The Qualitative Report

Volume 7 | Number 4 Article 1

12-1-2002

Using Metaphor to Make Sense and Build Theory in Qualitative Analysis

Peter Aubusson
University of Technology Sydney, peter.aubusson@uts.edu.au

Recommended APA Citation

Aubusson, P. (2002). Using Metaphor to Make Sense and Build Theory in Qualitative Analysis. *The Qualitative Report*, *7*(4), 1-14. https://doi.org/10.46743/2160-3715/2002.1962

Using Metaphor to Make Sense and Build Theory in Qualitative Analysis

Abstract

This paper proposes analogical mapping as a strategy for data analysis. Research is often messy. Where it explores the unknown and follows unexpected paths it often generates unanticipated findings. Presented with extensive data and the initial analysis describing 'themes' the researcher asks, "What does it all mean?" Thus we are challenged to make sense of the world we see, to theorise and not merely describe. This report outlines a method of analysis using metaphor as a thinking tool to interpret findings from a study in education. In the study reported here, metaphor provided a means of analysis to delve deeply into the nature of a school system, to offer insights and to generate a tentative theory

Keywords

Analogy, Metaphor, Qualitative Analysis, and Educational Change

Acknowledgements

The author thanks Mark Cosgrove and Lyn Schaverien for their advice on the method considered in this paper.

Using Metaphor to Make Sense and Build Theory in Qualitative Analysis
by
Peter Aubusson±

The Qualitative Report, Volume 7, Number 4 December, 2002

Abstract

This paper proposes analogical mapping as a strategy for data analysis. Research is often messy. Where it explores the unknown and follows unexpected paths it often generates unanticipated findings. Presented with extensive data and the initial analysis describing 'themes' the researcher asks, "What does it all mean?" Thus we are challenged to make sense of the world we see, to theorise and not merely describe. This report outlines a method of analysis using metaphor as a thinking tool to interpret findings from a study in education. In the study reported here, metaphor provided a means of analysis to delve deeply into the nature of a school system, to offer insights and to generate a tentative theory.

Key Words: Analogy, Metaphor, Qualitative Analysis, and Educational Change

Introduction

Research, that genuinely explores the unknown can be messy (Chenail, 1997; Gunstone, White, & Fensham, 1988). As researchers, we are challenged to make sense of the mess sense (Chenail, 1997), to interpret the data and findings by identifying trends and theories to explain and predict. Roberts (1996, p. 244) has expressed reservations about research reports, and qualitative research in particular. He implies that they are often limited to description where they should create a fresh 'conceptual framework ... by understanding and explaining events and phenomena better, more deeply and more systematically'. This article outlines a method of qualitative interpretation, analogical mapping using metaphor, which aims to provide such conceptual frameworks and to facilitate the communication of ideas.

The metaphors discussed in this report, to illustrate this process of analysis, were used to interpret the findings of a case study of a school science department that was attempting change. First, the problem associated with analysing the large volume of diverse data produced in qualitative research is considered. Second, the case for analogical mapping as a device for providing a conceptual framework to interpret research findings is made, by considering analogy as a thinking tool and by proposing the use of analogical mapping as a means of interpreting data and research findings. Third, the process of analogical analysis is illustrated by its application to a case study of a school science department. Finally, the sequence of steps involved in the analogical analysis is summarised as an exemplar for application to other research.

The Problem

A school science department, eight teachers, was attempting to introduce a constructivist approach to its teaching of science. To understand the process of change I investigated the influences that affected these teachers as they attempted their change. Data were obtained, over more than 15 months. As researcher, I visited the school one day per week for the first eight weeks of the study, then four days per week for ten weeks and at least one day per week for the remainder of the study. During these visits I recorded observations in and out of science classes, interviews and discussions between researcher teachers and students, and collected artifacts. These research procedures, applied over a long period, are effective ways of finding out how a particular culture (in this case members of this school science culture) views their world. Hence, this research could be positioned cognitive anthropology (D'Andrade, 1995).

The change the teachers were attempting was a shift from a range of individual teaching approaches (including transmission and process-led approaches) to a constructivist teaching approach, specifically an interactive teaching approach described in Osborne and Freyberg, (1985). The way in which the constructivist teaching was in harmony with or discordant with these teachers' existing views of science education, and other policies, traditions and practices in the school became one focus of the study. The long term and varied techniques of data collection resulted in a massive, untidy mess of information, as is often the case in this type of research (Gunstone, White, & Fensham, 1988).

