# PHENOMENOGRAPHY AS A TOOL FOR UNDERSTANDING OUR STUDENTS

Ioanna Stamouli and Meriel Huggard

Department of Computer Science, Trinity College Dublin, Ireland
E-mail: stamouli@cs.tcd.ie

## ABSTRACT

In this paper phenomenography and variation theory are presented in their theoretical and methodological aspects. The combination of these qualitative research approaches can provide an insight into how students understand the fundamental concepts of any given course, making them a very powerful tool for enhancing teaching and learning. Projects that have used these research practices to gain an insight into students' experience of learning in Engineering and Computer Science are then presented.

## INTRODUCTION

Based on the general observation that some people are better learners than others, a group of researchers in Sweden in the mid 1970s carried out a number of projects on learning that clearly showed that there is a variation in what people understand and in how they understand it [1]. This work laid the foundations for the research approach known as phenomenography. In simple terms, *"A phenomenographic research project reveals the qualitatively different ways in which a phenomenon can be experienced, understood or perceived by a student cohort"* [2].

Phenomenographic research projects often focus on mapping variations in a population's experience. The range of qualitatively different ways of understanding a particular phenomenon is captured in what are known as "*categories of description"*. The relationships between these categories of description are then analysed in terms of factors such as their inclusiveness and the encapsulated understanding. More recently, studies have focused on combining phenomenography and variation theory. Variation theory's proponents argue that *"learners can only discern a particular aspect when they experience variation on that aspect"* [3]. Thus these newer studies seek to identify the structure of awareness underlying the students' varying experience of phenomena [2, 4].

Phenomenography and variation theory have proven to be powerful tools in Engineering and Computer Science education research [5,6,7,8,9], since they allow a researcher to maintain focus on the underlying concepts and principles, while studying the learning of these concepts from the students' perspective. By using phenomenography one can identify how key concepts are understood by the learner, while variation theory can assist in identifying the aspects that need to be varied for the students to gain a deep, and complete, understanding; thus improving learning outcomes.

In the remainder of this paper phenomenography is discussed in terms of how the object of learning is viewed. The semi-structured interviews used for data collection and the patterns of variations that are observed through variation theory are then discussed. The

paper concludes with an overview of how Phenomenography and Variation Theory have been used to enhance undergraduate Engineering education.

## THE OBJECT OF LEARNING

At the centre of any phenomenographic research project is the object of learning; that is how a phenomenon is experienced by a specific group of learners and the variation in the ways this phenomenon is understood. Thus, such studies adopt a positive attitude towards learning by focusing on the understanding and conceptions that people hold rather than on the misconceptions.

In a phenomenographic study the object of the study is not the phenomenon itself, but rather the relation between the study's population and the phenomenon. As illustrated in Figure 1, the phenomenon cannot be seen in isolation, as the point of interest in the study is the way the phenomenon is understood and experienced by the learners. The aim of the research study is to discover this object of learning by analysing the relationship between the learner and the phenomenon at hand.

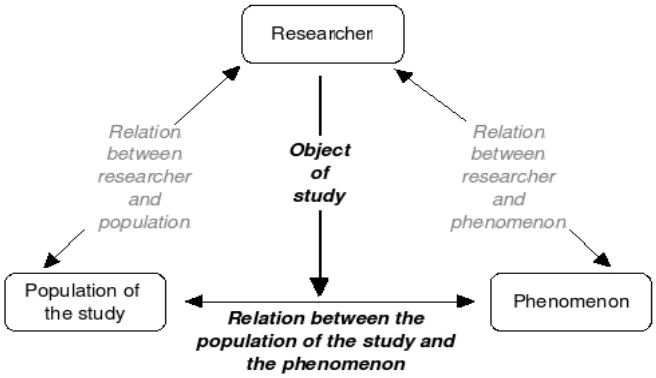


Figure 1: Object of Study (adapted from [10]).

