

Exploring the use of entity-relationship diagramming as a technique to support grounded theory inquiry

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Abstract

Purpose

This research compares fundamental concepts from the grounded theory approach to social science research and concepts from entity-relationship diagramming, a technique used to model data from the field of systems analysis, and proposes that entity-relationship diagramming can be a useful tool for grounded theory researchers. The deductive nature of entity-relationship diagramming may be particularly helpful to researchers during the process of ‘constant comparison’ of data.

Design/Methodology/Approach

The paper compares and contrasts concepts from the two different fields and demonstrates the construction of an entity-relationship diagram from data drawn from an existing grounded theory research project and demonstrates the correspondence between the data model constructs and the grounded theory constructs.

Findings

The research finds a correspondence between these two methodologies and suggests that the entity-relationship diagramming technique may be a useful addition to the social scientist's toolkit when carrying out research using the grounded theory approach.

Originality/ Value

The paper bridges two distinct fields - information systems and grounded theory – and proposes a novel way for qualitative researchers to analyse and depict data.

Paper type: *technical paper*

Keywords: **grounded theory, entity-relationship diagram, data model, visual.**

Introduction

This paper proposes the use of entity-relationship diagramming, a technique from the field of information systems analysis, in the grounded theory approach to qualitative research. Use of diagrams as an aid to data analysis and display is not new in qualitative research; indeed, Strauss & Corbin (1998:217-8) call for the use of diagrams and memos when carrying out qualitative analysis. Miles and Huberman's (1994) seminal work contains many examples of network and matrix based diagrams. These diagrams centre on a variety of phenomena: events, activities, incidents, decisions, causal links, timelines, roles or taxonomies. This paper proposes a diagram that centres on entities - things of interest to the researcher and that become known to the researcher as nouns - and their relationships to one another. Entity-relationship diagrams are widely used in the development of databases and information systems. This paper proposes that such diagrams may be useful to qualitative researchers.

The issue arises as to whether a technique from a positivist background such as entity-relationship diagramming can fit well with a research methodology from an interpretivist background such as grounded theory. We argue that it can. Firstly there is a growing literature pointing out the advantages of research using mixed-methodologies and even multi-paradigms. Secondly, entity-relationship diagrams are built using a process of semantic analysis, a process that is interpretivist in nature. Thirdly, we argue that the essential structural elements of entity-relationship diagramming have some similar correspondences with the essential structural elements of grounded theory, and that this close correspondence suggests that the two approaches could be used synchronously. Finally we argue not for the full-scale detailed completion of an entity-relationship diagram depicting the total situation being examined, as would be the case in the development of an information system, but merely that such a diagram can assist grounded theory researchers in exploring interpretivist data. We argue that such a partial implementation will support but not dilute the interpretivist nature of a research project. We now elaborate these points in turn.

In recent decades carrying out a research project using a mixture of qualitative and quantitative techniques has become relatively common and has developed to the point

that the field now has its own publication: the Journal of Mixed Methods Research. Teddlie and Tashakkori (2009) point out that mixed methodologies assume that research is carried out by cycling between inductive and deductive stages and the use of mixed methods facilitates this. They also point out that the commonly used research process of triangulation assumes use of mixed methods, and the more distinct the methods the 'greater opportunities for accurate inferences' (Teddlie and Tashakkori, 2009:75). In the traditionally positivist field of management science, soft methods - broadly speaking interpretive - are becoming more popular and are beginning to coexist with hard methods (Rosenhead and Mingers, 2001). Mingers (2001) advocates the use of multi-methods, and even multi-paradigms, as real world situations are multi-dimensional and different methods can be used to focus on different aspects of their reality. Faulkner (1982) suggests using a 'triad' approach to research on the basis that variety in the phenomenon being researched requires a requisite variety in the methods used to carry out the research. Tashakkori and Cresswell (2008) similarly view the use of mixed methods as a response to the need to examine 'social phenomena in a more eclectic manner, utilizing multiple perspectives'. Benton and Craib (2001:114) in their study of the philosophy of science suggest that there are 'different types and levels of scientific activity...and that these can coexist with each other'.

