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Computer Aided Phenomenography: The Role of Leximancer Computer Software in Phenomenographic Investigation

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Abstract

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Keywords

Qualitative Research Methodology, Phenomenography, Computer Data Analysis, and Leximancer

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The qualitative research methodology of phenomenography has traditionally required a manual sorting and analysis of interview data. In this paper I explore a potential means of streamlining this procedure by considering a computer aided process not previously reported upon. Two methods of lexicological analysis, manual and automatic, were examined from a phenomenographical perspective and compared. It was found that the computer aided process – Leximancer – was a valid investigative tool for use in phenomenography. Using Leximancer was more efficacious than manual operation; the researcher was able to deal with large amounts of data without bias, identify a broader span of syntactic properties, increase reliability, and facilitate reproducibility. The introduction of a computer aided methodology might also encourage other qualitative researchers to engage with phenomenography. Key Words: Qualitative Research Methodology, Phenomenography, Computer Data Analysis, and Leximancer

Introduction and Background

As students enter tertiary study with varying levels of literacy, tertiary institutions provide a variety of support mechanisms and programs to develop academic literacy skills (e.g., reading, writing). These are predominantly directed towards correcting problems which are evidenced in the students' early work. Although this has its use, students also need to be encouraged to be proactive in raising and refining their academic literacy skills prior to submission of their first assignments. Students will only access such literacy aid if they share the same understanding of what literacy is and if they recognise that their levels of skill could be further enhanced. A study aimed at identifying the conceptions of a range of terms relevant to academic literacy held by beginning university students enrolled in a teacher education degree program in an Australian tertiary institution was undertaken.

The relatively large number of written responses (274) prompted me to experiment with a computer aided form of analysis to streamline the traditional manual phenomenographic analysis process. Reporting on the data of the survey and on this methodological experiment was lengthy and divided into two papers. In this paper I report only on the two methods of lexicological analysis used with one set of data for illustration. The full data of the study is to be reported elsewhere (Penn-Edwards, 2009).

The data from a recent survey to ascertain how beginning pre-service education students conceive of the phenomenon of literacy was analysed using phenomenographic techniques as described by Marton (1994). Phenomenography is a qualitative research approach, aiming to capture and analyse lexigraphically subjects' qualitative observations and perceptions of events and propositions. It emerged from studies undertaken by Ference Marton and the Gothenburg School in the early 1980s which focused on the *experiences* of learning and teaching

Phenomenography is grounded in a distinct theoretical framework with an accompanying research methodology. It is a qualitative exploration of how a specific phenomenon is experienced by a group of people, each of whom may perceive the

phenomenon from a different standpoint. In education, the phenomenon under study may be a process or an act, such as that of learning or teaching. Here, researchers seek to qualitatively describe the subjects' expressed understandings or "accounting practices" (Säljö, 1997, p. 184) of the process. In phenomenography various tools of inquiry can be used to collect data in order to pursue investigation into the subject's conceptions of the phenomenon and aiming to "describe differences between conceptions" (Dahlgren & Fallsberg, 1991, pp. 151-152). In this study the researcher explores how beginning tertiary students in Education programs at an Australian university conceptualise the phenomenon of literacy, that is, what do they think the role of literacy is in learning and education.

The phenomenographic analysis of data is usually undertaken by the manual sorting of concepts inferred from transcripts into descriptive categories. This process is "a strongly iterative and comparative one, involving the continual sorting and resorting of data, plus ongoing comparisons between the data and the developing *categories of description*, as well as between the categories themselves" (Åkerlind, 2005, p. 324). The objective is to develop a coherent visual mapping or outcome space of the minimum number of categories which include all the variations in the data but also to demonstrate an internal consistency. The sorting process is time consuming and whilst it is seen as necessary in order to be reiterative and comparative, it provides an opportunity for analysts to be immersed in the data to better order and identify categories of description. The amount of data to be analysed generated by lengthy or multiple interviews can be overwhelming but the development of a computer software package, Leximancer, would appear to offer a fast, efficient method of sorting large amounts of transcripted data and identifying expressed concepts.

The Leximancer package was created by Dr. Andrew Smith in 2000 and contains techniques adopted from the areas of "computational linguistics, network theory, machine learning, and information science" (Smith, Grech, & Horberry, 2002, p. 1), in order to search or mine text automatically or through hand-seeding parameters devised by the user to identify "key themes, concepts and ideas" (Leximancer, 2007). It is a form of content analysis which "employs two stages of co-occurrence information extraction—*semantic* and *relational*" (Smith & Humphreys, 2006, p. 262). It aims to "make the analyst aware of the global context and significance of concepts and to help avoid fixation on particular anecdotal evidence, which may be atypical or erroneous" (Smith & Humphreys, p. 262). An important aspect of the automatic mining of the data is unsupervised ontology discovery (Smith, 2003, p. 23), that is, the results of analysis may contain "unexpected relationships that may be relevant to the user's investigation" (Watson, Smith, & Watter, 2005, p. 1234).