In an attempt to 'make sense' (Chenail, 1997) of this mess and understand the system being studied. The data was analysed as recommended by Erickson (1986) to identify influences on the attempted change. I mapped all the identified influences and used arrows among these to produce a web of interconnecting factors as a diagram. This attempt to describe and explain the function of the science education system produced an ever-growing network that graduated from A4 paper to A3 paper to a sheet of butcher's paper to sheets of butcher's paper stuck on my office wall. And, it never satisfactorily explained what was happening. The interconnectedness of all the varied factors in the system seemed to defeat this method of description and analysis. (A not uncommon experience, it seems, for many PhD students who embark on qualitative research.) The network produced was like an incredibly complicated food web where pulling any 'string' in the network eventually tugged at every other factor identified. It was a product only the researcher could love and one which failed to communicate my ideas to others.

The interpretation portrayed the complexity but failed to provide new insights to enrich or extend existing theory by merely offering 'a degree of complexity but little discovery' the analysis was at a low level of qualitative research according to criteria outlined by Kearney (2001, p. 146). I sought a different way of analysing and describing the data and findings through analogical mapping. Analogical mapping was not determined as the method of analysis *a prioi*. As argued below, however, this means of analysis was well suited to the underlying philosophy and purpose of the research that set out to interpret, understand and explain rather than merely describe. Thus the method of analysis is consistent with first principles proposed for judging the quality of analysis in qualitative research (Drisko, 1997; Garratt & Hodkinson, 1998; Seale, 1999).

Thinking

Analogies are valuable thinking tools because they allow unknown phenomena to be understood in terms of well know phenomena (Badcock, 1995). In science, for example, analogical reasoning is common place, a well respected way of thinking and modelling and often used as a device in communication (Dunbar, 1997; Eisenberg, 1992; Gentner et al., 1997; Holyoak & Thagard, 1995; Kurtz et al., 1999; Markman & Gentner, 1996). Consider Huygens view of light, for example, '(Light) spreads', he wrote, 'As sound does, by spherical surfaces and waves: for I call them waves from their resemblance to those which are seen to be formed on water when a stone is thrown into it' (cited in Eisenberg, 1992, p.144). Note that in this extract, the similarities between water waves and light are mapped one against the other identifying similarities and that these mappings provide insight into the nature of light (the unknown) through the well known and well understood phenomena of water waves. This analogical reasoning is a 'strong method' of reasoning, according to Kurtz et al. (1999), because it makes use of specific or abstract represented knowledge but its effectiveness depends on an appropriate source of knowledge being present. Thus, availability and selection of an appropriate analogue, as a source of knowledge, is critical in analogical analysis.

Mapping

Analogy is made up of two parts, the target analogue, which is the domain to be explained, and the base analogue, which is the domain that serves as a source of knowledge (Gentner, 1983, 1989). Both domain and base are analogues, things that are compared. If an analogy is to be valuable in producing knowledge, then the worth of the analogy does not lie simply in the overall number of similarities between target and base. The central requirement is that "a relational structure that normally applies in one domain can be applied in another domain" (Gentner, 1983, p. 156). Relational structures are attributes of the base and target that associate a similar causal relationship. They reveal a similar process and allow similar interpretations of base and target. Analogies may also have literal attributes Gentner (1983, p. 159).

The difference between a literal and a relational attribute can be illustrated by example. Aubusson and Cosgrove (1997) use the analogy of the teacher as nomad. The nomads served as the base and the teachers as the target. Consider the following selected attributes of the analogy. In the nomads' ritual (Bronowski, 1974), they traverse six rivers and accept high losses in their stock as a inevitable consequence of their way of life. Similarly, the teachers studied 'herded' their student cohorts through six years of secondary schooling. Each year their students had to 'traverse exams' and the teachers were tolerant of high rates of failure. The six rivers could be considered an attributes equivalent to the six years of secondary schooling but the number of obstacles, six, is merely a match of literal features with no explanatory power. By contrast, the acceptance of high culls by both the teacher and nomad as part of their way of life, suggests a causal relationship, derived from the nomad analogy, about the nature of schooling. The literal analogy provides a match that only illustrates a trivial similarity of appearance. By contrast relational similarities provide a system of connected knowledge for comparison.