Grounded theory is inductive in that it eschews commencing a research project with a preconceived theory, preferring instead to let the data speak atheoretically. It is interpretive in that theory is developed during the process of examining the data. However, through the process of constant comparison of data, grounded theorists are also engaged in deducing an understanding from the emergent data. Dacin et al (2010), for example, use a grounded theory approach to determine the theoretical structure underpinning formal dining at Cambridge colleges. The research team collected data using interviews and participant-observation; through a formal coding process they reduced the data into base categories; they then aggregated base categories into super-categories. While the second step in the coding process is interpretivist the first coding step is clearly reductionist. This is not surprising given the eclectic origin of grounded theory: Glazer's Columbia University positivism and Strauss's University of Chicago pragmatism (Charmaz, 2009). It is conceivable therefore that a technique from a positivist background such as entity-relationship

diagramming can find a home in the grounded theory stable. It should be noted however that recent developments in grounded theory have taken it in a more interpretivist and constructivist direction (Clarke, 2005; Charmaz, 2009).

Entity-relationship models are often built up by analysts and domain experts working together using a process of semantic analysis i.e. the analysis is based on determining the meanings of the constructs being examined and the associations between the constructs. There are many similarities between this analytical process and a typical grounded theory research project. Firstly, the project team are immersed in the situation being examined for long periods of time: weeks or months. Secondly, data for the model are often collected by interviewing a range of people who are involved in the situation¹. Locke (2001:65-66) describes similar top-down and bottom-up processes taking place in grounded theory projects. Thirdly, the boundary or scope of an entity-relationship modeling project is not always clear-cut and may change as the project evolves. Fourthly, there is often considerable discussion, and even disagreement, among the project team about the existence of and naming of entities and about the relationships between entities. Finally, it can be difficult to model certain aspects of reality, for example joint bank accounts i.e. bank accounts that are owned by more than one customer. It can be difficult to resolve the many-to-many relationship between bank accounts and customers: an account may be owned by one or more customers, and a customer may own one or more bank accounts. However, in order to progress the project and to deliver an information system, the entity-relationship modeling team must eventually come down on one particular interpretation of reality, even if the modeling team accept that a number of alternative views of that reality may exist. In this sense the entity-relationship diagramming approach is positivist: the development team must ultimately accept a single view of reality and propose to its steering committee that the entity-relationship diagram is a valid model of that reality. However, it is interpretivist in the way that it gets to that final model: by examining the meaning of the entities involved and if necessary examining a number of different views of that reality. Also, while the modeling team propose a final model for some, usually practical, reason - that it is the best fit, the

¹ An alternative approach exists: building up the data model from an examination of documents relevant to the situation being examined eg. forms, invoices, reports. The two approaches can also be used in tandem, one being used to confirm the other.

most practical, the cheapest to implement or that it provides most flexibility for the future - the team also accept that there may exist alternative views of that reality or at least of elements of that reality.

As we demonstrate in the paper there is a correspondence between the main elements of grounded theory - categories, dimensions and properties - and the entity-relationship diagramming elements of entities, attributes and values. However, entity-relationship diagramming also entails a formal mechanism for drawing relationships between entities. It is this formal diagramming of relationships, including their bidirectionality, cardinality and optionality, that we suggest could be a useful addition to the grounded researcher's toolkit. We are not however suggesting that grounded theorists should produce a fully-specified entity-relationship or data model. We only suggest that such a rigorous diagramming technique could aid in developing and understanding elements of the research situation under investigation. We see the entity-relationship diagramming technique primarily being used manually – using a whiteboard or flipchart – and only as a support tool in teasing out categories, properties and dimensions during a grounded theory research project. While software tools to support entity-relationship diagramming are widely available, for example Visio (Microsoft, 2008), we do not see their use as in any way essential². We suggest in the paper that entity-relationship diagramming strengthens a grounded theory research effort in that it combines analysis with representation (Clarke, 2005:8). It forces analysts to consider the cardinality and optionality of relationships between categories, and the bi-directionality of these relationships. It can also highlight elements of the research situation that may not be fully understood or developed such as one-to-one relationships between categories, many-to-many relationships between categories, and the existence of isolated categories; once highlighted, these elements can then be explored more fully.