In its developmental process Leximancer was used to analyse "sets of newspaper articles, a 50Mb sample of Usenet news posting, a 100Mb collection of job tracking list text data, the novel *Pride and Prejudice*, the King James Bible, and 50Mb of Federal Court judgements" (Smith, 2000, p. 3). Although a relatively unacknowledged analytical tool in methodological discussions, in practice it has been used to analyse message board transcripts (de la Varre, Ellaway, & Dewhurst, 2005), print media reports (Isakhan, 2005; Liu, 2004; Scott & Smith, 2005), accident reports (Grech, Horberry, & Smith, 2002), patient case studies (Watson et al., 2005), policy documents (Rooney, 2005), report form filings (Martin & Rice, 2007), interview transcriptions (Connolly & Penn-Edwards, 2005; Grimbeek, Bartlett, & Loke, 2004; Loke & Bartlett, 2003), and written surveys (Davies, Green, Rosemann, & Gallo, 2004)

Leximancer is used in the same areas of interest as phenomenography, such as education, and with the same type of data (interview transcriptions and written responses). There would appear to be some parallelism between that which Leximancer can provide and that which a phenomenographer seeks to discover. Curiously, although Leximancer has been available for a number of years, it seems not to have appeared in the literature for use as a

phenomenographical tool. It is reported only by the author collaborating with Connolly (Connolly & Penn-Edwards, 2005) and by research student Ferrers (2005, 2007), as part of a mixed methodological research assignment.

The study, the topic of this paper, was an opportunity to analyse data using both manual phenomenographic analysis techniques and Leximancer software and to compare the processes and findings to determine if, and how, they may be used together. If Leximancer can be shown to provide an analysis of a set of data which is comparable to a manual phenomenographic analysis of that data then there is some justification for arguing its use as a phenomenographic tool. This would be breaking new methodological ground and would invite other phenomenographers to validate the use of this software with their own data. It may also encourage researchers who may have dismissed phenomenography as a method of analysis for large amounts of data to apply a Leximancer aided phenomenographic analysis.

Analysis of Data

On the first day at university during Orientation week in Semester One 2006, prior to their introduction to any course material, 309 first year education students in a Queensland university responded to a survey requiring short written answers, of which 274 provided an answer to the question under focus. Ethical clearance was granted by the University Office for Research with each participant granting permission on a standard privacy statement after being assured that their responses would be anonymous to ensure confidentiality.

Out of the total 274 responses there were 89 (32%) from secondary (English major) pre-service teacher education students and 185 (68%) from primary pre-service teacher education students. Ages ranged from 17 to 47 years old with 16% males and 84% females.

Although the number of subjects in a phenomenographic examination can range from 15 to 20, Trigwell (2000) acknowledges that the small number is more a pragmatic consideration in dealing with long interviews than a general methodological one as "more than twenty transcripts from interviews as long as sixty minutes is a lot to wrap a brain around in one go" (p. 66). It follows that larger numbers of subjects are acceptable provided the data can be handled because the basic principle of phenomenography remains that "whatever phenomenon or situation people encounter, it is possible to identify a limited number of qualitatively different and logically interrelated ways in which the phenomenon or the situation is experienced or understood" (Marton, 1994, p. 4425).

In a phenomenographic survey the questions are open-ended. This encourages a response on how the phenomenon is conceived or as Bowden (2000) describes, it allows respondents to "decide on those aspects of the question which appear most relevant to them" (p. 8). The form of the questions is "designed to be diagnostic in order to reveal the different ways of understanding the phenomenon within that context" (p. 8). In the study reviewed, respondents were asked to write briefly answering several questions. The question, *What do you think the role of literacy is in learning and education?,* is commented on here.

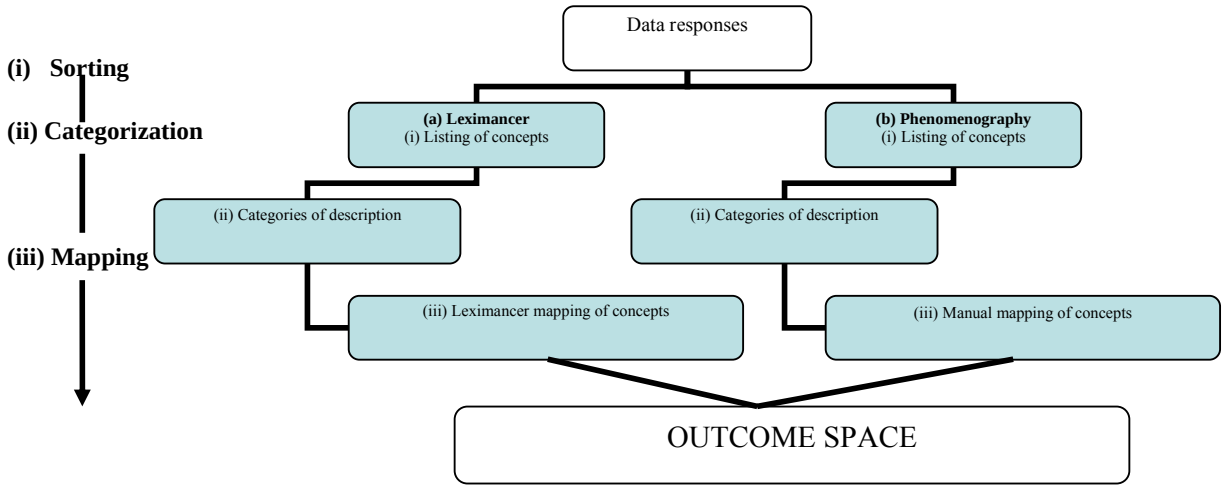
Overview of parallel analysis process

The analysis of data was undertaken in three steps (see Figure 1) with two parallel processes carried out independently of each other yet simultaneously: (a) Leximancer (automatic) and (b) phenomenography (manual):

(i) Sorting of data: The raw data responses were sorted in parallel, (a) by being run through the Leximancer software which identified phrases expressing similar ideas becoming *concept clusters*, and (b) by selecting responses which were first manually clustered into thematic groupings and then consolidated.

