams in ISD present problems in the design of diagramming techniques, as described for example by Moody *et al.* (1995).

Diagrams also facilitate reasoning. The use of mental models as an aid to reasoning is not new and issues of model accuracy, abstraction and realism are well documented (Johnson-Laird, 1983; Sibelius, 1992; Ramaprasad *et al.*, 1993). This last point is well-made by Bannon (1995:67) who said: "*Models are thus seen...as interpretations, as constructions, which for some purposes, under certain conditions, used by certain people, in certain situations may be found useful, not true or false.*" Korzybski (1936, para. 10) was more succinct when he said that "a map is not the territory" when discussing elements of General Semantics. White (1989) considers that diagrams have a role to play as a link between abstract concepts and real-world instances of particular phenomena.

Larkin and Simon (1987:98) present three reasons for the superiority of diagrams, *viz.* Diagrams can group together all information that is used together; diagrams typically use location to group information and diagrams automatically support a large number of perceptual inferences. Kulpa (1999) provides support for this view and points out that diagrammatic representations have several advantages (over other representations), namely: they are multi-dimensional (usually two, sometimes three dimensional); they facilitate the easy representation of structural and spatial relations; and that people are able to make perceptual inferences or draw conclusions from diagrams easily.

Diagrams and systems of diagrams combined with other models (e.g. DFDs and data dictionaries) are used to facilitate reasoning about requirements during ISD. Commonly they are checked for consistency and completeness, i.e. uncovering inconsistencies and gaps in requirements elicited from users. Systems analysts usually perform these tasks (Bostrom and Thomas, 1983).

However, reasoning with diagrams is not limited to systems analysts. It has been proposed that users may also use diagrams to reason about systems as an aid to discovering and documenting requirements (DeMarco, 1978). This requires either the development of notations that are so intuitive that only brief explanation is necessary – or training of users in how to make use of the diagrams.

EXPECTATIONS OF THE RESEARCH

The research in this study was part of a larger research programme intended to enhance and evaluate the Business Rules Diagram (BRD) method (McDermid, 1998). The work described here reinterprets the data collected during the study reported in Johnstone *et al*. (2000), which was originally conceived to investigate the qualities of BRDs in two main areas, analysis of e-business systems and training of users.

The development of the BRD method is consonant with the re-emergence of business process modelling as a tool for understanding the functions within organisations. That, coupled with the necessity to maintain state information in today's web-based transactions, suggests that process-oriented techniques (such as the BRD) may be useful in modelling e-business systems. Melão and Pidd (2000), for example, call for a pluralistic approach to modelling and suggest several perspectives on business processes (*viz.* deterministic machines, dynamic systems, feedback loops or social constructs).

An issue that emerged from a prior study (Johnstone and McDermid, 1999) was the need for more structured training to be delivered to the clients prior to the commencement of system modelling. As the clients had little experience with IS modelling, careful consideration was given to the nature of the training materials and the pedagogical delivery structure to ensure that the users received the depth of training required to successfully model their business processes.

Thus, the original study investigated several questions:

- Is the BRD suitable for modelling web-based e-business applications?
- What enhancements might be needed to make it more suitable?
- Is the BRD suitable for use by end-users (with sufficient training)?
- Is the BRD method practical, acceptable and efficient for clients to use?

- Why or why not?
- What improvements might need to be made to make the BRD suitable for end-users?

However, these questions did not examine or consider the uses of diagrams described in the literature above, nor did they consider the contextual issues of the actual conduct of the tasks of information requirements determination. In the subsequent analysis, these issues then confronted the study. These issues then lead us to a deeper level of analysis, which was facilitated by the rich data gathering of a qualitative study. This study reports our reinterpretation of the data gathered during the earlier study.

THE ACTION RESEARCH CASE/ CONTEXT

The research method used was action research. Action research is widely acknowledged as the most appropriate research method for achieving a high level of relevance in research about systems development methods and practice (Baskerville and Wood-Harper, 1996; Mathiassen, 1998). The guidelines of Baskerville and Wood-Harper (1996) were used in setting up an appropriate research contract. Later on, in order to ensure a suitable degree of rigour, we followed the guidelines for conducting interpretive research proposed by Klein and Myers (1999) in conducting and reporting this study.