The paper begins by briefly reviewing the grounded theory approach to qualitative research. The paper then discusses the entity-relationship diagramming technique as

² Note that many software packages exist to support qualitative data analysis (Atlas, 2008; MAXqda, 2008; QSR, 2008; Qualrus, 2008) but these do not support formal entity-relationship diagramming. See Miles & Weitzman (1994), Dohan and Sanchez-Jankowski (1998), Bazeley (1999), Bolden & Moscarola, 2000), Bourdon (2002), Richards (2002), Atherton & Elsmore (2007) and Robertson (2008) for a discussion of the use of computer aided qualitative data analysis software (CAQDAS).

used in the field of information systems analysis. The paper examines the parallels between the concepts of grounded theory and the entity-relationship diagramming technique and demonstrates the correspondence by applying entity-relationship diagramming to a narrative from an actual grounded theory research project. The paper then concludes by reflecting on ways in which entity-relationship diagramming could enhance the grounded theory approach in practice.

Grounded Theory Methodology

Qualitative research makes use of a variety of techniques to analyse and understand a particular situation in some depth; the techniques used are not usually quantitative or statistical (Strauss and Corbin, 1990:7). Denzin and Lincoln (1994) suggest the use of the French word *bricolage* (using whatever comes to hand to get the job done) as an analogy for qualitative research. Flick (1998:13) suggests that qualitative research methods are used to analyse and understand 'concrete cases in their temporal and local particularity'. Strauss (1987:2) suggests that '[q]ualitative researchers tend to lay considerable emphasis on situational and often structural contexts, in contrast to quantitative researchers, whose work is multivariate but often weak on context'. Qualitative research therefore tends to examine specific, complex, real-world situations using visual, aural, oral techniques rather than statistical. Flick (1998:13) summarises these tendencies in qualitative research: examining *particular* rather than general problems in *local* rather than universal situations in a historical, *timely*, context and relying greatly on *oral* material.

Grounded theory emerged during the 1960's as a specific way of carrying out qualitative research which sought to inductively generate theory where little is already known, rather than deductively from a priori assumptions (Glaser and Strauss, 1967; Glaser, 1978 and 1992; Charmaz, 1983 and 2007; Turner, 1983; Strauss and Corbin, 1990; Locke, 2001; Bryant, 2002; Goulding, 2002; Richardson and Kramer, 2006). While Glaser and Strauss first developed grounded theory in 1967 the field subsequently evolved in two directions with Glaser stressing the interpretive, contextual and emergent nature of theory development whereas Strauss emphasised complex and systematic coding techniques (Goulding, 2002: 47). The authors suggest that entity-relationship diagramming may be particularly useful to researchers adopting the Straussian approach to grounded theory inquiry.

Grounded theory methodology places strong emphasis on the systematic collection, coding and analysis of data. Development of theory from this data – i.e. theory grounded in data – is a key feature of the method. Grounded theory draws on the principles of symbolic interactionism, a principle tenet of which is that humans come to understand social definitions through the socialisation process (Goulding, 2002; Fendt and Sachs, 2008). Theory evolves during the research process and is a product of continuous interplay between analysis and data collection: the researcher is 'inductively building theory, through the qualitative analysis of data' (Strauss and Corbin, 1990:7). Bailey (1987:54) gives an example of dying patients: the variable *social loss*, defined as 'the degree of loss the patient's death will represent to his family and employer', emerged 'from the data during the course of the study' and the researchers 'probably could not have anticipated it prior to the study'.