(ii) Categorization of conceptions into categories of description: The final groupings of data responses in (a) sorted by Leximancer and (b) sorted manually, were then nominated as categories which appeared to express a coherent concept of the role of literacy, that is, "whenever there was sufficient evidence that a particular overall meaning had been expressed" (Marton & Pong, 2005, p. 337). These categories were then scrutinised in order "to identify within each unit [category] the elements of the phenomenon that were focused upon, and to devise a description of each conception" (Marton & Pong, p. 337) using terminology selected from the responses. These are termed categories of description in phenomenography.

Figure 1. Analysis processes



(iii) Mapping and identification of an outcome space: The relationship of the categories of description to each other is determined, (a) automatically by Leximancer from the data analyzed and (b) manually with the data analyzed phenomenographically. As the aim of phenomenography is to identify a set of qualitatively different conceptions held by members of a group when sharing the experience of the same phenomenon, logical relationships were established between the developed categories of conception and displayed in a hierarchically structured map known as an Outcome Space illustrating how "different experiences of the same object [are] related to each other" (Marton, 2000, p. 108). Because the resulting two maps arising from the automatic and manual processes proved to be close versions of each other they were integrated and rationalized into a finalised Outcome Space for that set of data.

Analysis process (a) using Leximancer

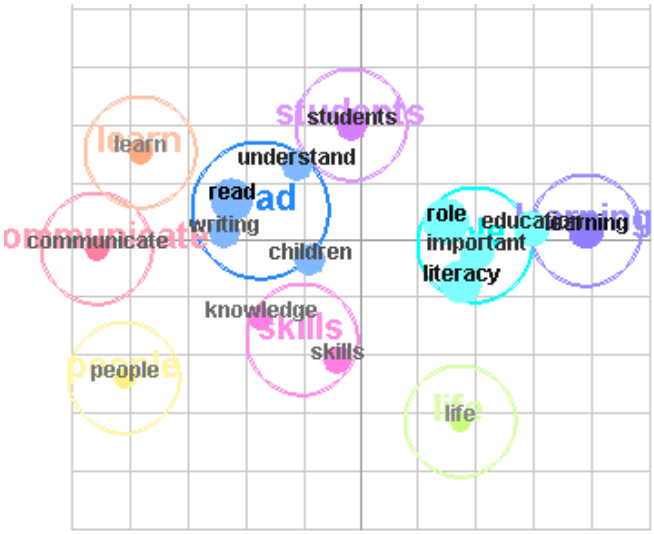
(i) Sorting of concepts: The 274 raw written data responses were uploaded into the Leximancer software for the program to sort and index conceptions into groupings having common key terms or associations in a way similar to the iterative and comparative manual phenomenographic process. The default settings for the program for the total number of concepts, number of names, learning threshold and so on were used except for lowering the sentence per learning block for the analysis from three to one as these were short answers not long interview transcripts.

(ii) Categorization of conceptions into categories of description: Leximancer was instructed to merge terms used by respondents, which for the purposes of this study were deemed to be indicative of the same concept, such as *write* and *writing, read* and *reading, understand* and *understanding.* However, *written* was usually used by respondents in reference to a text, a product, rather than in the sense of the skill of write(ing) and so was considered a separate concept. Leximancer gave these mergers the single headings of *writing, read,* and *understand.*

Leximancer produced a list of 16 key concepts. In order of declining occurrence these were *learning, role, literacy, education, important, students, children, read, skills, understand, writing, communicate, knowledge, people, learn,* and *life.*

(iii) Mapping and identification of an outcome space: The relationships of these groups of concepts to each other are shown plotted on the Leximancer map (Figure 2). Here "entity concepts are clustered according to weight and relationship, to create a concept cluster map" (Grech et al., 2002, p. 1719). The "concepts are contextually clustered on the map, that is, concepts that appear together frequently in the text or in similar situations will be close together on the map" (Leximancer Manual – Version 2.2., 2005, p. 16). The map is produced in colour with concepts sharing a theme in the same colour as their cluster group circle and cluster label. For example, in Figure 2 the dots indicating the concepts *knowledge* and *skills* are pink as is the cluster circle and its label *skills.* The written labels for individual concepts are shown ranging from black to grey with intensity of blackness indicating its relative frequency in the text, for example, *students* is given in a stronger black than *life.* Note that in this figure the concept label *read* is overlaid by *read/writing, role* by *important/education,* and *learning* by *education/learning*. Parameters of rank, percentage, and frequency figures are tabled, and a library of reference terms produced and stored which are available if required.