In this study the client was the management school of a large Australasian University. The project involved the development of a business to consumer (B2C) subscription-based electronic commerce system. The domain was that of electronic publishing. A small project team was established comprising a group of two clients and a trained business analyst (one of the researchers) acting as the group facilitator. The researcher had been a subject analyst in another study investigating the BRD (McDermid, 1998) and thus was extremely skilled with the method. The first client (User F) was an academic with a strong interest in web site development but no formal or informal training in development methods. The second client (User G) was a web site developer with experience in paper-based publishing but no training in systems development. Both clients were taught the notation and stages of the BRD method (using 4 x 2 hour facilitated, structured workshops) and then attempted to model the problem situation, aided by the researcher/analyst/facilitator. The group generated 84 business rules across twelve functional areas covering many aspects of journal publication (both traditional paper-based and electronic). The web site provides a way for non-subscribers to browse abstracts and journal tables of contents and allows them the option of subscribing via credit card across the Internet or other, more conventional means. The site also gives subscribers on-line access to full articles as well as the opportunity to provide an on-line commentary on selected articles.

The process used in the method to create a complete BRD is defined by McDermid (1998) as:

- Identify candidate business rules;
- Identify candidate events and signals;
- Identify candidate objects;
- Construct Object Life Histories (OLHs);
- Construct User Business Rule Diagrams (UBRDs);
- Construct Business Rules Diagram; and
- Construct Event Specification Table (EST).

Space limitations prevent further discussion of the method itself. However, later discussion makes reference to some of the above steps and terms used within the method and so the above serves to orientate the reader later in the paper. Further detail may be found in McDermid (1998). It should be noted that the BRD method is a method under development and thus continues to be refined and improved as it is tested in different application domains. Also, work is being done to extend the coverage of the method to more phases of the SDLC than analysis.

EVIDENCE COLLECTION AND THE STUDY PROCESS

The process of the entire action research study is depicted in Figure 1. The ISD activities studied are shown with ovals. The researcher activities are shown with rectangles. Softboxes (rounded rectangles) show the evidence collected.

Before the advent of the study, the researcher/analyst and the two users entered the situation with their individual *weltanshauungen* (world views, Checkland, 1981). These world views included their conceptualisations and expectations about how ISD is conducted, what they would be doing, and how they would interact with each other. The larger circle toward the top of Figure 1 shows the ISD activities themselves, divided into smaller circles, which are the individual sessions. In between the sessions, as shown by the upper rectangle to the left, the analyst/ researcher and the other two researchers engaged in discussions of the sessions and what was happening, reflections on what was happening and development of new conceptualisations and understandings, and re-planning of the remainder of the ISD sessions. At the conclusion of the modelling phase, as shown by the lower circle, the clients were interviewed by the researcher in semi-structured mode to gain the clients' perceptions of the modelling experience and how the BRD method assisted (or otherwise) in reasoning about the problem situation.

Evidence was collected at each stage during the study, as shown in the softboxes in Figure 1. Transcripts were made of each ISD session. Copies were kept of all the training materials and all of the BRDs generated during the ISD sessions. Following each ISD session, the analyst/researcher recorded a summary of his perceptions of the sessions in his research journal. Following each discussion session with his fellow researchers, the analyst/ researcher recorded a summary of the sessions in his research journal. The interviews were also recorded and transcribed.

As shown at the bottom of Figure 1, the analyst/researcher and his fellow researchers, in writing up this and prior reports of the results of the study, interpreted and re-interpreted the record of the study and discussed what was learned in the study. As stated earlier, this paper re-interprets the record of the study to identify and distil in more detail what was learned about how the clients and the analyst/researcher interacted and how this changed over time, and to suggest some theory to explain what was observed.