Key to the success of a grounded theory research project is the 'theoretical sensitivity' of the researcher, that is the 'insight, the ability to give meaning to data, the capacity to understand, and capability to separate the pertinent from that which isn't' (Strauss and Corbin, 1990:42; Service, 2009). Grounded theory inquiry proceeds by theoretically sampling emerging data, where future directions and decisions concerning data collection are based upon prior knowledge and understanding. In this process of 'constant comparisons' data collection and data analysis continue in parallel. Three formal coding techniques are used to analyse data: open, axial and selective (Strauss and Corbin, 1990). Open coding involves fracturing the data i.e. breaking down the data into distinct units of meaning. Such a process allows the researcher to place specific 'phenomena' into groups giving rise to early concept development for the emerging theory (Loonam & McDonagh, 2008). This classification of concepts into specific groups is referred to as 'conceptualising' the data (Strauss and Corbin, 1998:103). Axial coding involves moving to a higher level of abstraction and is achieved by specifying relationships and delineating a core category or construct around which the other concepts revolve. Higher level concepts, known as categories, are related to their subcategories to form more precise and complete understandings of phenomena (Strauss and Corbin, 1998:124; Orlikowski, 1993). Selective coding is to 'refine and integrate categories' having reached a point of theoretical saturation (Strauss and Corbin, 1998:143). Concepts are saturated when

new data provokes no revision of those concepts. Broad themes about the phenomenon being studied are therefore classified into categories; specific characteristics pertaining to a category are identified and formally termed properties; dimensions of each property - its location along a continuum - are determined (Strauss and Corbin, 1990:61-74). These three elements - categories, properties, and dimensions - form the rudimentary elements of a 'grounded theory'. Such a rigorous specification lends itself to the supportive use of formal models (Dohan and Sanchez-Jankowski, 1998). This paper proposes the supportive use of one such formal model: entity-relationship diagramming.

Entity-Relationship Diagramming

Entity-relationship diagramming (ERD) is a technique used to model the data requirements of an organisation, typically by systems analysts in the requirements analysis phase of a systems development project. While ostensibly a diagramming technique or visual aid it provides the basis for the design of the relational database underlying the information system being developed. The entity-relationship diagram together with supporting detail constitute the data model which in turn is used as a specification for the database.

The main elements of an entity relationship model are entities, relationships and attributes (Watson, 2002:155; Lejk and Deeks, 2002:113). Entities are objects of interest in the area of the organisation being modeled. Taking a university as an example, lecturer and module would be reasonable candidate entities as shown in the sample entity-relationship diagram in figure 1. Data models in a complex organisational situation can become very large: models with over a hundred entity types are possible.

Entities are usually named as singular nouns and represented as cushioned rectangles in the entity-relationship diagram. A relationship is an association between two entity types and is represented as a straight line connecting two entities. The cardinality of the relationship is represented by a crow's foot symbol for 'one or more' and absence of a crow's foot for 'one'. Optionality is represented as a dashed line; a solid line is used to depict a mandatory relationship. In the example given below the relationship reads from left to right as 'a lecturer sometimes delivers one or more modules' where

the dashed portion of the line represents 'sometimes' and the crow's foot symbol represents 'one or more'. Note that relationships are bi-directional and the relationship also acts from right to left as: 'a module is always delivered by one lecturer' in this case 'always' is represented by the solid end of the line and 'one' is represented by the absence of a crow's foot. These relationship statements represent the 'rules' of the organisation. According to the rules of the organisation being modeled in this example lecturers may exist who do not deliver modules; however, a module, if it exists, must be associated with a lecturer who delivers it.