Figure 2. Leximancer mapping of concepts



Of the 16 concepts identified by Leximancer, six were discarded by the author after detailed analysis of the relevant identified sections of the transcripts. The terms *role, literacy,* and *education* were used liberally by the students in their paraphrasing of the question, "*What do you think the role of literacy is in learning and education?"* within their responses and these did not aid in discriminating between concepts. The terms *students,*

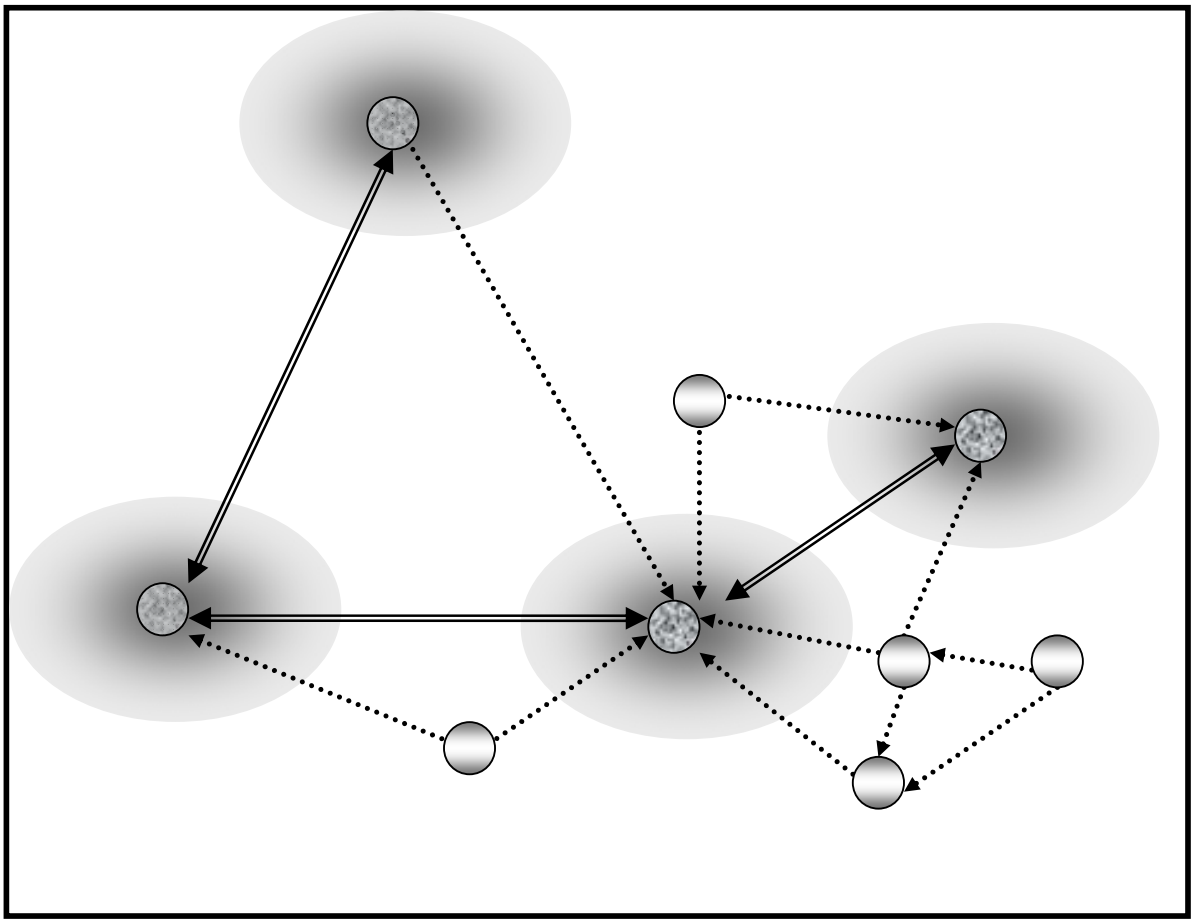
children, and *people*, were also discarded as in responding to this question students, of necessity, had to refer to a subject and used terms interchangeably. As these six terms were not considered *concepts* with regard to the phenomenon in question they were not included in any further steps of the analysis. *Learn* was merged with *learning*, thus leaving nine concept clusters: *learning, important, read, skills, understand, writing, communicate, knowledge,* and *life.*

Manual validation of Leximancer mapping - Researcher's addendum

As a researcher I attempt to have a clear conceptual understanding of each stage of my analysis, but when working with software a complete understanding is not always possible. As a phenomenographic study culminates in a visual representation of the categories of description of the conceptions found in the data, the mapping by Leximancer of the three dimensional relationship between concept clusters calibrated using various parameters of rank, percentage, and frequency onto a two dimensional map (Figure 2) was difficult to grasp at first. It is not the reliability of the mapping that I question as Leximancer presents "a high level of coding stability" (Leximancer Manual – Version 2.2, 2005, p. 22) and a map can be generated from the raw data as many times as desired, although a stochastic process showing possibly "different final positions for the extracted concepts each time" (Leximancer Manual – Version 2.2, p. 22) will present stable features. It was validating that the mapping procedure was aligned with phenomenographic practice.