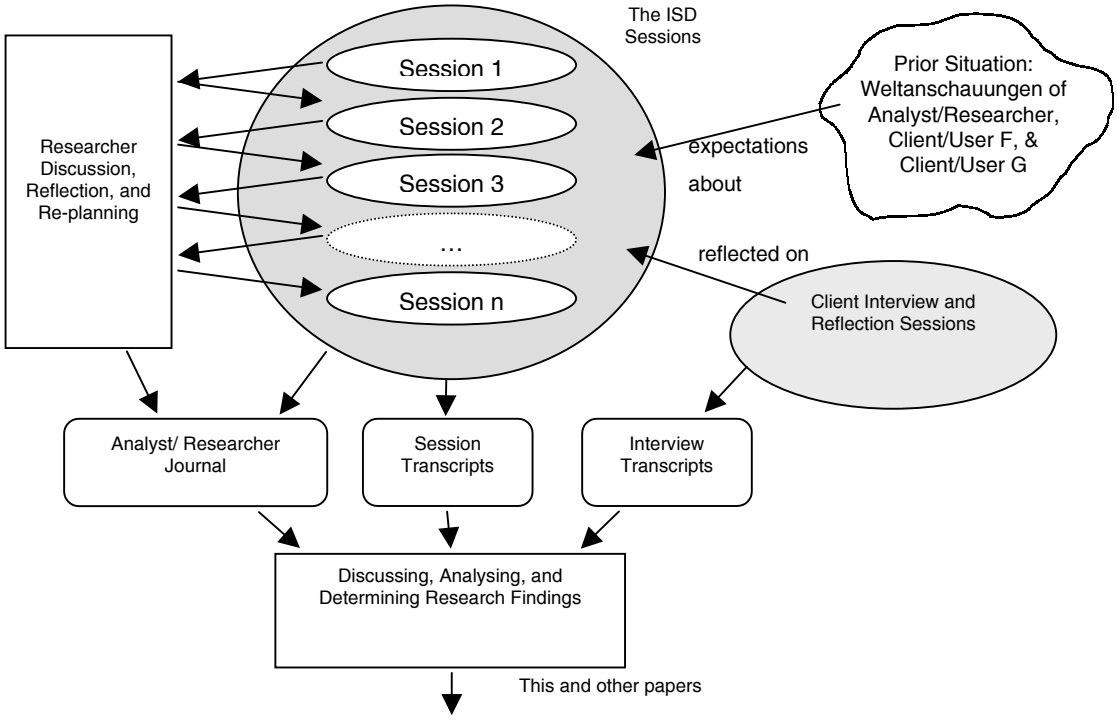

Figure 1: The research process, evidence collected, and researchers' analysis during this study

ANALYSIS OF THE EVIDENCE

In this section a number of excerpts from the interview transcripts will be provided together with an accompanying narrative that comments on these responses. They are discussed under headings entitled:

- Ability to define detailed requirements
- Reasoning about new requirements
- Reasoning about inaccuracies
- Recognition of the benefits of diagrams over text
- Ownership of models
- Re-alignment of user-analyst roles

Collectively, they represent an emerging perspective on user-analyst interaction during specification using diagrams. The headings are organised in such a manner as to show growing development or sophistication in the way that users look at the process. The first few headings deal with the ability of the diagramming technique to support the basic specification process.

Figure 2 shows a Business Rules Diagram typical of those developed throughout the study. Of interest is the use of Harel "blobs" to partition process logic (the larger blob) from navigation logic, a useful structuring mechanism for the development of e-Commerce systems.

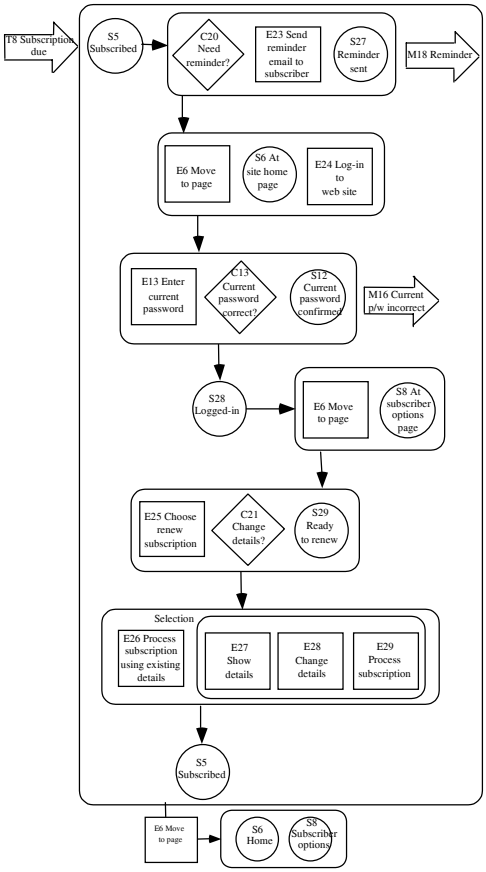

Figure 2: A Business Rules Diagram typical of those generated during the study.

