An overview of a theoretical framework of phenomenography in qualitative education research: An example from physics education research

Funda ORNEK

Bahrain Teachers College, University of Bahrain, Kingdom of BAHRAIN

E-mail: fundaornek@gmail.com

Received 23 Oct., 2008
Revised 17 Dec., 2008

Contents

Abstract

One or more theoretical frameworks or orientations are used in qualitative education research. In this paper, the main tenets, the background and the appropriateness of phenomenography, which is one of the theoretical frameworks used in qualitative research, will be depicted. Further, the differences among phenomenography, phenomenology and ethnography will also be briefly discussed. Lastly, how the framework of phenomenography is useful and significant in

depicting structures of some studies and in contributing to physics education research or science education research will be discussed.

Keywords: Ethnography, theoretical framework, phenomenography, phenomenology

Introduction

Theoretical Framework

There are several theoretical frameworks, depending on the researcher's goals and purposes, that guide qualitative research in order to analyze data in education. For instance, the researcher might want to describe behavior, understand beliefs or explain phenomena. To explore these themes, the researcher should observe students, interview with students or engage with students in the field to be studied. Therefore, he or she should follow one or more theoretical frameworks. In this paper, phenomenography, developed by Marton (1986) as a qualitative research theoretical framework, is presented. According to Marton (1986), "Phenomenography is an empirical research tradition that was designed to answer questions about thinking and learning, especially for educational research."

Phenomenography

What is phenomenography? Phenomenography is the empirical study of the different ways in which people think of the world. In other words, its aim is to discover the qualitatively different ways in which people experience, conceptualize, realize and understand various aspects of phenomena in the world around them (Martin et al., 1992). In phenomenographic research, the researcher chooses to study how people experience a given phenomenon, not to study a given phenomenon. Marton (1986) and Booth (1997) described phenomenography as:

"Phenomenography is focused on the ways of experiencing different phenomena, ways of seeing them, knowing about them and having skills related to them. The aim is, however, not to find the singular essence, but the variation and the architecture of this variation by different aspects that define the phenomena" (Walker, 1998).

Phenomenography is related to a field of knowledge, which is defined by having experience as the subject of the study. It takes a non-dualistic ontological perspective; meaning that object and subject are not separate and independent of each other. When a textbook and someone who is reading it are considered, we cannot assume the text in itself and the reader's conceptions are separate things.

There is not going to be a textbook in itself, it always has meaning to someone and it is not going to be independent from the reader (Walker, 1998). Here is another example to make the relationship between the subject and object clearer. When children are asked how the number 7 can be obtained, one might sense it as 5+2, but another one may say 6+1 or 4+3. Their conclusions may be the result of an experience of the number 7, the result of reflection or some other possibilities. In all cases, 7 is seen as a sum of two pairs, 5 and 2, 6 and 1, or 4 and 3. Therefore, we simply cannot deal with an object without experiencing or conceptualizing it in some way. In this sense, the subject (children) and object (numbers) are not independent.

There are various ways in which people experience or understand a given phenomenon, because different people experience a phenomenon in different ways. Phenomenographers seek to identify the multiple conceptions that people have for a particular phenomenon. The conception of researchers about a given phenomenon is not the focus of the study, because the focus of phenomenographical study is about the conceptions that people have on certain phenomenon. For instance, as referred to above about the textbook and the reader, we cannot say the textbook is the same for each reader since each reader reads it in his or her way from his or her own perspective. The purpose is to look at the ideas of readers about the textbook from their perspectives (Walker, 1998). The researcher tries to be neutral to the ideas of the participants in the study. As phenomenography is empirical research, the researcher or interviewer is not studying his or her own awareness and reflection, but awareness and reflection of the subjects or participants (Orgill, 2002). This is labeled “bracketing”. In other words, bracketing means that the researcher must approach both the interview and the data to be analyzed open-mindedly without any input from his or her perspectives.

For instance, investigating ways of experiencing of an introductory physics course by physics students through a qualitatively designed study, is best viewed through the framework of phenomenography, since this study is concerned with the ways of experiencing of an introductory physics course by physics students. Likewise, it is concerned with the ways in which physics students experience or understand selected concepts and principles of physics (Martin et al., 1992). What is meant by “a way of experiencing? According to Morton (1986) and Booth (1997), a way of experience is twofold. The first is the way in which the phenomenon is distinguished from its context. This is sometimes called “external horizon”. The latter is the way in which the phenomenon and its parts are related to one another. This is sometimes called “internal horizon”. So, a way of experiencing depends on how the parts of the phenomenon are distinguished and appear at the same time in the learner’s focal awareness and the parts of it move into the background. While some aspects of the phenomenon are brought into focal awareness (called the

theme), other aspects of the phenomenon remain in the theme (called the thematic field).