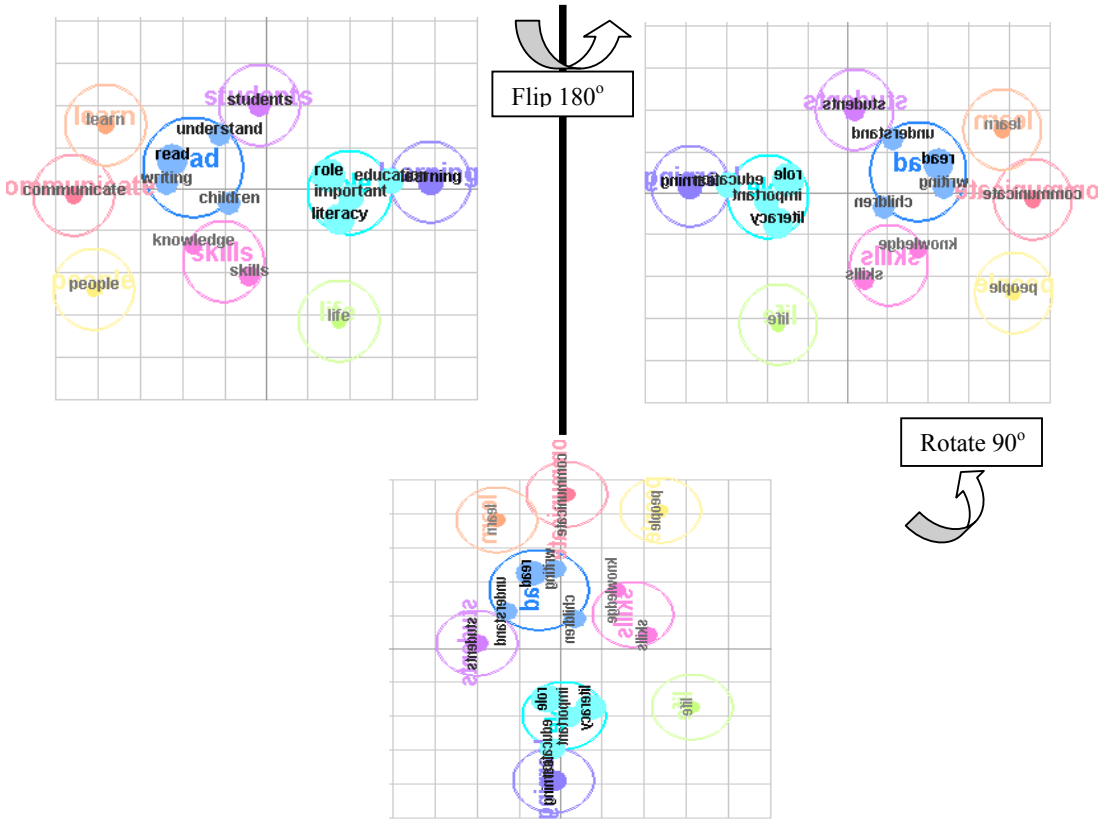
As the aim is to interrogate Leximancer as a tool, the association of the strongest relationships between linked concepts identified by Leximancer (e.g., the term *read* was used most often by respondents in conjunction with the term *writing* and vice versa) was carried out by an additional manual mapping (Figure 3). The nine concepts were considered manually identifying the strongest relationships between linked concepts with an arrow indicating a strong co-occurrence of a concept with another. These may be in a relationship where they are mutually co-occurring, such as where the concept *read* co-occurs most often with *writing,* and *writing* most often with *read* (identified in Figure 3 with a two headed double line arrow connection (⟺), or where they are non-mutually co-occurring (identified in Figure 3 with a dotted arrow connection (·····►). The latter has a single arrow head with directionality from the concept with the highest co-occurrence, such as where *knowledge* co-occurs most often with *understand (*single arrow head connection directed from *knowledge* to *understand)* but *understand* occurs most often with other concepts, in this case with *read* and *communicate.* Plotting these co-occurrences manually resulted in a diagram (Figure 3) which was then compared to the Leximancer produced map (Figure 2).

Figure 3. Manual mapping of Q1. Leximancer identified concepts



It was found that by flipping the Leximancer map (Figure 2) along the vertical axis, then rotating by 90^{o} as shown in Figure 4, the relative placements of the concept clusters and their relationships to each other were essentially the same as shown in the manual mapping.

Figure 4. Flipping the Leximancer map (Figure 2) along the horizontal axis, then rotating by 90°