The exploration of relational similarities allows the process of reasoning to be transferred from one domain to another, to infer causes and processes in a target analogue. Relational structures provide access to an existing knowledge system in the base. High order mappings (Gentner, 1983) generate deeper understanding of the target. Such deeper understanding characterises high-level qualitative research (Kearney, 2001). In analogical mapping, high-level interpretation is characterised by mapping relationships, reasoning and argument rather than the mere identification of similar attributes in objects. In selecting an analogy for mapping, then, we seek a metaphor with extensive relational correspondence rather than simply many similarities.

The problem of the initial analysis of the data in this research was that it merely described and communicated this description poorly. By contrast, analogical mapping provided a means to shift to a higher level of qualitative research (Kearney, 2001, p. 148) where interpretation of data might 'convey new meaning' or 'reveal something unknown'. Analogical mapping does this not by mapping a uncharted landscape but by viewing the landscape in another way, just as alternative maps, street maps, topographical maps, relief maps and land use maps reveal and explore different features of geography. In this way, it provides one path to 'discovery' - 'the presentation by researchers of new perspectives on … human phenomena', as defined by Kearney (2001, p.146).

Analogies can be mapped against phenomena (Gick & Holyoak, 1983; Hesse, 1966) to describe and identify: similarities - where there is a correspondence between the phenomena and analogy; differences - where the analogy and phenomena under study are fundamentally different; and ambiguities - inconclusive areas where the correspondence between analogy and phenomena is unclear. Analogical mapping provides a way of bringing an established, well-understood theory to bear on data about new situations and events. Gick and Holyoak (1983) recommend that analogical mapping be divided into two stages, an initial mapping and a second more extensive mapping. The purpose of the initial mapping is to find a analogue with a potential to provide insight into the target domain.

Initial Mapping

Initial mapping identifies the obvious general features of the phenomena, case or episode under study. It then looks for a match between these features in the target and base analogue. When this is found, the well-understood base analogue is elaborated in detail. This allows other similarities and differences between the target and base to be identified. These steps in analogical mapping are illustrated below.

Initial Mapping

The purpose of this initial mapping is to find an appropriate analogue to interpret the target (a school science department). The general features of the phenomena under study, the school science system, were identified (Aubusson, 1998). These were:

1. Complexity - a huge range of interconnected factors influenced what teachers did as they attempted change.
2. Stasis - despite the attempt to radically change, there was little long term change evident in the school. The teachers taught at the end of the study much as they had at the beginning, though minor variations emerged. This stasis appeared to result from dynamic resistance to change derived from the complex interconnectedness of factors in the system.

3. Unpredicatability and gradual subtle change (later described as evolution).

Using these features, analogues were sought which might provide insights into the science education system. These were then subjected to a first mapping seeking a one to one correspondence between these listed features and the analogue. Some were tried and rejected. Analogues were sought in chemistry and physics, for example. Le Chatelier's principle was mapped against these features of school science and, while it provided insights regarding equilibrium, it could not explain the characteristic of unpredictability. Similarly, inertia resulting from balanced forces seemed to lack the complexity and dynamism of the school system. An analogue was sought in biology because biology provided systems with these difficult to explain characteristics, 'living systems are characterised by a remarkably complex organisation ... (with) a steady-state balance in spite of much input and output. This homeostasis is made possible by elaborate feedback mechanisms, unknown in their precision in any inanimate system' (Mayr, 1988, p. 14). Thus a biological analogy suggested a potential to shift from models based on 'simple cause and effect to … thinking dealing with complex interactions' (Kelly, 1994, p. 2).

Homeostasis is built upon the connectedness within a biological system (a connectedness evident in the school system under study) and the ultimate level of biological 'organisation' is the ecosystem. In Miller's (1975) description of ecosystem, he identified the very factors identified in this case study of the school system: complexity, stasis, variation and, paradoxically, gradual change. In an ecosystem) everything is connected to everything; everything feeds back through the ecosystem on itself. The interconnectedness preserves the overall system. The natural tendency of any complex ... ecosystem is to maintain a dynamic steady state despite environmental stresses, changes and shocks. Even where stresses are too great ... a biotic community can evolve a new steady state in balance with changed environmental conditions (p. 77). This initial mapping revealed a good relational match and this suggested that an ecosystem might be a fruitfully explored as the base in an extended analogical analysis of the case study.