Here is an example from physics context to make the theme and thematic field clear:

A small insect flies directly into the windscreen of a bus traveling down a freeway and is immediately killed as it is splattered onto the windscreen. Compare the relative size of the impact force experienced by the insect and the bus, respectively, for the period of impact. The thematic field may include the different aspects of the above situation as distinguished by students or individuals such as the bus, the insect, the relative masses and velocities of the bus and insect, general ideas about force and momentum, Newton's Laws and intuitive ideas about collisions. For example:

1. In one case, the focal awareness might be on the relative masses and velocities of the bus and the insect. This focus on the small mass and velocities of the bus and the insect can lead students to think that the insect must experience a bigger force (big enough to squash it) compared with the force which the bus experiences (so small it is not noticeable).

2. In another case, the focal awareness may be on the bus and insect as two bodies interacting, according to Newton's Third Law. This focus can be on the identical, but opposite, forces that each body exerts on the other; and in this case, the relative masses can be considered not with different size forces, but instead, with different changes in velocity experienced by the bus and the insect.

In above physics example, students' experiences of physics phenomena depend on which parts of the phenomena are brought into focal awareness. A scientific understanding or experience of a physics phenomenon causes students have some critical aspects of the physics phenomena in their focal awareness. These critical aspects of the phenomenon are necessary for developing the scientific understanding in education. For example, in Newtonian mechanics, one critical aspect may be the relationship between the body's motion and the net force action on it. Through a phenomenographic view, learning is about changing those aspects of the phenomenon that are in the theme, and the role of teaching might focus on the educationally critical aspects of a phenomenon. Therefore, the teachers can bring some different variations into their local awareness for the students. For instance, if the teacher extends the students' experience of motion, this can expose the fact that the friction can be brought into the students' focal awareness (Linder & Marshall, 2003).

As was shown in the physics example above, students might experience a physics phenomenon in different ways.

Another example related to this can be given from the educational psychology. Research was done by Walker (1998) about investigating children's learning. The children were asked to tell their thoughts about how they understand learning.

Child A's perspective: A seven-year-old girl. She enjoys school and thinks that she is a good "learner" and wishes to be correct in her presentation and answers. When she is learning and spelling, she strives to have learned all her weekly words correctly. She describes a "look, cover, write, say" method which, having learnt at school, she applies and practices at home. She likes to be in a quiet place when she is learning and insists that her mother test her accuracy at breakfast most days. She describes the words as "sliding into her head and sticking". She understands that learning spelling helps her to do well in the weekly spelling test and also enables story writing without constant reference to a dictionary which she feels allows her down. She likes writing stories.

Child B's perspective: B sees learning spellings as "boring" and does not try to learn spelling at home. He is unclear about the "look, cover, write, say" method taught at school, and when asked to display his approach, he looked at the word, covered his eyes and then tried to write with his eyes on the word to be copied, not the word he was writing. All the while B was repeating the word himself. B notices no reason for learning spelling other than to take the weekly test.

In above examples, the children have formed some ideas on learning spelling. The experience of learning spelling is different for each child. Child A is successful, and child B sees learning spelling as meaningless and not worth the effort.

To apply phenomenography in educational research for data collection and analysis, the interview, which is a semi-structured individual interview, is the preferred method. The aim of the interview is:

To have the participant reflect on his/her experiences and then relate those experiences to the interviewer in such a way that the two come to a mutual understanding about the meanings of the experiences (or of the account of the experiences). (Orgill, 2002).

Interviews can be developed according to both the interviewee's conversation and his or her response to the predetermined questions. If the interviewee wants to further explain his or her understanding about the phenomena, the interviewer should let him or her do so. When explanations are not clear, the interviewer should ask questions such as "could you explain that further?" (Barnard et al., 1999). The

interviewer has to make it clear that the interview is open and interviewee can think aloud, be doubtful and also pause. It is important for the researcher not to evaluate the answers as being right or wrong. However, the researcher should show that he or she is really interested in getting the subjects to express themselves clearly (Sjöström & Dahlgren, 2002). Interviews focus on the world of the interviewee and seek to reveal their beliefs, values, reality, feelings and experience of a phenomenon (Barnard et al., 1999). For example, the following questions were obtained from Ornek's study (2006), which guided the study about discovering students' thoughts, experiences, beliefs and feelings about the physics course that they took.

1. *Before you started this course, I am curious about what you expected the course to be like.*

   o What did you think would happen in lecture?

   o What did you think would happen in lab?

   o What did you think would happen in small groups?

2. *a) How do you feel about lectures?*

   b) How do you feel about working in small groups?

   c) How do you feel about computer simulations?

Also, as referred to above, to discover the way physics students' experience or understand selected topics or principles of physics, such as Newton's Laws, think-aloud protocol interviewing can be used in phenomenographic research. The think-aloud protocol approach reveals what is happening in a person's head when he orshe is performing a task. This task might be solving a problem such as a physics problem or painting. Take, for example, a physics problem. While the student is solving a physics problem, the goal is for the interviewer to ask questions and have the student talk about what her or she is thinking. In other words, the basic strategy is to get students, who are solving problems, to verbalize their thoughts and feelings as they solve problems (Patton, p385). There is an example, which is a physics problem, of a student's response to a problem, including his thinking stage while he was solving the problem, from Ornek's study (2006) in Table 1.