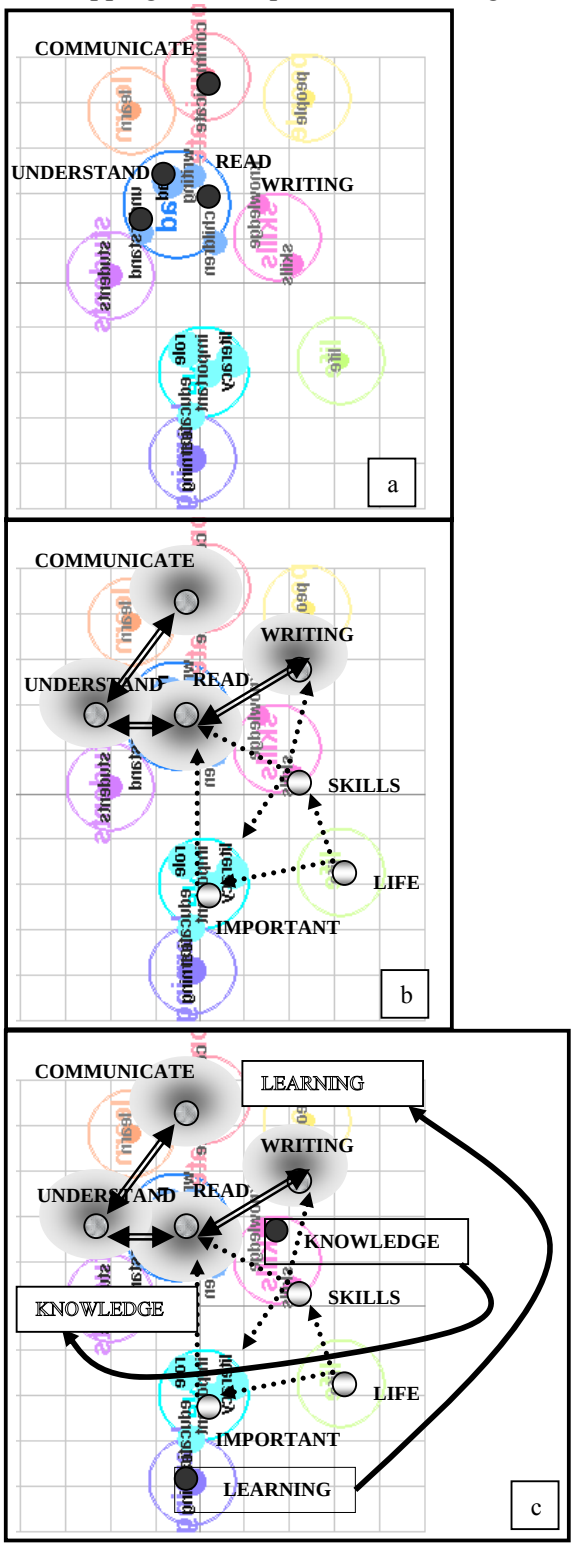
The manual mapping (Figure 3), showing the more basic attractions between concept clusters conceptualised in a two dimensional space disregards the three dimensional pulls between them which the Leximancer map factors in. Figure 5 shows that for graphic simplicity and to enable clear arrow connections to be drawn, the placements of *read* and *writing* are slightly modified (Figures 5a-b), as has been *knowledge*, and *learning* (Figure 5c).

This congruence of the relative placements of the concepts on the manually produced map and the Leximancer map was to be expected as the placements were both constructed from the relative pull of concepts "on each other … with a strength related to their co-occurrence value" (Leximancer Manual - Version 2.2, 2005 , p. 7). Undertaking this process however, validated, to me as a phenomenographer, that Leximancer is an acceptable phenomenographic tool. Working through the data and providing myself with a two dimensional map (Figure 3) of the three dimensional plotting of concept connections presented by Leximancer (Figure 2) also allowed a conceptual grasp of the connections.

In the last stages of writing this paper I was fortunate enough to correspond with the creator of Leximancer, Andrew Smith, who advised me that an adjustment of parameters may have lead to an identification of some of the additional categories later found by hand and that,

> the latest releases [of Leximancer] … have increased the number of auto-selected concepts to go deeper down into the conceptual hierarchy. The top level concepts stay the same. (Andrew Smith, personal communication, August 15, 2008)

Figure 5. Projecting the manual mapping of concept clusters onto Figure 2 Leximancer map



Analysis Process (b) Using Phenomenography

(i) Sorting of concepts: In parallel with the above analysis, a manual process was carried out starting again with the 274 raw data responses which were sorted into 18 collective groups of expressed conceptions (Table 1, Column 1) and then identified by abstracting a key word from the data in that group. In the case of three groups in which responses were couched in terms of comprehensive generalities, generic descriptions were adopted: *foundation* for *major, vital, basic, building block; a means* for *process, medium, link, delivery, method, tool*; and *everything* for those that listed most or all of the other concepts.

(ii) Categorization of conceptions into categories of description: Following the iterative nature of phenomenographical analysis the data was further able to be consolidated into nine categories (Table 1, Column 2) many of which aligned with the nine Leximancer concepts (Table 1, Column 3) although not directly one to one.