As can be seen in Figure 1, there is an unavoidable relationship between the researcher and the phenomenon that is investigated in any study; this is because the researcher is required to have a thorough knowledge and understanding of all aspects of the phenomenon that they are attempting to analyse. This is necessary so that the researcher is able to discuss and query the learner about the various facets of the phenomenon. However the researcher needs to be careful not to impose their own interpretation of the phenomenon on the student cohort. Also, the researcher's relationship with the population of the study may impact on their viewpoint and analysis. These potential problems are overcome through the use of methodological guidelines which form part of the phenomenographic research approach [11]

A structured model for the analysis and description of learning has been developed, see Figure 2 [2]. The experience of learning is something that can be seen through the *how* aspect and *what* aspect of the experience. The *what* aspect constitutes the direct object of learning which is the contents of the construct that is learnt and, furthermore, the

phenomenon that is under investigation. The *how* aspect refers to the learner's approach in achieving his or her task. In other words, how does the learner go about understanding and learning the construct in question. The how aspect is broken down into the act of learning and the indirect object of learning. Thus, the act of learning refers to *"the experience of the way in which the act of learning is carried out"* [2] and the indirect object of learning refers to the goals that the learner is trying to achieve (i.e. their motives [5]). However, as [5] points out, this distinction between the *what* and the *how* aspects is entirely analytical and is only used by the researcher to assist in the analysis.

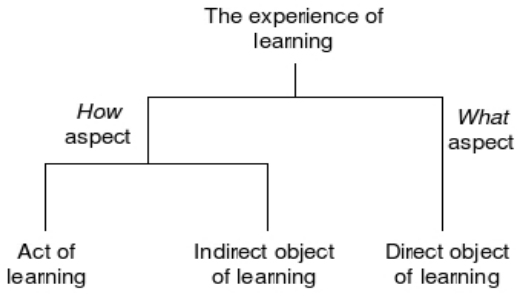


Figure 2: The Experience of learning.

## VARIATION

Marton argues that by *"experiencing variation, people discern certain aspects of their environment; we could perhaps say that they become "sensitised" to those aspect"* [14]. The point being made by Marton is that unless you have a point of reference and a variation from it, discerning and understanding something in its entirety is not possible. The aspects that are considered important in understanding a phenomenon are called critical features [12]. For example, if the phenomenon under consideration is the colour red then one should experience the variation of other colours, and possibly textures and objects of that colour, to gain a complete understanding of the phenomenon. Four different patterns of variation have been identified. These signify the difference between the elements that stay invariant in a learning situation and those that do not. These are [12]:

1. *Contrast:* A person needs a point of reference to compare something with something else. As in the case above, in order to understand red you need to know about green so that you can discern the contrast.
2. *Generalisation:* Variation in values of that aspect is necessary to discern the phenomenon. Thus, cherry red and strawberry red would constitute values in this pattern of variation.
3. *Separation:* In order to experience certain aspects of the phenomenon, and in order to be able to separate these aspects from other aspects, the phenomenon must vary while other aspects remain invariant.
4. *Fusion:* In cases where the phenomenon has to be experienced in its entirety, it is necessary that a situation should be present where these aspects are all experienced simultaneously. Therefore, there is a fusion within the dimensions of variation of the specific critical aspects.

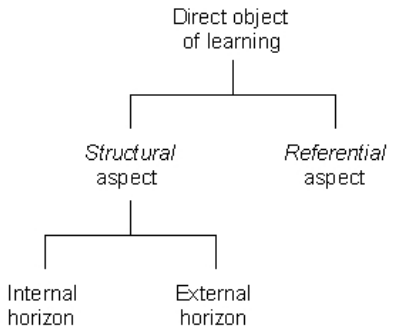


Figure 3 Internal and External horizon of the direct object of learning.

In order to identify the variation that facilitates certain types of understanding, the direct object of learning (the "what" aspect in Figure 2), may be further analysed [2] (see Figure 3). The ways of experiencing something, for example the construct of a class in object-oriented programming, differ in both their meaning (what a class is understood as) and structure (the relationship between the parts of a class). The meaning is termed the referential aspect while the structure is referred to as the structural aspect. The structural aspect of the learning experience is further broken down into the internal and external horizons of the experience. The former denotes the focus of the attention and the relationships between the aspects and elements that are in focus. The latter denotes the elements and aspects that surround the phenomenon along with the elements that the phenomenon is related to and is a part of [2].