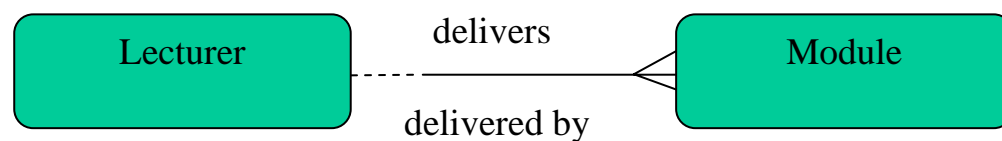


Figure 1: Entity-relationship diagram

Attributes give further detailed information about an entity type. For example, specific details required about a lecturer may be: surname, first name, room number, telephone number, email address, department, employment start date, age, and gender. Each of these specific items is an attribute of the entity type. Attributes and relationships represent the structure of an entity type. Attributes in turn have an internal structure, for example: name, type (numeric, alphabetic, alphanumeric), maximum length, and permitted values. For example, surname may be defined as alphabetic of maximum length 30 characters, gender as alphabetic with a maximum length of six characters and with permitted values 'female' or 'male'.

Several different styles of entity-relationship diagramming exist. In this paper we use the format suggested by Lejk and Deeks (2002:ch7) which follows on from the information engineering format (Martin, 1986:ch.2; Finglestein, 1992:ch.2; Bell and Wood-Harper, 1992:ch.6). This format is relatively easy to understand for readers new to data modeling as it allows only binary relationships between entity types and uses a straight line to depict this relationship. Alternative approaches allow n -ary relationships - a relationship between n different entity types - and use diamond-shaped boxes to depict relationships (Yourdon, 1989:235; Yourdon, 1993:49-69; Wieringa, 1996:148).

Correspondence between Grounded theory and ERD concepts

Clear parallels exist between the grounded theory and the entity-relationship diagramming approaches. Both are essentially a form of semantic analysis: analysis based on the meaning of the themes being explored. Data is gathered in a similar fashion under both methods: by observation, interviews with individuals, or by group workshops. Both approaches comprise several clearly differentiated levels of analysis: a classification level, a detailed structural level, a level depicting associations, and a level depicting allowable values.

The primary element of the classification layer in grounded theory is termed category and in the ERD approach is termed entity. Both of these terms are used to classify separate and unique themes of the study. The structural layer takes these themes and determines their detailed structure. In the ERD approach these detailed structural elements are attributes of the entity while in the grounded theory approach they are called properties of the category. The value layer in grounded theory is represented by the dimensions of a property and in the ERD approach by the permitted values of an attribute. The association layer in both approaches is represented by the word relationship: in grounded theory relationships exist between categories and in the ERD approach relationships exist between entities. These correspondences are summarised in figure 2.

<i>Level</i>	<i>GROUNDING THEORY</i>	<i>ERD</i>
Classification	Category	Entity
Structure	Property	Attribute
Value	Dimension	Permitted value
Association	Relation	Relationship

Figure 2. Correspondence of grounded theory and ERD elements

An application of entity-relationship diagramming to grounded theory

Strauss (1987:14) gives an example of the development of grounded theory from an actual study:

Imagine that in a study of whether and how the use of machines in hospitals affects the interaction between staff and patients, we observe that many machines are connected to the sick persons. We can formulate a category - machine-body connections - to refer to this phenomenon. Our observations also lead us to make a provisional distinction (which may or may not turn out to be significant after further research) between those machines where the connection is external to the skin of the patient, and those where the connection is internal (through various orifices: nose, mouth, anus, vagina). This distinction involves two dimensions of the machine-body category: internal and external connections. The basic operation of making those distinctions is *dimensionalising*. But since further distinctions can be made - either by thinking about previous observations or making new ones - the process of dimensionalising will continue. That is termed subdimensionalizing. Subdimensions may also be generated analytically by questions that sooner or later will occur to us about some of those distinctions. Thus, about the internal connections: Don't they - or at least some of them - hurt? Are they safe? Are they uncomfortable? Are they frightening? We can think of these subdimensions (hurt, safety, discomfort, fear) dichotomously - as yes or no - or as continua running from very much to not at all. Or we can slice up a continuum roughly into "more or less" subcategories, as for instance, terribly uncomfortable, very uncomfortable, a bit uncomfortable, not at all uncomfortable. (In quantitative analysis, continua can be given "values", running from 0 to 100). All of these subdimensions, subcategories, and questions come not only from inspection of field/interview data but, understandably from our experiential data (those orifices are sensitive, so that connection probably hurts: or, that tube looks horrible coming out of his belly, so is it really safe?).

