Engineering Phenomenography

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This chapter extends the phenomenographical research method by arguing the merits of engineering the outcome space from these investigations to effectively communicate the outcomes to an audience in technology-based discipline areas. Variations discovered from the phenomenographical study are blended with pre and post tests and a frequency distribution. Outcomes are then represented in a visual statistical manner to suit the specific target audience. This chapter provides useful insights that will be of interest to researchers wishing to present findings from qualitative research methods, and particularly the outcomes of phenomenographic investigations, to an audience in technology-based discipline areas.

INTRODUCTION AND BACKGROUND

This chapter contributes to the phenomenographic research method by describing its use and extension with emphasis on how the results may be presented in a manner that is meaningful for a specific community, in this case educators and researchers in the engineering community. The title of the chapter points to phenomenography as a research method, and it is deliberately ambiguous: is the chapter about how to engineer phenomenography, or is it about phenomenography in an engineering context? The answer is both. It explains a process of designing and constructing the outcome space, a key element of the depiction of variation, in a particular way, and this is done in the context of engineering education in order to communicate easily with the community of engineering educators. It also details a specific example of the blending of approaches used in a phenomenographical study to engineer the outcome space to suit that audience. Since this context addresses a knowledge area that is not commonly referenced in educational literature, it provides (valuable) insights that will be of interest to researchers wishing to present qualitative research findings, and particularly the outcomes of phenomenographic investigations to

an audience in technology-based discipline areas. Although many phenomenographic studies have been conducted in technology education (for examples see Baillie et al., 2001; Berglund, 2002; Booth, 1992; Ingerman, 2002) we believe this is the first time that potential disciplinary influences have been explicitly discussed.

The aim of this chapter is therefore to describe the extension of qualitative research methods, and particularly the outcomes of phenomenographic investigations, to present outcomes in a convincing manner to an audience in technology-based discipline areas. The chapter outlines a personal odyssey taken by the lead author whilst completing a professional doctorate. At the time Gibbings was heavily involved with educational research in a Faculty comprising mainly Engineers and later became Associate Dean (Learning and Teaching) in that Faculty. He was researching a question aligned to qualitative research methods and these were largely unused, and viewed with some suspicion, in his Faculty. Therefore, he was keen to legitimise qualitative, and specifically phenomenographic, research within his sphere of influence. This led to the need to adopt and argue for particular approaches to analysing and reporting findings so they were considered acceptable to this technology-based community, as well as to enhance prospects of publication in the engineering education conferences and journals. The chapter opens with a brief description of relevant epistemological and ontological aspects of phenomenography and variation theory. It is then argued that a quantitative-positivistic approach has benefits when presenting qualitative research (particularly phenomenographical) outcomes to a technology-based audience, and this argument is then illustrated with an empirical example. The argument is further reinforced by a description of the challenges associated with publishing such work in the technology disciplines.

Researchers' Philosophical Perspectives

Of importance to the ensuing discussion is an analysis of the authors' philosophical views. Prior to his doctoral study, the first author was in a position similar to that described by Åkerlind (2005) in Chapter 6 of the edited book by Bowden and Green (2005). Coming from a positivist background, his research until that time had been mainly focussed on quantitative methods. Like Åkerlind, he also was of the opinion that the content examination and general thematic analysis he had previously carried out on various survey-based and open-ended responses to specific questions, constituted qualitative research.

During the course of his doctoral research, he became oriented towards an essentialist/foundationalist ontology incorporating a belief in some objective truth. In accordance with this ontology and a realist epistemology, inclined towards critical realism, he believes that knowledge can be both created and constructed, that experiences are important to this knowledge creation/construction, and that the manner of creating or constructing this knowledge can be studied empirically.

Given the initial stance of the first author, he sought a research methodology for his doctoral study that was participant-centred and explored participants' world views, and that could be communicated to his peers in a convincing manner. His personal stance is in accord with the non-dualist stance adopted by phenomenography, where the outer world is not constructed internally by an individual, nor is it imposed on an individual from the outside – rather it is considered that there is only one world that includes the individual and the 'real world' around them - as described by Marton and Booth (1997, p. 13), 'There is only one world, but it is a world we experience, a world in which we live, a world that is ours.' Phenomenography adopts this stance through describing variation in the relationship between people and their world as they

experience it. Nevertheless, phenomenography can take different forms and can be interpreted in different ways.

