Exploring liminality using phenomenography: Engineering students' conceptions of technology as an example

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INTRODUCTION

Coming to understand a new concept or discipline is a difficult journey, both intellectually and emotionally, and involves the occupation of a *liminal space* (Meyer and Land 2006). This journey may look different for different learners (Cousin 2009):

> Some learners hover at the edges in a state of pre-liminality in which understandings are at best vague. Some will fake understandings (mimicry); some will frequently get "stuck" and most will oscillate between grasping a concept and then losing that grasp (p. 204).

In this paper, we argue that phenomenography is a fruitful approach for exploring what the liminal space looks like when a certain group of learners grapple with a certain concept. We first describe the concepts and methods of phenomenography and then illustrate the phenomenographic approach by drawing on a study that investigated how engineering students conceptualize the notion of technology (Kabo and Adawi 2011). The qualitatively different conceptions that emerged correspond to "states" or potential "stuck points" in the liminal space and shed light on what is required to make progress from one conception to another in the liminal space.

THE CONCEPTS AND METHODS OF PHENOMENOGRAPHY

The key concepts and methods in the phenomenographic research process are illustrated in Figure 1, and are described more fully in this section. Phenomenography is a qualitative research approach aiming to reveal and describe the variation in which a certain group of people experiences a certain phenomenon (Marton and Booth 1997). This requires a process of *selective bracketing* (Adawi et al. 2001), or reflexivity, where the researcher is aware of the influence of his or her own understanding of the phenomenon on the research undertaking – aware of what is being "bracketed" and what is essential to the study.

The most commonly used method for collecting data in phenomenographic research, to explore this variation, is the semi-structured interview and the verbatim transcription of the interviews forms a *pool of meaning*, containing everything the researcher can expect to find. The ensuing analysis is essentially a *hermeneutic process*, involving reading and re-reading the transcription, where the textual elements of the pool of meaning are interpreted first as isolated fragments, then in relation to the whole from which they are taken, next in relation to isolated fragments from other wholes, and finally in relation to the totality of data. During this iterative analysis, elements of the pool of meaning are brought together, or synthesized, to form *categories of description* on the basis of their similarities – certain *critical aspects*, or "core elements", of the phenomenon. These critical aspects can often be grouped into different *dimensions of variation* and the critical aspects can be seen as different states in each dimension of variation.

The categories of description represent the variation in ways of conceptualizing the phenomenon at a *collective level* since they are analytically drawn from all the collected data while individuals only contribute fragments of data to a certain category. Marton and Booth (1997) described the meaning of the collective level in the following way:

> The description we reach is a description of variation, a description on the collective level, and in that sense individual voices are not heard. Moreover, it is a stripped description in which the structure and essential meaning of the differing ways of experiencing the phenomenon are retained, while the specific flavors, the scents, and the colors of the worlds of the individuals have been abandoned (p. 114).

The resulting set of logically related and empirically grounded categories of description is called the *outcome space* for the phenomenon. Marton and Booth (1997) have described three criteria for the quality of the outcome space that can be seen as methodologically grounded:

> The first criterion that can be stated is that the individual categories should each stand in clear relation to the phenomenon of the investigation so that each category tells us something distinct about a particular way of experiencing the phenomenon. The second is that the categories have to stand in a logical relationship with one another, a relationship that is frequently hierarchical. Finally, the third criterion is that the system should be parsimonious, which is to say that as few categories should be explicated as is feasible and reasonable, for capturing the critical variation in the data (p. 125).

When these criteria are fulfilled the set of categories arrived at can be seen as satisfactory.

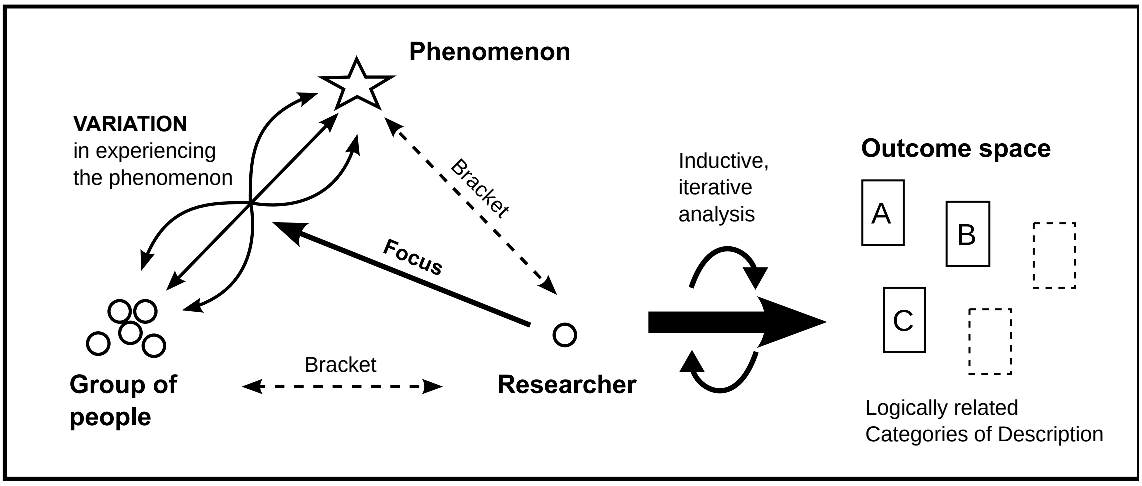

Figure 1. The key concepts and methods in the phenomenographic research process.