We now produce a data model and entity-relationship diagram based on the information given in the above narrative. Candidate entities are: staff, patient, machine, and machine-body connection. Candidate relationships determined from the above narrative are as shown in figure 3; to keep the diagram simple relationships have not been named in both directions. No information is given about staff in the narrative and so no relationships for this entity can be proposed at this time. Further research would be necessary to determine whether a staff member is assigned to one or more machines or to one or more patients or to one or more machine-body connections; all of these relationships are feasible – further research would be necessary to determine which relationships are valid in the particular context being examined. It is clear that many machines can be connected to a patient at the one time i.e. many machine-body connections can exist, either simultaneously or sequentially; the two crow's feet in figure 3 indicate the relevant cardinality.

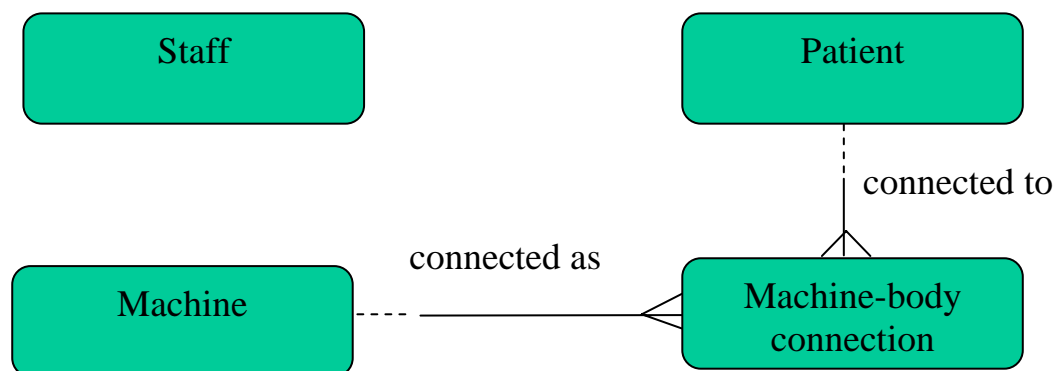


Figure 3: Entity-relationship diagram for hospital machine example

The structure of each entity can now be determined. Several aliases were used in the grounded theory narrative, for example patient and sick person are assumed to represent the one entity. No attributes for entities staff or patient were suggested: more research would be needed to determine these, assuming that they are important to the study. Several sets of permitted values are evident in the above narrative, e.g. internal connection can be to several allowable orifices - nose, mouth, anus, vagina. External connection location is not explicitly suggested as a property in the narrative; however, the fact that the internal connection orifice is important suggests that the external connection location may also be important; this suggests that some further research would be needed here. Details of the data model gleaned from the above narrative are summarised in figure 4.

The data model (entity-relationship diagram plus descriptive detail) produced so far poses questions for further research: Is 'connection type' an attribute of machine or an attribute of machine-body connection? For example, if a machine can be connected both internally or externally then it is an attribute of machine-body connection as the value will only be assigned when the circumstances of a particular instance are known. The data model detailed in figures 3 and 4 assumes that connection type is an attribute of machine i.e. a machine is capable of being connected internally or connected externally; machines that are capable of being connected both internally and externally are assumed not to exist; if this assumption is incorrect further research would be needed to determine if machines with multi-modal connections exist or are likely to exist in the future. Is the external connection location significant and if so do specific values exist e.g. right arm, left arm, right leg, left leg, back ...? Is another

attribute necessary to record where the connection entered below the skin e.g. tissue, vein, artery, muscle ...?