The authors had a fundamental desire for the research to focus on understanding and explanation, an important trait of educational qualitative research, rather than simply reporting empirical findings or underlying mechanisms that might then lead to prediction or generalisations as is conventional in the research of the technology disciplines. The outcomes needed to be useful, and the knowledge gained needed to have a purpose and not simply be knowledge for knowledge sake (essentially an applied axiology). Developmental phenomenography (Bowden, 2000) was chosen as a suitable research approach since it aligns with the first author's personal orientation and is sympathetic with this applied axiology (knowledge must have a purpose).

Although the prime audience for the research outcomes were those in technology-related fields, there was a realisation that the method needed to develop a theory about the phenomenon under investigation from the data that would ultimately be acceptable to a much wider audience than represented by any individual's philosophical stance. In particular, the presentation of the qualitative research outcomes needed to appeal to a broad section of practitioners in technology-related disciplines. As described later in the example case, the vehicle developed to achieve this was a before-and-after analysis and frequency distribution superimposed on the outcome space from the developmental phenomenographical study. The broader context and relationship to previous research (for example, Enbenezer & Fraser, 2001; Minasian-Batmanian et al., 2005; Prosser & Trigwell, 1999) is discussed in more detail later in this chapter.

While the co-authors shared many aspects of the first author's position, they had usually adopted interpretivist orientations to phenomenographic research, which

precluded the use of frequency analyses. They also had not previously privileged the dominant perspectives of the research discipline audience in their work. They were accustomed to working with alternate paradigms as they affiliated with the developmental purpose of the work.

PHILOSOPHICAL INTERPRETATION OF PHENOMENOGRAPHY AND VARIATION THEORY

Over the last thirty years phenomenography has come to be interpreted in different ways to align with different philosophical views of researchers. Several authors have critiqued phenomenography through different philosophical lenses. For example, Denzin and Lincoln (2000, p. 20) placed phenomenographical research into four interpretive paradigms: positivist/post-positivist; constructivist/interpretivist; critical; and feminist/post-structural. Similarly, Lincoln and Guba (Lincoln & Guba, 2000) noted phenomenography had evolved to include: positivism, post-positivism, critical theory, and constructivism. Lupton (2008, p. 40/41), acknowledging these earlier works, suggested different approaches to phenomenography belonged to a continuum from 'positivist-objectivist' approaches on one side to 'interpretivist-subjectivist' approaches on the other. Lupton carried out her work on information literacy to highlight curriculum implications with the intention that the results would influence academics and policy makers. This is consistent with Bowden's developmental phenomenography, which he used to describe contexts where the phenomenographical research is undertaken in a clear attempt to achieve something, such as bring about a change in the way the world operates, and where there is a purpose for the knowledge gained.

In the example case described later in this chapter, the large majority of the intended audience for the research study publish their own technology-related research using a quantitative research paradigm and may therefore be considered to commonly have an essentialist/foundationalist ontology and a logical empiricist epistemology. We believe this aligns with Lupton's description of the positivist-objectivist approach to phenomenography. Similarly, staff adhering to an anti-foundationalist ontology may align with Lupton's interpretivist-subjectivist approaches. Consequently, we use Lupton's continuum as a useful framework to demonstrate different philosophical stances and approaches taken by the authors on the phenomenographical study provided as an example later in this chapter.

THE TECHNOLOGY-RELATED RESEARCH COMMUNITY

Given the focus of this chapter, it is necessary to further explore the typical philosophical stances of the academy in technology-related fields. Although it is difficult to generalise, it may be considered that those with quantitative orientations might commonly reflect an essentialist/foundationalist ontology and an empiricist epistemology. On the other hand, researchers espousing the qualitative paradigm might commonly adhere to an anti-foundationalist ontology and a realist or idealist epistemology (either direct or critical realism) (Grix, 2002). It is clear then that some tension may be exposed when outcomes from a phenomenographical study are presented to those who adhere to a strict quantitative research paradigm.