Detailed Mapping

Having established the one to one correspondence in this first mapping of general features, the next stage was a move to a more detailed mapping by mapping the school science system against an elaborate representation of an ecosystem. The purpose of this is to use what we know about an ecosystem to inform our interpretation of the school system. As a heath ecosystem was well known to me it provided a well-understood analogical base from which to identify attributes of an ecosystem. These attributes were identified and refined by eliminating literal similarities to expose similarities with potential as 'relational structures' (Gentner, 1983). That is, overlaps were sought which may reveal matching, causal relationships in the base that might be transferred to the target. Potential, relational features of the heath ecosystem (Aubusson, 1998) are stated briefly below:

- *Complexity* of interactions in that there are the many interrelationships among plants, animals and their surroundings.
- *Homeostasis* such as the heath's capacity for self-maintenance and perpetuation in spite of stresses.

- *Succession* where over a long time communities change their environment making it more suited to other types communities than themselves. Different stages of succession are present in different parts of the ecosystem at the same time.
- *Fitness* such as a sundew's carnivorous adaptation to impoverished soil.
- *Generation - regeneration*, in that the heath ecosystem generates itself from within through succession and regenerates itself in response to fire.
- *Opportunism* when for example the house mouse exploits the short term plentiful food and altered environment after fire resulting in a rapid growth in population.
- *Reproductive maturity* in that species, if they are to survive, have to pass on information present in their genetic code to successive generations.
- *Fragility* when changes in the frequency of fire can eliminate species.
- *Evolution* as organisms have evolved through natural selection of variations, generating fitter species.
- *Purpose* in that the organisms function as if there is an unconscious purpose, the survival of the species [after Plotkin, 1994] through such adaptations as the Banksia's production of nectar 'to' attract animals 'to' pollinate its followers.
- *Knowledge* present in the gene pool [after Plotkin, 1994] which enables it to respond to its environment).

This outline of ecosystem brings to the fore biological propositions of adaptation, evolution and interactions among organisms and their environment, These characteristics, paradoxically, maintain robust stasis but allow, fragile, unpredictable change.

These attributes of this ecosystem were then mapped onto the case study to identify the similarities, differences and ambiguities (after Hess, 1966). For the purposes of this paper, which only uses the case study to illustrate the method of analysis, only two mappings will be considered in brief. The first attribute, complexity, is a relational similarity, the second, purpose, illustrates ambiguity. These examples show how the well-known analogue provides an extensive knowledge base to interpret the case under study.

Complexity

This school science system is complex. The complexity could be seen in many different interacting features of the school's science education system. There were interactions among the following: the teachers competing views of purposes, teaching and learning; the different official (state syllabus and school program), taught and learned curricula; aspects of conflicting teaching/learning paradigms such as behaviourism, constructivism, objectivism and inquiry; the tension between the learning a set of science processes and knowledge acquisition; and aspects of school, science department and teacher practices unsympathetic to constructivism, such as methods of assessment and reporting. These complex interactions operated across organisational levels (state, school, science department and class) paradigms (views of teaching learning and teaching); and purposes (evident in teachers views, school programs and State syllabus). These complex interactions maintained the conditions such that little changed. The constructivist change teachers sought was counteracted by dynamic interactions in the complex system including: assessment processes emphasising the measurement of accurate recall rather than the social and individual construction of knowledge; the organisation of learning in fixed blocks of time rather than fexibility recognising that students have different backgrounds and capacities which, among other things, led to students requiring different amounts of time to learn; and remnants of behaviourism, such as learning described in terms of behavioural objectives, which reduced the indicators of cognition to simple predicted behaviours. The interconnectedness of these features produced a steady state system, stable and resistant to change.