AN EXAMPLE OF A PHENOMENOGRAPHIC STUDY

To illustrate the phenomenographic approach, we now describe a study that investigated how engineering students conceptualize the notion of technology (Kabo and Adawi 2011; Kabo 2006). We interviewed ten engineering physics students who were in the latter stages of, or had just finished, their education and thus had little or no professional experience as engineers. As the aim of the study was to identify and describe different conceptions of technology, the notion of technology was discussed from different angles without leading the interviewees to certain answers. To help the interviewees to explore and articulate their conceptions of technology, the interviews were based on a series of "exercises" in which various "props" were used (see Kabo 2006, pp. 13-15 for a detailed description). The interviews were recorded and transcribed. The transcripts were then analysed in the manner described above.

We identified six different categories of description corresponding to an increasingly more complex understanding of technology. We also identified four *dimensions of variation* (DV) that relate the categories to each other and structure the outcome space. These are: **DV I:** The *nature* of technology (product or process), **DV II:** The *purpose* of technology (implicit or explicit), **DV IIIa:** The *construction* of technology (vague or clear), and **DV IIIb:** The *relation* between technology and science (one or the other dominates or there is a reciprocal relation). It is the variation in the dimensions of variation that distinguishes the categories of description from each other. The structure of the outcome space for the engineering students' conceptions of technology is summarized in Figure 2. In this short paper we briefly describe each of the six categories of description and highlight the variation in the dimensions of variation. The empirical support for each category in the form of student quotes can be found in our previous publications (Kabo and Adawi 2011; Kabo 2006).

Category 1 – Technology as artefacts with certain characteristics
In this category, technology is seen as artefacts with certain characteristics (**DV I**). Technology has no clearly stated purpose (**DV II**). The focus is on the artefacts themselves and their characteristics, which are quite vague or general in their nature (**DV IIIa**). Common characteristics appear to be: a complex construction; requires a power-source; manufactured; and modern.

Category 2 – Technology as artefacts with a purpose to satisfy certain needs
In this category, technology is seen as artefacts (**DV I**) with a purpose to satisfy certain needs. Here technology has a clearly stated purpose (**DV II**), for example to accomplish a specific task or to solve a particular problem. The emphasis lies on the function or purpose of the artefacts rather than their construction or specific characteristics (**DV IIIa**). Common purposes of technical artefacts appear to be: to facilitate life or certain tasks, and to entertain.

What is significant in this category in comparison to Category 1 is a shift in DV II from an implicit to an explicit purpose.

Category 3 – Technology as how artefacts work and are constructed
In this category, technology is seen as the inner workings and the actual construction of an artefact (**DV I**). In other words: how artefacts work (**DV IIIa**). The purpose of technology is not articulated (**DV II**).

What is significant in this category, and what distinguishes it from Category 2, is a shift in DV IIIa (from vague to clear construction) rather than in DV II. We see both of these shifts as complementary and important for a more complex understanding of technology (e.g., as a process). Thus, we place Categories 2 and 3 on the same hierarchal level in the outcome space.

Category 4 – Technology as an independent discipline
In this category, technology is seen as an independent knowledge domain (**DV IIIb**) with the purpose to satisfy the needs of humans through the creation of new technology or improvement of existing technology (**DV II**). Technology is here a process where the outcome is the products of the previous categories (**DV I**).

In this category, technology as a process comes to the foreground while the product aspect slides to the background. What is significant here is the shift in DV I from product to process, which we see as the most important shift in the whole outcome space. With this shift DV IIIa becomes obsolete (if the purpose is to create products then their construction needs to be known) and the driving force in the creation of new technology comes into view (DV IIIb: science and/or technology).

Category 5 – Technology as applied science

In this category, technology is seen as applied science (**DV IIIb**). The purpose of technology is to use science to satisfy the needs of humans through the creation of new technology or the improvement of existing technology (**DV II**). Technology is here a process where the outcome is (new) artefacts (or products) (**DV I**).

This category represents the other side of the coin of Category 4, with DV IIIb on the other extreme, while DV I and DV II being the same. Thus, we place these two categories on the same hierarchal level in the outcome space.

Category 6 – Technology as reciprocal to science

In this category, technology is seen as reciprocal to science (**DV IIIb**). The purpose is similar to that of the two previous categories, i.e., to satisfy the needs of humans through the creation of new technology or the improvement of existing technology (**DV II**). However, the focus might have shifted more to the actual technical development. Here technology, again, is a process (**DV I**).

This category represents more of a synthesis of Categories 4 and 5, with DV IIIb in balance between science and technology, and DVs I and II remaining the same. This category corresponds to a more contemporary description of the close ties and dependence that exist between science and technology today. With Category 4 corresponding to a more historical view and Category 5 corresponding to a widespread misconception, we place this category on the highest hierarchal level in the outcome space.