The logical empiricist (positivist) epistemology often associated with quantitative research has traditionally been seen as the dominant research paradigm, with qualitative research being seen as somewhat less prestigious (Åkerlind, 2005), and this is still widely the case in the technology disciplines, which include the engineering

community. In these disciplines, statistical analysis is usually the research tool of choice and it seems this reflects the situation that has long persisted because, due to their 'ubiquitous reverence to numbers', they see 'empirical science [and] quantitative measurement' as the 'mark of validity in educational research' (Lagemann, 1997, p. 7).

Lagemann noted that this situation had continued (supposedly up until around 1997 when her work was published) despite going through several stages of development. From around this time Paul and Marfo (2001) noted some weakening in the dominance of quantitative research, at least partly due to publications challenging the epistemology of logical empiricism and logical positivism. Nevertheless, it is difficult to present qualitative research findings in a convincing manner to those who will judge the research from a positivist world view such as colleagues in technology-related fields like engineering.

It is not our intent to pass judgement on this philosophical stance, we point this out simply to explain potential difficulties of presenting outcomes originating from a different philosophical stance (as outlined by Paul & Marfo, 2001).

As alluded to earlier, we believe it is possible to present qualitative research findings from a phenomenographical study, in such a way that it is more likely to be seen as valid and acceptable to peers in technology-related disciplines. This can be done by presenting the outcomes in a positivist-objectivist style that is considered conventional in their own research domains. This is now illustrated by an empirical example.

EXAMPLE

This example provides a reflective analysis of a phenomenographical study carried out by a doctoral study research team comprising the first author as chief investigator and

two supervisors (co-authors) acting as research mentors and collaborators.

This research study sought to discover the qualitatively different ways students experienced problem-based learning (PBL) in virtual space. The study was undertaken in the context of an Engineering course offered in the distance education (off-campus) mode by the Faculty of Engineering and Surveying at the University of Southern Queensland (USQ). In operation since 1967, USQ is a small regional university that has developed an international reputation for offering high quality academic programs in the on-line delivery mode. The phenomenographic approach was adopted for the study that frames this example due to its epistemological and ontological underpinnings as discussed earlier, and because of its capacity to reveal qualitative variations in the ways that external students experience learning, and the differences in these variations that are brought about as a consequence of a PBL course.

The purpose of the research was to create a balanced theoretical and empirical report on variation in the student experience of PBL engineering education in virtual space. In keeping with the applied axiology of the study, the outcomes were intended to: contribute to improved design and delivery of PBL courses; make a significant contribution to existing theory with respect to the emerging problems associated with offering PBL in virtual space; and influence policy and practice with respect to subsequent similar course development at USQ.

The outcome space from the study is represented in graphical form in Figure 1. The numbers represent categories of description that were discovered by the researchers, each representing a qualitatively distinct manner in which people voice the way they experienced PBL in virtual space. Five categories of description were discovered from which it was revealed that PBL in virtual space may be seen as: Category 1: ‘A necessary evil for program progression’; Category 2: ‘Developing skills

to understand, evaluate, and solve technical Engineering and Surveying problems'; Category 3: 'Developing skills to work effectively in teams in virtual space'; Category 4: 'A unique approach to learning how to learn'; or Category 5: 'Enhancing personal growth'. The range of categories represent increasing awareness of certain aspects of the phenomenon as outlined in other studies (Gibbings, 2008; Gibbings et al., 2009).

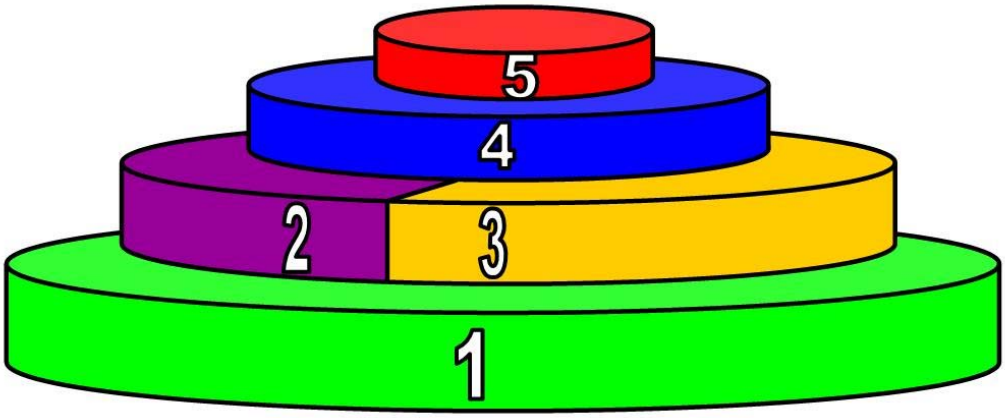

Figure 1. Structural relationship and expanding awareness associated with categories (Gibbings, 2008; Gibbings et al., 2009).