## DATA COLLECTION AND ANALYSIS

In phenomenographic projects the main source of data are the semi-structured interviews that the researcher has conducted within the population of interest. A number of key questions should be used to set the theme of the interview and make sure that all the members of the sample population are discussing the same phenomenon. Questions are usually phrased in terms of the students' perceptions, understanding and experience (for example “what is your understanding of an array?”), but the interviewer can deviate from those when interesting angles of understanding are exposed through the discussion. [11].

The selection of the theoretical sample for the interviews is an important influence on the data collected. The sample should capture as broad a range of relevant population characteristics as possible (e.g. background, prior experience, gender, age). These characteristics should be representative of the group under investigation, as well as of other similar groups in different educational settings.

The interview data is then transcribed verbatim and the highly iterative process of analysis commences. In order to identify the different ways people are experiencing the phenomenon in question, the text of the interview data are read repeatedly and the patterns that are particular to distinct understandings are noted. Initially the transcripts are seen as a whole and within the context of the particular subject, while in later stages the interview excerpts that are relevant to an understanding are de-contextualised and compared to each other. The excerpts are grouped and regrouped as the researcher further

analyses and compares the quotations, until the data remain in a stable condition and the outcome space is formulated.

It is important to note at this point that phenomenography assumes that there is only a limited number of qualitatively distinct ways a phenomenon can be understood [13]. These are summarised in the categories of description. The categories of description form a hierarchy that extends from basic to more complex understandings. However, this is not passing judgement on better or worse ways of understanding [14]. The hierarchy of the categories is formed based on both logical premises (i.e. which understanding is less comprehensive compared to another) and, more often, on the inclusiveness of the understanding. Some categories that are more complex often presuppose the understanding that is encapsulated in a simpler category, and this imposes a hierarchical structure.

## DISCUSSION AND CONCLUSIONS

A number of phenomenographic studies have been carried out in the field of Engineering and Computer Science Education. In [7] Booth studied what it means to learn how to program within a functional programming course among first year Engineering students. Bruce [8] also conducted a phenomenographic study into how beginners experience learning to program in an Information Technology course. Both studies suggest that the constructs of a programming language should be introduced to the students in as many different ways as possible to encourage variation and enable students to experience programming from all it perspectives.

The authors of this paper have conducted a phenomenographic study of how Computer Science students' experience learning object-oriented programming by investigating a) the *theoretical*, b) the *object-oriented* and c) the *general* aspects of programming from the students' perspective [15]. The results suggest that learning the various components of programming is characterised by a growing awareness of the field of programming and the development of qualitatively better conceptions of the constructs. The development of abstract thinking, and general programming skills, is experienced as the capability to draw from the learning environment the appropriate elements that enable deeper understandings. The study discusses the implications for educators when teaching object-oriented programming. Our findings indicate that educators should primarily be aware of the range of understandings held by their students and actively encourage the acquisition of richer conceptions through carefully designed programming exercises and assignments. Also teaching should not be limited to the expert presentation of topics, but rather should provide students with a number of ways to discern the desired understanding. Through this students will develop a holistic view of programming by becoming experts through practical work and experience.

Phenomenography and activity theory have also been used to investigate students' understanding of computer networking protocols [5]. In another study, Cope [16] looks at students' understanding of information systems; highlighting the complexity of the constructs and the different levels of understanding that students should achieve. Many

more examples of phenomenographic and variation theory studies can be found in the literature in other educational settings such as physics [6] and mathematics [9].

In conclusion it can be said that the combined research approach of phenomenography and variation theory presented in this paper has proven to be a powerful tool for educators. As Ramsden says *"To teach is to make an assumption about what and how the student learns; therefore to teach well implies learning about students' learning"* [17].

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