Purpose

The teachers revealed that they held many purposes for science education which arise from competing pressures. These included that students, learn to think, learn science facts, work things out for themselves, learn process skills, appreciate science, perform well in exams etc. These purposes are eclectic and not always consistent with each other. By contrast, the ecosystem functions as if it has a single purpose. The organisms function as if their purpose is to ensure survival of the species. This notion of purpose in evolution has been contentious among biologists, according to Williams (1993) and Ayala (1993). Yet, natural selection serves a purpose (Ayala, 1993; Williams, 1993) though the preferred terminology for purpose is teleology or teleomy rather than purpose. Williams (1993) explains

...the designation of something as the means or mechanism for a certain goal or function or purpose will imply that the machinery involved was fashioned by selection for the goal attributed to it... This is a convention in general use already, perhaps unconsciously ... Thus I would say that reproduction and dispersal are the goals or functions or purposes of apples and that the apple is a means or mechanism by which such goals are realised by the apple trees. (pp.182-183)

The organisms in the heath ecosystem survive because everything that happens serves this survival imperative; for instance, setting seeds and growth responses to fire. This singular purpose, survival, in the heath seems to distinguish it from the science education system where the purposes identified in the case study are many and intentional. In purpose, the relationship between the analogue and this school science system seems inconclusive and requires further consideration.

Consider the three types of teleology in biology identified by Ayala (1993, pp.189-190). The first of these, intended teleology, is actions or objects that are purposeful in that the end state is consciously intended by an agent (for example, a person mowing a lawn or a lion pack hunting antelope). In the second, there is artificial teleology where objects are the result of purposeful behaviour (for example, a bird's nest or a knife). The third is natural teleology, in which features are not the result of the intended, purposeful action of an agent but natural process (for example, the wings of birds which serve an end, flying).

Purpose, an apparently inconclusive feature of the mapping, seems in the school science system to be intended but in the heath to be natural. However, like the adaptations in the heath, this school science system is also a natural teleology. If the purpose of education is to promote the survival of the human species through the transfer and development of knowledge across generations (and extended nurturing among humans has long been considered an adaptation by biologists) then science education (a part of this nurturing survival strategy) is a natural teleology. In purpose, there is a contentious parallel between this science education and the heath ecosystem analogue. In biology, natural selection, through courtship, has resulted in characteristics that are, other than in courtship, disadvantageous. Consider for example, the oversized tail feathers of the peacock, the huge antlers of the extinct Irish elk and the excessive bulk of the male sea lion. Has schooling similarly gradually evolved through selection to develop characteristics fundamentally inimical to its teleological purpose? For example, have its testing regimes, rigid timetables and timelines and packed curriculum evolved for sound reasons, such as ensuring rigorous education but might they inhibit the teleological, purpose - learning?

There may be some relational parallel that informs our understanding of schooling. However, the multiplicity of sub-purposes and the pre-eminence of intended purposes in the school science system, which may not contribute to this primary drive for survival, are not consistent with the ecosystem analogy. Analogy Conclusion

Mapping the heath ecosystem analogy onto the school science system identified relational similarities (e.g., complexity) and contentious features (e.g., purpose) and has resulted in an ecological model of stasis and change in education (Aubusson, 1998) Some similarities identified in the analysis provided insights into the functioning of school science and had implications for research. In particular, the ecological notions of reproductive maturity, adaptation and fragility can explain the varied impacts of attempted innovation in school science. Specifically, a 'new' teaching approach might thrive for a short time in a trial school, if supported by sufficient energy or in exploitation of opportunity, but it is unlikely to survive in the long term. Analogically, a new teaching approach is an exotic species, which has not evolved in the school to which it is introduced. It is less well adapted to the existing environment than are the established 'species', practices and procedures. It rarely reaches reproductive maturity, a point at which the ideas and practices are dispersed among other teachers and in other schools. It may flourish briefly but it is fragile and usually dies (Aubusson, 1998). In this article, the nature of purpose in an ecosystem has resulted a consideration of the purpose of schooling and raised questions about how the fundamental purpose may be derailed as a result of 'natural' selection.

Trusting Analogy

Although well established as way of thinking and interpreting the world, the formal application of analogical mapping in qualitative research in the social sciences is atypical. Hence an important consideration is how the trustworthiness and quality of analogical analysis may be judged. This is considered in detail in Aubusson (1998). I consider trustworthiness here to assert the quality of this research (as required by Drisko, 1997; Garratt & Hodkinson, 1998; Seale, 1999) but also to promote discussion on this novel method of analysis.