<i>Entity/ Category</i>	<i>Alias</i>	<i>Attribute/ Property</i>	<i>Permitted value/ Dimension</i>
Staff	Personnel		
Patient	Sick person		
Machine-body connection		Internal connection orifice	Nose, mouth, anus, vagina
		External connection location	
		Hurt experience	Terrible, very, somewhat, a bit, not at all
		Safety experience	Terrible, very, somewhat, a bit, not at all
		Discomfort experience	Terrible, very, somewhat, a bit, not at all
		Fear experience	Terrible, very, somewhat, a bit, not at all
Machine		Connection type	Internal, external

Figure 4. Data model detail

Note that the connection experience could also be modeled as a separate entity type rather than here as a set of attributes; this may be advantageous if several kinds of experience exist or could exist in the future. For example, if the discomfort experience changed over time one could record the initial level of discomfort and then the discomfort after one hour, one day and so on; to do this would require discomfort experience to be modeled as a separate entity (or in grounded theory parlance: as a separate category). It is interesting to note that in the above narrative Strauss refers to dimensions and sub-dimensions rather than properties and dimensions. This appears to be a departure from strict grounded theory format.

Reflections

Jones and Noble (2007) have suggested that grounded theory is in danger of losing its integrity having 'become so pliant that management researchers appear to have accepted it as a situation of "anything goes"' to the point where it has almost become a generic term for any qualitative research approach. They emphasise the need to instill more discipline into the approach by eliminating the 'laxity and disorder that currently prevails'. Use of a formal but well-known data modeling technique that forces a systematic approach to data analysis, such as described in this paper, could act as one such discipline.

While grounded theorists do use diagrams to visualise data and to aid in the research process (Strauss and Corbin, 1998:236) these diagrams are not always consistent and are infrequently used. For example, very few diagrams are contained in the book of research papers edited by Strauss and Corbin (1997) and several of the papers contain no diagrams at all. Bowen (2008) refers to a diagram that 'provided a visual representation of relationships among concepts' but does not give an example of its use. Padilla (1991) gives several examples of models which graphically depict concepts (which are broadly equivalent to categories or entities) and the relationships between them but again the diagramming approach is not standardised, even between the two concept model diagrams given in the paper. Crilly et al (2006) suggest the use of diagrams as visual elicitation stimuli during the interview stage of data collection. While many qualitative research software packages support some form of diagramming of data they use a proprietary diagramming convention and often model at instance rather than class level thus creating relatively cumbersome diagrams. However, it should be noted that Miles and Huberman (1994) strongly advocate the use of diagrammatic techniques as an aid in analysing qualitative data. Clarke's (2005) supplement to grounded theory – situational analysis – also recommends use of a variety of diagramming techniques in support of an interpretivist approach to research; Clarke emphasises relationality and puts forward a relational diagram (pp.104-5) not dissimilar to the entity-relationship diagrams suggested in this paper.

Entity-relationship diagramming may also provide a mechanism to bridge between the artistic and scientific aspects (Strauss and Corbin, 1998:13) of grounded theory

research as the model is both rigorous and graphic. Diagramming may also facilitate the process of conceptualisation of data and the hierarchical placement of concepts, particularly in moving from ‘fractured data’ to ‘categories’. It can also assist during the open coding stage when categories (entities) are discovered, and in the axial coding stage when relationships between categories (entities) are surfaced. During the process of axial coding entity relationship diagramming could provide researchers with unique support in identifying causal relationships and building a network diagram to reveal emerging concepts. The primary concern at this stage is ‘conceptualisation of data’ and it is useful for grounded theorists to have an eclectic array of tools to draw on for support. Diagrams and memos play a role in assisting researchers in documenting and visualizing the unfolding story: they “help the analyst to gain analytical distance from materials. They force the analyst to move from working with data to conceptualizing” (Strauss & Corbin, 1998: 218). Gasson (2004) supports the use of different tools in GTM stating that ‘a holistic view of any research question requires multiple approaches, as the selection of a research strategy entails a trade-off: the strengths of one approach overcome the weaknesses in another approach and vice versa. This in itself is a powerful argument for pluralism and for the use of multiple research approaches during any investigation’ (2004:99). Examples of other methods of inductive coding include, ‘discourse analysis, soft systems conceptual models, process modelling, and inductive categorisation’ (Gasson, 2004).