Ability to define detailed requirements

The following is an excerpt in which User F confirmed that the method assisted him in modelling the detailed behaviour of the site.

> (User F) Well, it helped us … in detecting … vagueness in saying "the site will do this". If you actually have to identify what part of the site does what and what button

> you need to click on to make that happen, you begin to find, that say, especially with signals where something, some information is being moved from one part of the site to another or information is entering or leaving the site altogether, that is where you kind of assume that "oh, it will just happen", but it won't. I mean you need a delivery method for that so there's that signal something going through the database back end or is that an email message, so that kind of thing, not so much inaccuracies 'cause we did find a few of those in our site design and we found those before it was too late obviously and clarified them but it is more...removing the vagueness of the language description of how the site would function, that [is] what it really helped with for me anyway.

At another point in the interview User F was quite explicit in explaining how he used the method to reason about the complexities of subscription, in this case being able to recognise redundant behaviour as well as extract common behaviour.

> (User F) Well I think we had problems with subscription 'cause that was very complex. We had to divide subscribers into new subscribers who wanted to pay on-line, new subscribers who can't pay on-line 'cause they don't have a credit card or other facility so they need to pay by cheque, renewing subscribers whose details we should already hold - they don't have to go through the whole process again and often we don't think about the technical or structural implications of treating these people, when they really are different. If you just said on the surface, "well they are all subscribers, they are all the same", they are really not and if we had just modelled it as "you subscribe to do this" and when an existing subscriber's subscription ends after a year and they want to subscribe again - if we did something simple like treated them as a new subscriber we could get ourselves into all sorts of problems. Even just simple sort of financial records type problems - it would be difficult to track ongoing subscribers and other things so it was really important that we worked those kind of details out. The diagrams helped in that aspect because we were really able to do separate case studies for each type of subscriber and worked out precisely where they differed, so in a sense we worked out the reusable parts of the subscription process that might simplify the site design a little but we've identified those areas of difference that have to be treated quite separately.

One interesting aspect of the first excerpt is in understanding the initial mindset or world view that the user has of user-analyst interaction. It is clear here that the user had a initial view that the user was expected to specify the requirements at a high level of abstraction (e.g. by specifying that something has to 'happen' on the website without supplying all details) and that further it was expected that the analyst would be able to pick this up, and fill in the gaps as it were. Towards the end of the first excerpt it becomes clear that the user had begun to rethink that viewpoint – in other words to acknowledge that the user needed to supply more detail in requirements. A further acknowledgement of this repositioning occurs in the second excerpt where User F went on to explain how the mechanics of defining more detail took place with subscription processing. It is interesting to note the kind of vocabulary used by User F. He used terms such as "reusable" and "separate case studies". Such terms indicate, to the authors at least, that User F was now operating at a higher level of thinking and abstraction with regard to the activities involved in defining detailed requirements.

Reasoning about new requirements

The above excerpts were in response to questions about whether the diagram helped in defining the detail of requirements. In themselves, the questions did not specifically ask if the diagram supports the user in *reasoning* about the specification as opposed to describing or defining the specification. User G had this to say regarding the process of reasoning about new requirements.

> (User G) Yeah, Yeah. Definitely. O.K. … the difference between somebody who is subscribed and somebody who is not subscribed in particular, I think, came out because we want non-subscribers to access the first few pages, I think it was and then subscribers to be able to get deeper into it...and then we had at that stage the notion of the interactive paper and that was quite complex. It was far more complex

> than I actually thought and as we went through it, I could see there was more, as we modelled it through the process, you sort of saw and said "well, where the hell do I go to from here?" and I could then fill the gaps in whereas previously if I was doing this I would be inclined to be saying "what the bloody hell do I do now?" so then I'd have to go back and change it as I said in the previous answer, so yes it did, definitely.

From the perspective of a researcher interested in how diagrams and techniques support the development process, it is observed that the shift from thinking "what do I do here?" to "where do I go from here?" is significant. It suggests that the technique is orientating the user to ask questions about what happens next in the *application* as opposed to leaving users floundering about what the method *requires* him/her to do at that juncture, a particularly important point, well-made by Wastell (1996).

Reasoning about inaccuracies

In response to a similar question about reasoning, this time regarding inaccuracies, the following was stated.