The range of categories represent increasing awareness of certain aspects of the phenomenon. The expanding awareness is not obvious from Figure 1: those aspects are clearly described in Gibbings, et al. The explanation of expanding awareness is not central to our arguments in this chapter though a short summary is provided in the next paragraph, the key point is that the diagram provides a familiar (and therefore acceptable) mechanism for communicating with the engineering community. Figure 1 represents the metaphor of a series of terraces. The higher levels represent higher level awareness and conceptions at these levels would normally be expected to include those of lower levels. An interesting point to note is that level four may include aspects of

awareness from category two only, or from category three only, or from both categories two and three.

The following summarises the critical dimensions that vary across the categories.

- In category one, there is an awareness that team work in virtual space is necessary to solve the PBL scenarios (realistic situation or case used to present the PBL 'problem') in order to successfully submit assessment items.
- In category two this fundamental awareness expands to realising the need to develop skills to help the team solve technical problems.
- In category three this fundamental awareness expands to realising the need for better use of communication and other technology to aid team work in virtual space.
- In category four, students understand that the learning in virtual space is quite a different experience from on-campus study, and that working in virtual space is seen as important for their future professional careers.
- In category five, successful mastery of the challenge of studying effectively through PBL in virtual space is deeply rewarding at a personal level and an experience from which they gain a great sense of accomplishment.

Other aspects that demonstrate expanding awareness across the categories are:

- How students view the use of their time to undertake the course;
- How students use their team with respect to communication, mentoring, critiquing, and evaluation;
- how students see and relate to their team in the context of a learning community and how they interact with the team;
- How students use self-reflection and feedback;
- How students connect their academic programs and future professional careers; and
- How as individuals they consider social responsibility and personal ethical values.

Presentation of the Research Outcomes

The large majority of the first author's peers (from a regional university in Australia) publish using the quantitative research paradigm. As a consequence of this logical empiricism, there seems to be a feeling, particularly amongst senior staff, that the standard for truth, validity and reliability of any research (including educational

research) is the same as the scientific research in their core discipline areas: that is the standard of *good science* based on the traditional logical empiricist epistemology.

To overcome this tension the phenomenographic research method was used in a manner that was unusual in several respects. A key feature was that the qualitative phenomenographic process was combined with a before-and-after quantitative frequency analysis of the number of student responses falling into each category of description, which were part of the outcome from the phenomenographical study. The superimposition of a frequency analysis on the discovered categories of description is not common practice, although is observable in some of the literature and is associated with learning studies.

It is noted that some researchers have in the past successfully combined phenomenography with quantitative approaches (Prosser, 2002) a classic example of which involves the superimposition of a frequency distribution over the categories of description (Minasian-Batmanian et al., 2005). Prosser and Trigwell (1999) have carried out a form of frequency analysis to establish correlations, for example between conceptions of teaching and conceptions of learning. Magub (2005) quoted percentages of quotations falling into categories of description. Marton and Pang (2006) took this further and used a distribution of the conceptions in a target group compared with a comparison group and reported the numbers and percentages of occurrences in each of the categories (or conceptions). In a study by (Ebenezer et al., 2010) once the categories of description from a phenomenographical study were generated, students' responses were expressed in a single word, a string of words, or a statement, and then placed into the broad descriptive categories. These were then counted and a frequency distribution was used to compare between the pre- and the post-tests. In this case the frequency distribution was based on counts of words, phrases, or statements and no

attempt was made to look for the highest category evident from the full response. However, the approach we are discussing in this example is different. The key point of departure is that, in this study, the response frequency analysis required relating each individual student response back to the conceptions using the highest discernible conception from the response. We believe this is an important distinction because it more justifiably represents a variation in perception than word counts, particularly when used in conjunction with a before/after analysis. We believe this pushes the boundaries enough and to go further may invalidate the research method, particularly with respect to presenting the collective voice! Adoption of this approach later proved essential to the acceptance of the research outcomes within the engineering (technology-based) education community.