First, recognise that in this research, analogical mapping initially interprets principal findings and only then raw data sets. Thus a first step in establishing the worth of the analogical mapping depends on the same principles or criteria for collecting and analysing data outlined in the many articles and books on qualitative research (e.g., Drisko, 1987; Garratt & Hodkinson, 1998; Lincoln & Guba, 1985; Seale, 1999). This paper does not set out to provide a 'complete' report (after Drisko, 1997) of the data or research project. Rather it deals primarily with analogical. In early sections of this paper the principles guiding the selection and testing of the analogy against data and findings have been outlined. The reader is perhaps best placed to make a judgement on the value of the analysis based on this research report and its relevance to other settings (Seale, 1999). Nevertheless, researchers should make explicit their reasons for their interpretive judgements and provide evidence that these judgements have been subjected to scrutiny (Garratt & Hodkinson, 1998). Here, I will limit the discussion to just two strategies related to judging the worth of the analogical mapping (by means other than testing for its consistency and inconsistency with research data and findings, which has already been discussed). These two strategies are checking by participants, peers and experts; and interpreting other cases.

Expert, Peer, and Participant Checking

Analogical mapping sets out to communicate ideas and render phenomena more understandable. It follows that 'good' analogical mapping should help others to make sense of the phenomena under study. I set out to scrutinise the extent to which this was achieved as part of the research process by discussing data and my analysis with peers in a university research group, experts in science education and change, reporting the interpretation to the teachers involved in the study and reporting the analytical interpretation to meetings of other science teachers and academics. This procedure provided a check on the interpretation by those who shared direct knowledge of the phenomena, the teachers in the school studied, as well as those with knowledge of similar contexts, other teachers, members of the research groups and academics at conferences. The overwhelming response of these was the recognition of features of this analogy in their own contexts. Where criticisms were raised or alternative interpretations were suggested these were explored and tested against data and findings. The discussion of 'purpose' outlined in this paper was the result of one such criticism; a criticism which had to be tested against the data by looking for confirming and contradictory instances. Thus, one test of 'goodness' is peer review both by experts and participants in the research and evidence that alternative interpretations and criticism have been examined in light of data and findings.

Interpreting Other Cases

If the ecological interpretation is to be useful it needs to have relevance in settings other than that studied. One of my main concerns about the analogy was that it predicted both stagnation and the potential for radical change. Yet the metaphor was derived from a case characterised by stagnation and little change. In the ecological view proposed, organisms and particularly humans change aspects of their environment. (The first life on earth altered the atmosphere, plants change the moisture and organic content of soil, beavers build dams and humans shape the environment to meet needs and exploit opportunity.) So far, this ecological interpretation might suggest that the school and ecosystem only prevent change by selecting species/ideas that fit and maintain the existing system. However, the metaphor also suggests that change does, has and will occur.

In this research, the analogy was tested by reinterpreting findings of two well researched projects where significant change in the teaching of science had been reported, the Project to Enhance Effective Learning (PEEL) (see Baird & Mitchell, 1986; Baird & Northfield, 1992) and the Learning in Science Project (LISP) (see Bell, 1993; Bell & Gilbert, 1996). The interpretation of these two other cases is reported in detail in Aubusson (1998) and briefly in Aubusson and Cosgrove (1997) where it was concluded that the ecosystem metaphor, through introduced species and the application of energy and resources, could explain radical change as well as stagnation in a school system.

Limitations

There are many different ways of interpreting and reporting research. I do not assert that all research be analysed analogically. Indeed, all data and findings do not lend themselves to analogy. A well understood base analogue may not be available as a source of established theory. Even where available it may prove unproductive. Note that in this research a number of unproductive anologues were tried. When seeking dense, descriptions analogical mapping is not a substitute for phenomenology, phemoneography, narrative, and evocative or fictional accounts. Analogical analogy comes after initial analysis and reporting to provide another means of analysis and an alternative way to view the phenomena under study. Where the researcher is satisfied with the explanation yielded by other methods and judges that the outcomes of the research are evident and readily communicated then analogical analysis may be unnecessary. However, where a more parsimonious explanation is sought and clear grounded theory proves difficult to generate, analogical mapping provides a way of bringing established knowledge to bear on the problem. It provides another layer to interpret, communicate and increase understanding of human contexts. Used without a thorough, initial interpretation of the data, it is just as likely to mislead as to provide insights.