> (User F) I think it does simply because we've spent a lot of time getting it right and we've tried to be very thorough and organised about it and we've gone over each event or action in the system and tried to determine how it works, firstly on an individual basis and secondly within a sort of larger view of the site as a whole…Whether from some sort of omniscient point of view this really reflects what we have thought … I am confident but not certain.
>
> (User G) I can't be certain of that because it's like everything else. Until you actually see the real thing you are not quite certain that you've got everything however I would say that it models it more accurately and probably in more detail than I would have done when I first started this. I think for the actual person that is working on this, it is far better for them than what I would have done [prior to learning about the BRD method]…

A theme that emerges from both answers above is the concern over how *certain* they were of the accuracy of their work. In terms of the degree of sophistication of their understanding of the specification process, it would appear that this process has taken them to a position where they now appreciated more clearly the difficulties of defining requirements with absolute certainty. This is evidenced particularly by phrases such as "trying to be very thorough" and "than … when I first started this".

So far, the above excerpts have been in response to straightforward questions about the diagram and how it aided the mechanics of specification. The next few excerpts move the discussion forward by discussing themes of a more reflective and thus advanced nature that emerged from the interviews.

Recognition of the benefits of diagrams over text

A number of comments were made by both User F and User G with respect to a view that considered diagrams superior to text as a means of developing specifications. The comments arose in answers to other questions i.e. questions not specific to comparing diagrams to text as a specification medium.

> (User F) … but it is more ... removing the vagueness of the language description of how the site would function, that what it really helped with for me anyway.
>
> (User F)… and so using the diagrams kind of enables people who are planning a site like we have been to weed out the kind of wishy-washy talk about "you'll be able to do this and you'll be able to do that". It really forces you to think in a very structured and coherent way, which is what you need to do to create a structured and coherent site.
>
> (User G) It surfaced some of the underlying requirements that hadn't really been considered. So it surfaced those requirements and allowed them to sort of … "hey, we've got a gap here. what's the problem. bring it out and see it" … and also the linking of those diagrams because they go into different depths so it also allowed

> you to … you've got one diagram and from that another box that goes into another diagram and I found that quite useful 'cause you could then sort of follow the flow and that also fits in with what I used to do when I was strategic planning something – you'd do the flow diagram and then you'd have a box with a whole complex thing and that would be the next level so I was quite comfortable with that.
>
> (User F) The diagrams helped in that aspect because we were really able to do separate case studies for each type of subscriber and worked out precisely where they differed, so in a sense we worked out the reusable parts of the subscription process that might simplify the site design a little but we've identified those areas of difference that have to be treated quite separately.

An important point to observe from the above excerpts is that the experience of this study (or certainly, the interview process) caused the users to reflect upon the pros and cons of text and diagrams as media for conducting specification. The fact that they chose to bring these observations up in response to other questions strengthens the 'value' of their response and indicates the level of reflection going on in their minds, i.e. that they were beginning to critique alternative types of specification techniques.

Ownership of models

During the study, the team derived a dozen use cases from the existing business rule set and then, for each use case, role-played a typical dialogue between the system and a user, from which the first-cut UBRD was developed *in-situ*. The team then considered abnormal behaviour (e.g. a visitor to the site attempts to subscribe but the amount required for the transaction exceeds their credit card limit) and amalgamated this behaviour into the first-cut diagram. Initially, the analyst (as pedagogue) modelled a dialogue between the system and a user (as is done with use cases) and then progressed (at the user's request) to skipping the text dialogue and drawing the diagrams directly. During one of these sessions, User G actually grabbed the marker pen from the analyst and started to draw on the whiteboard. Afterwards, during an interview, the analyst asked User G about this behaviour.

> (User G) That's right. As we got into the process I think that both User F and me got the same feeling - "hey, I want to get this down". Let's do it without you saying … Yes, If User F has a suggestion, then if he wants to describe it or he can do it, so give them pens and get them to do it.

A key point that emerged from this study, as exemplified in the above excerpt, was what Avital and Vandenbosch (2002) call psychological ownership. As more diagrams were developed the users elected to omit the use case dialogue step and chose to draw the diagrams directly. The users also began to model abnormal behaviour directly. At this stage the users were able to take full control of the diagram and used it to reason about the logic of web site navigation. The users also used the UBRD to analyse the expected interactions between a user and the system as well as using it to check the logic and validity of the business rules themselves to some extent, although this cross-checking was a role they preferred to defer to the analyst.