To aid the interpretation of the outcomes from the phenomenographical study, the response frequency analysis presented in Figure 2 provided a visual statistical interpretation. In accordance with normal practice, discovery of the categories of description required interpretation of student responses to questions. Carrying out the response frequency analysis required relating each individual student response back to the conceptions using the highest discernible conception from the responses: a process described by Marton, Dall'Alba, and Beaty, as ‘priority rule’ (1993, p. 295). Although this sort of response frequency analysis had been applied in the past (Magub, 2005; Marton & Pang, 2006; Minasian-Batmanian et al., 2005; Prosser, 2002), it is not commonly associated with a phenomenographic study.

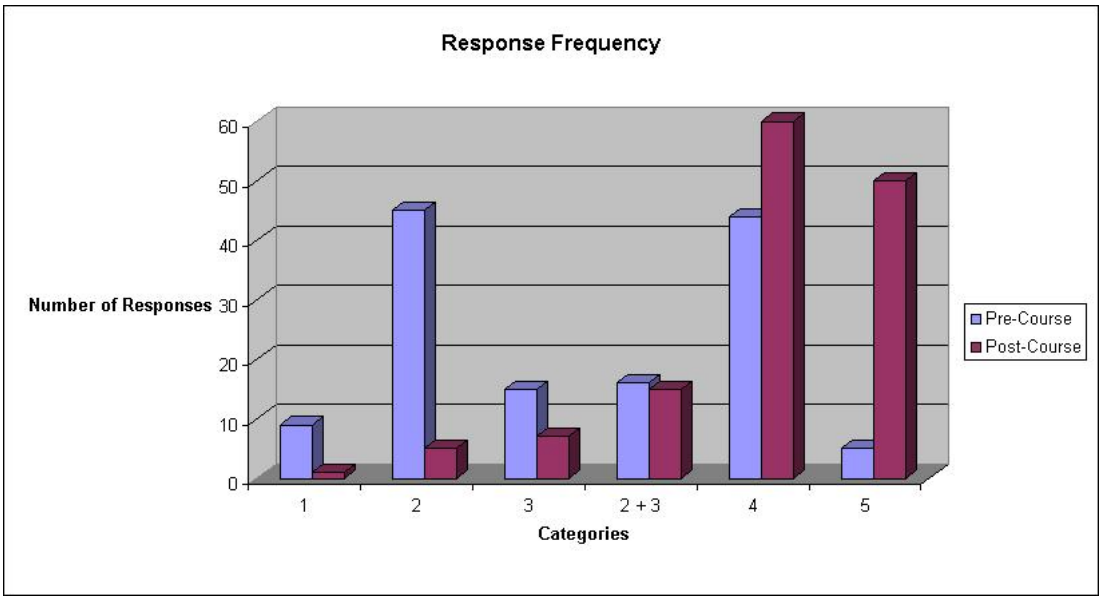

Figure 2. Pre and post response frequency (Gibbings et al., 2009)

The explanation following Figure 1, made clear that level four may include aspects of awareness from category two only, or from category three only, or from both categories two and three: in this graph '2+3' represents the latter.

The evidence of the existence of a range of students' conceptions presented in the outcome space, augmented with this response frequency analysis, provided some indication as to why these conceptions might be present. This represents a further departure from accepted practice in phenomenographical research. Phenomenography does not normally seek reasons why phenomena are experienced in particular ways, but for this study, reasons why were considered a logical extension. The frequency analysis provided a mechanism to at least carry out cursory investigations into reasons why particular ways of experiencing might be present.

Importantly though, such insights represent the type of research output that engineering education researchers are generally expecting, due to their background in technology-based engineering fields. Thus, the presentation of the frequency analysis was also necessary for pragmatic reasons to allow peers to interpret the outcome space

in ways that made sense to them: it facilitated the presentation of outcomes from quantitative research in their language. This meant the outcomes were more easily identified with what they interpret as 'good science' and thus the validity and reliability of the research were more readily accepted.