Qualitative researchers are usually very sensitive to the context bound nature of their research and findings, often leaving it to the reader to judge their applicability to other contexts (Seale, 1999). Yet, transferability is often important to consumers of research who want to make use of grounded knowledge in other settings (Drisko, 1997). In this research the metaphor was tested against two other similar cases. These two cases were selected for specific reasons, first they were dissimilar to the case under study in that they reported radical change but they were very similar to the case examined in this research in that they were promoting a very similar constructivist approach, in similar secondary schools, in similar settings. The use of metaphor (in this study, school science as ecosystem,) identifies key relational similarities between two sets of information. This brings to the fore features, principles, perhaps a comprehensive theory explaining data and findings. For example, aspects of evolutionary theory and ecology are tentatively proposed as a way to understand observations of school science in one school - one context, one setting. The metaphor provides a set of propositions that can then be considered in other settings. Discussions with researchers in the field of science education and educational change, as well as the examination of two other cases, indicate that the ecological metaphor provides an effective device for the communication of ideas. Many researchers have commented that they recognise that a similar interpretation has relevance to educational settings they have studied. However, further research is required before asserting any broad application to other examples of science education and attempted change.

Conclusion

Analogical mapping provided a means of interpreting the findings of a qualitative study and gave rise to unexpected insights into the nature of school science. Although analogical mapping need not rigidly follow a set of steps, the sequence of analysis in this study can be summarised as:

1. The key, general features of the target domain are identified. Here, the key features of the school case study were identified as complexity, stasis, and evolution.
2. A well understood base analogue is sought. Here it was sought in a range of disciplines including biology.
3. The target and base are compared to test for a match of the key general features. This is called the initial mapping.
4. The well understood base anaolgue, here the ecosystem, is then teased out in detail to identify its salient attributes.
5. The base is then used to interpret the target domain seeking similar, different and ambiguous relationships. Literal attributes are discarded. In this case the detailed attributes of a (heath) ecosystem are tested for a match in the school case study. This is called the detailed mapping. This purpose of this step is to provide new ways of thinking about or a conceptual framework for theorising about the case under study.
6. The analysis provides a conclusion. In short it answers the question, what do we now know about the case under study that we did not know before?

The analogical mapping not only rendered the data and system more understandable but also yielded a model, the ecosystem (well established in biology) to explain the nature of science education. It may suggest a theory of how 'sustainable change in school science might be achieved based on principles of ecology principles (Aubusson, 2002). Finally, it allows predictions, for example,

- that science education might progress through succession resulting in a mosaic of different forms of science education in different locations; and
- that as the science education ecosystem responds to change (however well intentioned) it may be expected to suffer degradation as well as progression, just as an ecosystem does.

References

Aubusson, P. (1998). *Towards an ecology of science education*. Unpublished thesis. University of Technology Sydney.

Aubusson, P. (2002). An ecology of science education. *International Journal of Science Education, 24*, 27-46.

Aubusson, P., & Cosgrove, M. (1997). *Teacher as technologist*. Paper presented at Australasian Science Education Research Association 28th Annual Conference, 4-7 July, Adelaide University of South Australia.

Ayala, F. J. (1993). Teleological explanations. In M. Ruse (Ed.), *Philosophy of biology* (pp.187-197). Englewood Cliffs: Prentice Hall.

Badcock, C. (1995). *PsychoDarwinism; The new synthesis of Darwin and Freud*. London: Harper Collis.

Baird, J. R., & Mitchell, I. J. (Eds.). (1986). *Improving the quality of teaching and learning: An Australian case study - The PEEL Project*. Melbourne: Monash University.

Baird, J. C., & Northfield, J. R. (Eds.). (1992). *Learning from the PEEL experience*. Melbourne: Monash University.

Bell, B. (Ed.). (1993). *I know about LISP but how do I put it into practice? Final report of the Learning in Science Project: Teacher development*. Hamilton: Center for Science and Mathematics Education Research, Waikato University.

Bell, B., & Gilbert, J (1996). *Teacher development: A model from science education*. London: Falmer Press.