The fact that ownership of the models and indeed of the process was being felt by the users is significant in terms of understanding the degree to which this study was succeeding in its aims of providing a viable diagramming technique with which to specify requirements. It demonstrated that the approach was 'working' as far as the users were concerned and also that the espoused features of the diagram of being able to support reasoning etc appeared to be correct.

Re-alignment of user-analyst roles

Once the ownership of the modelling was transferred from the analyst to the group as a whole, the rate of progress increased markedly. At this stage the users were not interested in the precise syntax of the BRD method and saw that particular role as being the domain of the analyst as the following interview excerpt indicates:

> (User G) Yeah but the other issue was maybe instead of you [the analyst] doing it down – I know you are the facilitator type thing, but maybe it would be better if you let them get it down and then go back and start doing the detail and change it as

> necessary. I mean we all know that you put something down, there's always going to be changes to it, you know. So rather than you do it and then talk about what you've just done, that little bit, let us get it all down, then you back and facilitate the changes.

This excerpt raises questions about the nature of user-analyst interaction particularly about user and analyst expectations about what is right' or acceptable in a given situation. In terms of gauging the degree of development or 'sophistication' that users had achieved since the beginning of the study when they were relatively passive in the behaviour, it is clear that the emergence of user suggestions to change the modus operandi of the specification activity is a positive indication of learning and development.

THEORETICAL EXPLANATIONS

In the previous section, we identified a number of detailed areas in which expectations, role, and behaviours interacted with each other. We can generalise theories that provide partial explanations of these interactions. Before we propose a model of analyst/client interaction to explain the relationship between the formal and informal aspects of shared understanding, we provide a summary that we believe encapsulates the essence of the crucial interactions. Further, we use Mumford's (1983) characterisation of the interaction between task, technology, organisation, and people to explain how expectations and roles changed over time.

Initially, the clients entered the situation with particular world views and sets of expectations. An examination of minutes of early group meetings in conjunction with interview records shows that the clients thought in terms of screen and website design most likely due to their prior ad-hoc experience with web design. The analyst's world view and expectations were shaped by prior knowledge and experience with the BRD method as well as experience designing web systems. In addition, the analyst was also the researcher and thus brought a set of expectations in relation to the research goals of the project.

At the informal level, it was noted that there was a difference in vocabulary and the level and rigour of conceptualisation between the analyst and the clients which suggested that there was a clash of mental models used to articulate the problem – which is perhaps not unexpected at the early stages of modelling. It was observed that the clients held the bulk of the business knowledge whereas the analyst was the custodian of the method thus both parties had knowledge that could be usefully shared as well as aspects to be learned.

By the time that the problem was formally structured, these hidden aspects had been expressed, shared, discussed, captured and resolved and both the analyst and the clients had a good understanding of the business and the method. Thus shared understanding was achieved.

We now propose the model in Figure 3 to represent the process by which the analyst/researcher and the clients jointly attempted to perceive, discuss, and agree upon a satisfactory shared interpretation of the previously unstructured business problem and choose a solution, using the mechanism of a (semi-)formal diagram or model. At the outset, both the analyst/researcher and the clients brought in their world views and expectations of how the process ought to take place. The process itself used the mechanism of a diagramming method (the BRD), to achieve a more detailed, precise, correct, and shared understanding of requirements. This was arrived at through various forms of formal and informal communication. In order to achieve a shared context, the analyst taught the modelling method to the clients. This enabled both parties to establish common referents for the problem under consideration. This is evidence of formal (rational) knowledge transfer. Informal (intuitive) knowledge transfer also occurred between the analyst/researcher and the clients (as well as between the clients themselves). This initially took the form of natural language statements. Gradually, assertions about the business problem began to take the form of more formal statements using the BRD. However, this doesn't totally supplant the less formal communications, as natural language statements are always needed that refer to the formalisms (BRD in this case) and establish the formal language's correspondence to the business situation. Over time, a shared understanding is built using the formal diagram

and, when familiar enough, its capabilities for supporting reasoning lead to its adoption and usage in the conversation about requirements.