So, how successful was this approach in the example case? To the great surprise of the first author, the study and outcomes were accepted as valid and reliable when presented to senior members of his Faculty.

DISCUSSION

Positivist vs Interpretivist Phenomenography

The different world views of the authors (doctoral candidate and supervisors in this case) meant that during the doctoral study and subsequent publications many aspects had to be negotiated between the authors. The following three instances are highlighted to demonstrate some of the tensions that may come about due to different orientations:

1. In accordance with the first author's positivist-objectivist background, he established the need to carry out an inter-coder reliability check (Dall'Alba, 1994; Prosser, 1994; Säljö, 1988) that involved an independent second researcher analysing a subset of transcripts and comparing categories from the outcome space. In accordance with the supervisors' interpretivist-subjectivist stance, they would have been more comfortable restricting this to a dialogic reliability check involving more than one researcher discussing and critiquing the categories and agreeing on the most suitable outcome space (John A. Bowden, 1994, 1996; Prosser, 1994). In this study the inter-coder check was used and was key to improving acceptance of the outcomes in the wider community.

2. Superimposing a frequency analysis onto the outcome space facilitated the presentation of the research outcomes in graphical form. This proved much more acceptable for Faculty staff and was sympathetic to the first author's positivist-objectivist background. However, it did not sit well with the supervisor's interpretivist-subjectivist stance and negotiations ultimately led to the frequency analysis being placed in a separate chapter entirely in the doctoral thesis. The frequency analysis did remain, and again proved vital to acceptance of the work in the engineering education community.
3. The before-and-after graphical presentation allowed readers to easily see at a glance that there were significant differences being noted before the course compared to after the course. Although subservient to the prime research outcomes of the categories of description and dimensions of variation, it did at least provide a *good science* hook for the staff who were used to quantitative research and adhered to a positivist-objectivist stance. Similar to point 2, subsequent to discussions with the supervisors, the before-and-after analysis was placed in a separate chapter with the frequency distribution.

Over the last decade or so, researchers have successfully combined phenomenography with quantitative approaches (for example Prosser, 2002). Marton and Pang (2006) took this further and used a distribution of the conceptions in a target group compared with a comparison group and reported the numbers and percentages of occurrences in each of the categories (or conceptions). In all of these cases, researchers used positivist-objectivist approaches to present outcomes from phenomenographical studies.

None of these cases replicated the blending of approaches used in the phenomenographical study discussed here, where the outcome space has been

engineered to suit a specific audience. The qualitative phenomenographic process was combined with a before-and-after quantitative frequency analysis of the number of responses falling into each category of description. This was done to aid interpretation of the outcomes, and also to overcome the tension evident when outcomes from the phenomenographical study were presented to those who are used to outcomes from quantitative research.

CONCLUSIONS

The aim of this chapter was to describe the extension of qualitative research methods, and particularly the phenomenographic research method, to present outcomes in a persuasive manner to an audience in technology-based discipline areas. To do this we discussed the benefits of presenting the outcomes in a positivist-objectivist style that may be more familiar to the intended audience.

This was demonstrated with an example involving the superimposition of a before-and-after response frequency analysis on the outcome space from a phenomenographical study to provide a visual statistical interpretation. These response frequencies offer a visual analysis of statistics and allow the data to be presented in a manner that would be more readily acceptable to a discipline-based audience.

This treatment of the research outcomes is not commonly used in association with the outcome space from a phenomenographical study. However, we believe this has emphasized the potential to extend the phenomenographical research method beyond its current boundaries. But we have pushed those boundaries enough, and we believe to go further may not be valid, nor consistent with the phenomenographical research method.

The authors have also noted that it has been much easier to have results published in the Engineering Education field than general higher education journals. This may be because the subject matter relates to Engineering, or perhaps it is because of the appeal the before-and-after analysis and the frequency distribution has to the technology audience. In the words of Greene (1994, p. 459), '*The labels ought not matter*.', what does matter is an acceptance of tension and conflict shared in a common quest for meaning and understanding. If the engineering of phenomenography described in this chapter has proven useful, then it ought to be acceptable to those subscribing to both the interpretivist-subjectivist and positivist-objectivist stances, because after all it is a pragmatic approach suited to developmental phenomenography and based on a need to communicate within a specific discipline.

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