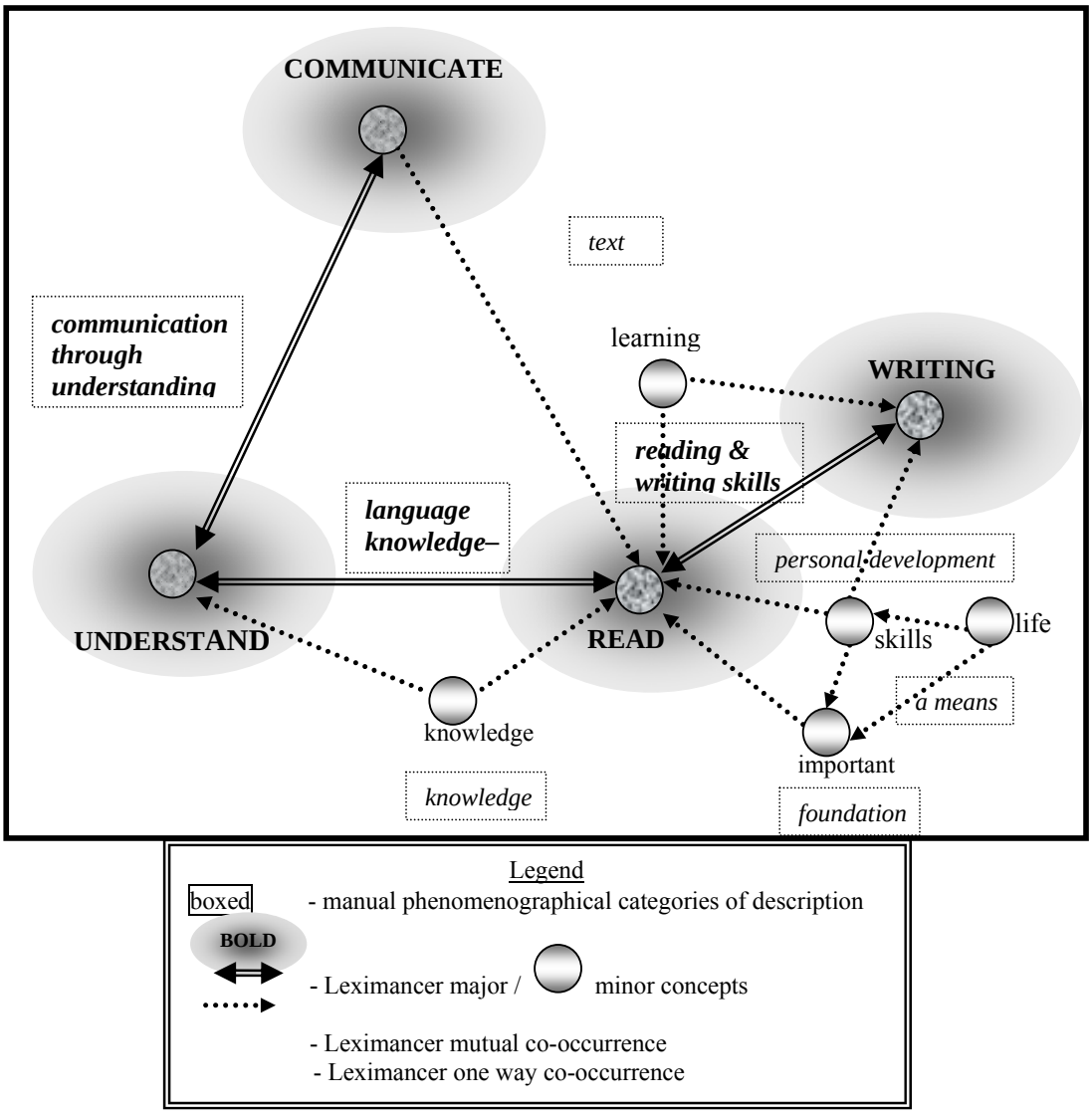
Table 1

Data groups and categories of description compared to Leximancer concepts

Phenomenographic Groups of data – key words (18)	**Phenomenographic** Categories of description (9)	Alignment with **Leximancer** concepts (9)
• Reading, writing undertake tasks/subjects teacher, teaching	Reading and writing - skills	Read, writing, learning
• Texts (written) • genres, medias	Texts	No matching concepts (but implicit in *read, writing* concepts above)
• English • language	Language knowledge: English as a language and language in general	Knowledge (first meaning)
• Communication • Understanding, express, expression	Communication through understanding	Understand, communicate
• Life skill • personal growth/development/awarenes s	Personal development	Life skills
• Gain knowledge, information	Knowledge	Knowledge (second meaning)
• Major/vital/basic • building block	Foundation	Important
• Process/medium/link • Delivery/method/tool	A means	No matching concepts (but implicit in *communicate, life skills* concepts above)
• Everything	Combinations of most or all of the above – subsumed into above categories	Not applicable as identified in above clusters (but is a combination of the above concepts)

(iii) Mapping and identification of an outcome space: The nine categories of description of the manner in which the role of literacy as a phenomenon is conceived by beginning pre-service education students (as listed in Table 1, Column 2) can be shown in an outcome space as a set of logically related categories (Figure 4) using the Leximancer mapped concepts (Figure 2 & Figure 3) as a base.

Figure 4. The role of literacy is ... Outcome space - Leximancer concepts with manual phenomenographical categories of description overlays (boxed)



The Outcome Space displaying concepts and categories of description the responses to Question 2, *What do you think the role of literacy is in learning and education?*, show that communication through understanding knowledge/understanding of English/language (learning reading and writing skills) and development of reading and writing skills are considered essential for personal and life purposes.