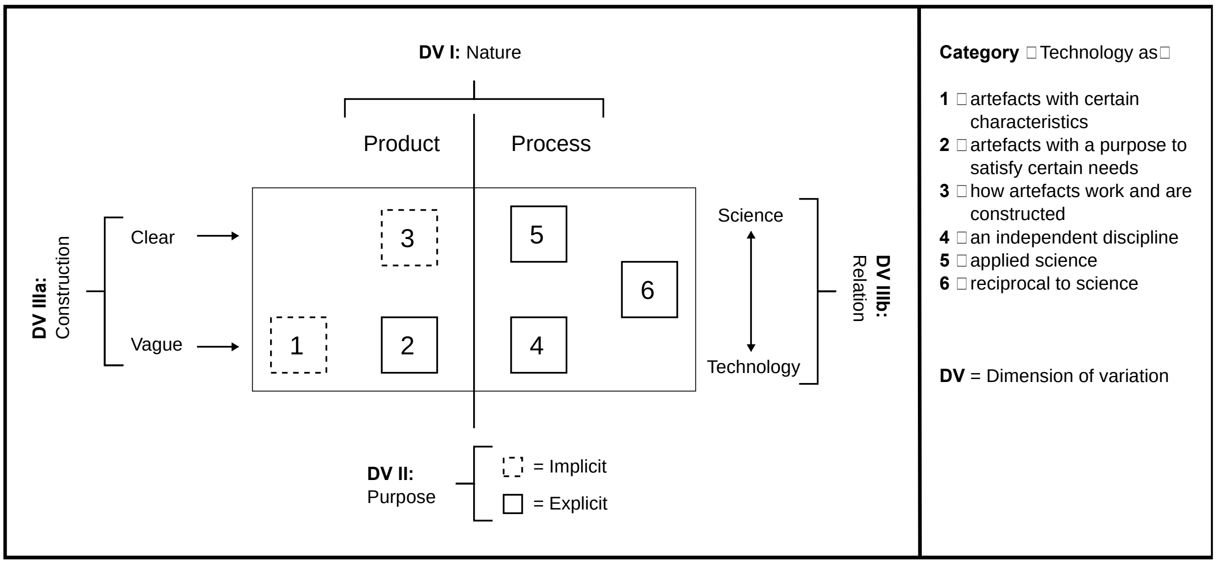

Figure 2. The structure of the outcome space for engineering students’ conceptions of technology.

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DISCUSSION

This paper provides another contribution to the recent line of inquiry to better understand what the liminal space looks like when learners come to understand a certain concept (e.g., Kabo and Baillie 2010; Pettersson 2012; Taylor and Cope 2007; Åkerlind et al. 2011). Using phenomenography as an analytical approach, we have described the structure of the outcome space for engineering students' conceptions of technology. The six categories of description (i.e. qualitatively different conceptions of technology) that emerged correspond to "states" or potential "stuck points" in the liminal space and the dimensions of variation shed light on what is required to make progress from one category or state to another in the liminal space.

Navigating liminality often involves oscillation between different states or conceptions. We see this as parallel to the phenomenographic idea of individuals carrying multiple and simultaneous conceptions of a phenomenon. For example, all of our interviewees spoke of technology in terms of both products and processes. However, which conceptions that will be in a person's focal awareness at a given time will vary. Moreover, conceptions do not replace each other, but more complex conceptions often encompass less complex ones. Both of these aspects can be seen in the following pair of quotes from the same interviewee:

> For me technology very much is gadgets, devices, things that humanity has invented to make everyday life easier (Category 2).
>
> The purpose and goal of technology is to… to perform things for humans in some way. Yes, to use the science that we have been given in some way to produce more things, better things, or to make it easier, more flexible, more fun… to facilitate our lives (Category 5).

Both quotes deal with the same theme but in the first the focus is on technology as products while in the second the focus is on technology as a process driven by science. The purpose (to facilitate the life of humans) remains the same. It is easy to see that Category 5 can be said to encompass Category 2 while there also has been a major shift in one of the dimensions of variation (DV I: from product to process). The two quotes describe oscillation between two different states in the liminal space and this supports the parallel between categories of description and liminal states.

The second quote above (and the corresponding category) highlights a potential "stuck point", with the focus on science as the driver of technological development, as this is a misconception (Gardner 1997). However, this would perhaps not be apparent from the quote/category by itself but becomes clearer when compared and contrasted with Categories 4 and 6. As we have pointed out in a previous publication (Kabo and Adawi 2011):

> The results of this study can be used as input when [discussing] "what is technology?" The idea, drawing on variation theory (Marton and Tsui 2004), is to expose students to variation in how technology is conceptualized by someone in a similar context. This would make them more aware of what the critical aspects of technology are and help them to develop a more complex understanding of technology.

From a phenomenographic point of view, variation can be seen as the "mother of all learning" (Marton and Trigwell 2000) and good teachers thus help their students to experience variation in the critical aspects of the phenomenon. This approach to teaching will hopefully make the journey through the liminal space more stimulating and less difficult for our students.

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