Mumford (1983), based on the Socio-technical systems literature, proposed a model of the interaction of technology, task, people, and the organisation designed to show their interdependent nature (see Figure 4). This model largely presumed the technology was information systems, however we believe that the model also applies when the technology is `diagrams used in ISD. There is an ongoing interplay between the four elements as new accommodations are reached between the participants.

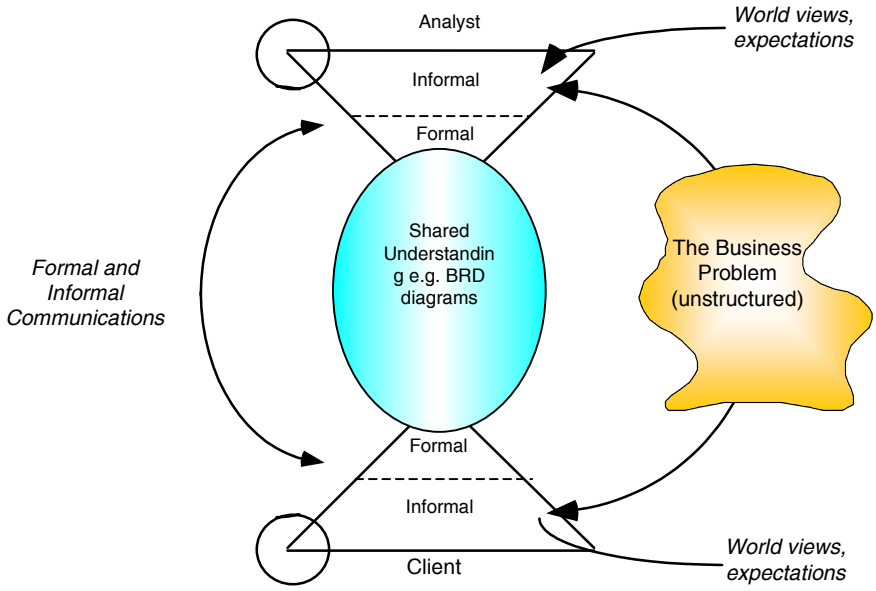

Figure 3: A Conceptual Model of the Analyst/ Client Interaction

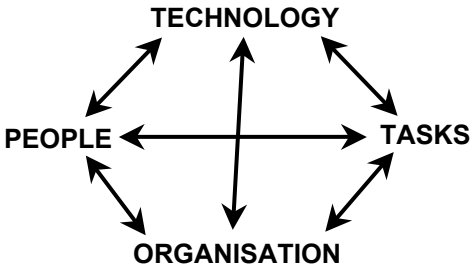

Figure 4: Interdependence of technological and non-technological aspects (adapted from Mumford, 1983)

At the beginning of the study, the various people had expectations about the other parts of the model in Figure 3. The analyst/ researcher had his expectations about how the tasks would proceed, what roles the others would play, and how the technology (the BRD method) would be employed. The clients/users also had their own expectations. To some extent these expectations are set by the organisation. These expectations were then negotiated into ways of working with the technology (diagrams) that evolved over time. In some cases, this resulted in changed behaviour as was evidenced by the people (clients in this instance) taking control of some tasks. At the same time, the technology (diagram) itself evolved as the BRD method was modified. This then caused further re-negotiations. Thus, over time, the expectations of people, their changing roles in the tasks, and the technology itself were negotiated and re-negotiated in what Checkland (1981) called the life-world flux. Ultimately, this can be thought of as typifying the constantly (re)emergent, socialised nature of work within organisations.

CONCLUSIONS AND FUTURE RESEARCH

In this paper we have presented an analysis of the nature of analyst/ lient interaction in the context of the adoption and use of a diagrammatic model during systems analysis. While this particular study was a small scale one, with a single analyst and two clients, and thus is not simply generalisable, the work on the study and the reflection thereafter provided an insight into the nature of the complex relationships that form during system development. The intention is to improve the conceptual model such that it forms a useful framework for analysts to use in requirements analysis. In order to address the issue of generalisability (following the principles of Klein and Myers, 1999), two further studies are underway that will test particular aspects of the conceptual model, assist in refining the model, and provide further case material.

We have identified a number of specific aspects of the interaction. We have also suggested new, and extended existing theory that provides generalised explanations of the findings (noting the above caveat). We also suggest that further qualitative, detailed research is needed on this and other diagrammatic techniques and methods to further explore their use as a means for improving their use and design.

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