Conclusion

Leximancer analysis of the data presented a list of nine concept clusters. A parallel manual analysis of the same data identified 18 collective groups of expressed conceptions culminating in nine categories of description six of which aligned with single Leximancer concept clusters (*knowledge* with *knowledge, foundation* with *important*) or with combined Leximancer concept clusters (*reading and writing - skills* with *read*, *writing*, and *learning*). Leximancer labels concept clusters using a key word from the cluster data, for example, *knowledge*. Replacing this with the descriptor of the matching category of description, as identified by the phenomenographic researcher, is more explicit. So *knowledge* becomes *language knowledge* which is identified as a combination of *English as a language* and *language in general.* Of the nine manually identified categories of description, three (labelled *texts, a means, combinations of most or all of the above)* are not directly aligned with Leximancer concept clusters. They are however, clearly associated with some clusters: - *texts* is implicit in the *read* and *writing* concepts*; a means* in *communicate* and *life skills* concepts; and *everything* is a combination of all of the concepts. The differences discussed above are likely to decrease as the phenomenographic researcher becomes more adept with varying Leximancer search parameters in the analysis of the data.

Discussion

In describing the different ways in which students conceptualise the role of literacy in learning and education and seeking to advance the phenomenographic analysis process, a comparison between two methods of data analysis (traditional manual and computer aided) was undertaken. That Leximancer is able to provide researchers a foundation sorting and mapping of concepts which can be used in the first stage of a phenomenographical analysis of data in a more expedient way than conventional manual phenomenographic analytical processes, especially when dealing with large amounts of transcript material, is established in this paper.

The researcher's role in the process of analysis is central to traditional phenomenography. However, the researcher's ability to remain without bias in the reduction process of converting transcribed data into a limited number of categories is often debated and addressed by having researchers explicitly identify and "'bracket' [their] own socially and historically 'contaminated' conceptual apparatus" (Webb, 1997, p. 200). Marton (1994) addressed this issue making two main points, that "the analysis is, however, not a measurement but a discovery procedure" and that "the discovery does not have to be replicable, but once the outcome space of a phenomenon has been revealed, it should be communicated in such a way that other researchers could recognise instances of the different ways of experiencing the phenomenon in question" (p. 4429).

Pang (2003) takes up this discussion nearly a decade later identifying the above researcher's role as one of what he calls the "first face of variation" which is "the researchers' description of their experience of variation between different ways of experiencing various phenomena" (p. 154) and proposes a new dimension to phenomenographic analysis, that of the second face of variation centred on the "researchers' description of the learners' experience of variation" (p. 154). Leximancer would seem to have a place in the latter as it provides a clear *bracketing* process in identifying the concepts embedded in the responses. The automatic nature of the process is such that "any researcher bias is removed …, thereby removing issues such as coder reliability and subjectivity" (Isakhan, 2005, p. 9). As Leximancer can be applied to a massive amount of raw data,

researchers can "avoid the problem of selective case reporting while still allowing the analyst to cope with a vast quantity" (Watson, Smith, & Watter, 2005, p. 1234) of material.

Leximancer is seen to contribute to the "improved reliability and validity in coding" (Scott & Smith, 2005, p. 90) of content analysis and, states its creator, "offer[s] less uncertainty to the user than keyword indexing, thus achieving better recall and precision" (Smith, 2000, p. 3). These aspects of the tool have been compared to manual content analysis methods finding them to be statistically comparable (Grech et al., 2002). As Rooney (2005) comments, "Leximancer addresses reliability in two ways. First, it affords stability and second, reproducibility" (p. 410). The validity parameters of Leximancer (stability; reproducibility; face, correlative, and functional validity) are thoroughly addressed by Smith and Humphreys (2006) who found them to be methodologically sound.

At this juncture in the discussion of the use of Leximancer, due regard should be paid to its possible limitations. Researchers de la Varre, Ellaway, and Dewhurst (2005) found Leximancer analysis useful but commented that, "as Leximancer only examines the syntactic properties of text there is a certain ... level that it is not able to capture, such as style or implied tone of voice" (p. 9), so they also manually scanned their data for samples of gendered conversational differences in their transcripts of electronic discussion board messages. In response Andrew Smith says that:

> … it is true that Leximancer *by itself* may not clearly identify style or tone. However, our analysts can certainly use the system to seed tonal concepts from hints of sentiment on the map or in the frequent word list. We also find that Leximancer is quite good at identifying signatures of genre. (Andrew Smith, personal communication, August 15, 2008)

From the foregoing it would appear that a cogent belief exists that Leximancer is useful as part of the research process "to support other quantitative methods if the database contains both natural language and quantitative information" (Watson et al., 2005, p. 1238).

In this project Leximancer was used with default settings and at a base level, but it validated and informed the listing of concepts, the development of phenomenographic categories of description, and the mapping of these categories without losing the embedded role of the researcher which is an integral part of the methodology. Leximancer has also been shown to be a useful tool within a phenomenographic study investigating teachers' conceptions of *Values Education* (Connolly & Penn-Edwards, 2005), and in current studies being carried out by the author on students' conceptions of literacy (Penn-Edwards, 2009).

During the writing of this paper, Leximancer Version 3 has been released which may now be accessed through an ordinary web browser. The Leximancer production team claims that this version can handle larger data sets, multiple spreadsheets, and more complex queries as well as providing a more reader friendly visual map (University of Queensland, 2008) thus strengthening the argument for Leximancer to be included in phenomenographic studies.

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