A diagramming technique such as ERD may be useful in several respects: simply being able to visualise the data in diagram form may aid the researcher - a picture being worth a thousand words (Bryans and Mavin, 2006); the very act of putting concepts down in diagram form during the research project may aid the researcher in thinking through the meaning of their data and the relationships between the data objects as they go along - the extended example used above demonstrated how formalising the data as a data model provoked several questions for further research. A diagram can be easily scanned visually and missing relationships or isolated entities quickly identified suggesting avenues for further research. Finally, the use of formal diagrams may also aid in presenting the results of the research to readers. These uses broadly correspond to Crilly et al’s (2006) suggested use of diagrams for ideation, elicitation and communication. This approach also supports Bourdon’s (2002) call for

the role of tools to shift from 'handy utensils to fully integrated parts of the very design of research projects'.

The entity-relationship diagramming technique yields more than diagrams however: it also yields a robust, precise and detailed model: relationships named in both directions, with their cardinality and optionality defined in both directions, with attributes defined for each entity and with permitted values defined for these attributes. While entities, relationships and attributes have a direct correspondence with grounded theory elements, optionality and cardinality are new concepts to grounded theory. This provides further detail on the nature of a relationship, adding useful additional specific knowledge of the 'rules' of the situation being examined. Interestingly, Richards and Richards (1994) suggest the teaching of 'data modeling on sociological methods courses - that might help to critique the current often meaningless use of diagrams in sociological literature'.

This brings us to a possible limitation in the use of entity-relationship diagrams as a supporting tool in carrying out a grounded theory research project. In information systems development entity-relationship diagrams are typically used in a positivist manner in that they specify a single agreed world view of the situation under concern. This is necessary in order to carry out their purpose in information systems development: to provide the specification for an organisation's data base and information system. Using an ERD in this manner could make it an unsuitable vehicle for detailing the nuances and multiple meanings inherent in a social science research project. Certainly this paper does not advocate attempting to build a full-scale entity-relationship diagram of the entire situation being examined. In any case it is unlikely that this would be possible or advisable: reducing a social situation to one single diagrammatic model runs the risk of aggregating away the multiple meanings that are inherent in a social situation. The paper primarily suggests using entity-relationship diagrams as a useful way of teasing out the meaning of small portions of the situation under exploration, and detailing these portions in diagram form such as shown in figures 3 and 4. This teasing out could lead to the development of several entity-relationship diagrams of the one situation, each representing the views of different actors. These different but precise views could then be used to interpret the underlying different views of reality. The precision of the technique allows these

different views to be precisely compared and the exact nature or nuance of the difference in views identified. Our final words are: use the technique only to the extent that it is useful, and do not use it where it is not.

Conclusion

This paper is seeking to contribute to the mixed methods debate, by highlighting the possible role of entity relationship diagramming in assisting grounded theory explorations. Interpretivist inquiries call upon many tools to assist the investigator with data collection. An eclectic mix of data collection tools is often heralded as an imperative for increasing study depth and breath. However, such a vast range of data can overwhelm prospective investigators, it therefore becomes vital that effective data analysis techniques are deployed. The grounded theory investigator is furnished with a clear data analysis coding strategy. To contribute to this strategy, the authors propose deploying an entity relationship diagramming technique. This technique may assist investigators in displaying and visualizing emergent data. Such illustrations could provide a more thorough exploration of prospective concepts and their relationships to other emergent concepts.

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