Bronowski, J. (1973). *The ascent of man*. London: BBC.

Chenail, R. J. (1997). Keeping things plumb in qualitative research. *The Qualitative Report, 3*(3). Retrieved February 17, 2002, from http://www.nova.edu/ssss/QR/QR3-3/plumb.html

D'Andrade, R. G. (1995). *The development of cognitive anthropology*. Cambridge: Cambridge University Press.

Drisko, J. W. (1997). Strengthening qualitative studies and reports: Standards to promote academic integrity. *Journal of Social Work Education, 33*, 185 -197.

Dunbar, K. (1997). How scientists think: On-line creativity and conceptual change in science. In T. B. Ward, S. M. Smith & J. Vaid (Eds.), *Creative thought* (pp. 461-493). Washington, DC: American Psychological Association.

Eisenberg. A, (1992). Metaphor in the language of science. *Scientific American, 266*, 144.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed.) (pp. 119-161). New York: Macmillan.

Garratt, D,. & Hodkinson, P. (1998). Can there be criteria for selecting research criteria? A hermeneutical analysis of an inescapable dilemma. *Qualitative Inquiry, 4*, 515-539.

Gentner, D. (1983). Structure mapping: A theoretical framework for analogy. *Cognitive Science, 7*, 155-170.

Gentner, D. (1989). The mechanisms of analogical learning. In S. Vasniadou & A. Ortony (Eds.), *Similarity and analogical Reasoning* (pp. 199-241). London: Cambridge University Press.

Gentner, D., Brem, S., Ferguson, R., Wolff, A. Markman, A. B., & Forbus, K. (1997). Analogy and creativity in the works of Johannes Kepler. In T. B. Ward, S. M. Smith, & J. Vaid (Eds.), *Creative thought* (pp. 403-459). Washington, DC: American Psychological Association.

Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*, 1-38.

Gunstone, R., White, R. T., & Fensham, P. J. (1988). Developments in style and purpose of research on learning of science. *Journal of Research in Science Teaching, 25*, 513-529.

Hesse, M. (1966). *Models and analogies in science*. Notre Dame, IN: Notre Dame Press.

Holyoak, K. J., & Thagard, P. (1995). *Mental leaps: Analogy in creative thought*. Cambridge: Bradford.

Kearney, M. H. (2001). Levels and application of qualitative research evidence. *Research in Nursing and Health, 24*, 145-153.

Kelly, K. (1994). *Out of control: the new biology of machines*. London: Fourth Estate.

Kurtz, K. J., Gentner, D., & Gunn, V. (1999). Reasoning. In B. M. Bly & D. E. Rumalhart (Eds.), *Cognitive science* (pp. 145-200). San Diego: Academic Press.

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. New York: Sage.

Markman, A. B., & and Gentner, D. (1996). Commonalities and differences in similarity comparisons. *Memory and Cognition, 25*, 235-249.

Mayr, E. (1988). *Toward a new philosophy of biology: Observations of an evolutionist*. Cambridge, Massachusettes: Belknap.

Miller, G. T. (1975). *Living in the environment: Concepts, problems and alternatives*. Belmont: Wadsworth.

Osborne, R., & Freyberg, P. (1985). *Learning in science: The implications of children's science*. Auckland: Heinemann.

Plotkin, H. (1994). *The nature of knowledge: Concerning adaptations, instinct and the evolution of intelligence*. London: Penguin.

Roberts, D. (1996). What counts as quality in qualitative research? (Guest Editorial). *Science Education, 80*, 243-248.

Seale, C. (1999). *The quality of qualitative research*. Thousand Oaks: Sage.

Williams, G. C. (1993). Adaptation and natural selection. In M. Ruse (Ed.), *Philosophy of biology* (pp.182-184). Englewood Cliffs: Prentice Hall.

Author Note

[+]*Dr Peter Aubusson* is associate professor in science and technology education at University of Technology, Sydney where he is a member of TLD, (Teachers, Learning and Development Research Group). His main research interests are educational change and developments in science and technology education. He can be contacted at Faculty of Education, University of Technology Sydney and his email is: Peter.Aubusson@uts.edu.au.

Acknowledgements

The author thanks Mark Cosgrove and Lyn Schaverien for their advice on the method considered in this paper.