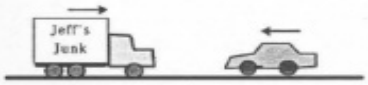
Table I: *Problem-Solving Protocol (the think-aloud protocol approach)*

I. There is a collision between two cars of equal mass where one car is initially at rest.

A. Draw a free body diagram for each car during the collision showing all forces.

B. Rank the magnitudes of all the horizontal forces and give your reasoning.

II. Now think about a head-on collision between a moving van and a Ford Escort. Each vehicle is initially moving at the same speed. The following questions refer to what is happening during the collision.



A. Does the moving van exert a force on the Ford Escort?

B. Does the Ford Escort exert a force on the moving van?

C. If the answers to questions A and B are yes, which force is larger? Explain your answers to A, B, and C.

III. Write out a complete statement of Newton's third law in terms of forces in your own words. (You may use a diagram if you wish.)

The following excerpts are got from Ornek's study (2006). A student solves a physics problem using the think-aloud protocol. While the student is solving the problem, the goal is to have the student talk about what he is thinking. The pseudonym Clark was used.
Clark solves the problem correctly. He drew and identified some forces except for the gravitational forces in a correct free-body diagram for two cars. He solved the first part of the problem by Newton's third law instead of the momentum principle containing Newton's third law. Later, and for the second part, he used the momentum principle and got Newton's third law from the principle. The excerpt below is taken from the interview.

C: Alright … Uh, diagram..car one..car two..toward the other car. [Sighs] It's got no motion since it is at rest. It's zero. So each car during the collision. Showing all forces. Car one..car two.. [sighs]. The force exerted..on car two by car one is equal and opposite to the force on car one by car two. That's Newton's Third Law. [Pause] [mumbles something] [pause] [sighs]. Actually,

Clark stopped talking while he was solving the problem. The researcher asked him what he was doing. After that, he started to talk again. He used the momentum principle to solve the second part of the question. And he got the correct answer. He explained step by step to make everything clear to be understood.
C: Alright. Um, just drew, uh… So, I just drew a line at the top that shows the direction of the force- forces acting on the cars. 'Cause I want it to be clear that they are- if they were reading it they'd understand that there's a forces acting this way on this- on this car and forces on this one acting on this car. Um, the car during the collision... [pause] that would be F. Equal magnitude but opposite direction. The forces, uh, rank the magnitude of the horizontal forces. Give your reasoning. Uh, so the momentum principle of p equals f net dt. [Sighs] And..[makes noises] be that one car... Say car two and delta p equals f net times dt. Uh, time for the collision for both of them is equal. So we have...the equations form... [mumbles]. Relate the change in momentum in net force acting on the car. [Sighs]

equal to f net..[mumble] change in momentum of one car over the net force on one- on that same car is equal to the change in momentum over the net force, um, of the other car.
C: The delta t is the same for the collision so the force is acting for the same period of time on both cars. D- during the collision. So... [mumbles] This is just the magnitude and this would be direction. Which...[pause] …The original car is moving in the positive x direction. So the forced applied on car one would be negative. P sub one and p sub two…delta p sub one will be opposite of delta p sub two. So on delta p it can be- since they are not relativistic model and the mass- non relativistic model and the masses are not changing you can take mass as a delta p. You have m times negative delta p. Then equals m sub two times p. And since the masses of both cars are equal... v- I mean delta v not delta p on that. And because the mass of the cars are then same get this down to the change in velocity. For car two is equal and opposite in the change of velocity of car one. So…magnitude. Horizontal forces and give you reasoning. I just went through that already, ok. Um, the magnitudes. Magnitudes of all the horizontal forces are equal.

At this point he also used Newton's third law as if he wanted to makes sure he was doing it right.

C: Um, the magnitude of the forces are equal and in opposite direc- but in opposite directions. By Newton's Third Law it said that the forces would be equal in that case.

For the second part of the question, Clark uses the linear momentum principle.

C: It's because the Ford Escort, um, has a change in momentum which by the momentum principle says that there is a force acting over a certain period of time. And there's- the only...other object in this system that it would interact with would be the moving van. So the moving van would s- is applying the force…against the Ford Escort. I mean which the Ford Escort is experiencing. Uh, (b). Does the Ford Escort exert a force on the moving van? Uh, yes it does. Same thing as the last case. There's a change in momentum of the moving van. And other objects being acted- only other object being considered in this diagram would be the Ford Escort. And the force is a, uh, is proof of an interaction. So any other way it could interact with the Ford Escort is through physical contact. Which it would be during the collision. And (c). If the answers to (a) and (b) are yes which force is larger? Explain your answers to (a), (b), and (c). Alright, here's the fun part. Which force is larger? So now delta v and delta p equals f net delta t that would be our Ford escort here. And delta p of the moving van f knot and then delta t. So, same way the collision happens over the same period of time. So delta p of the Ford Escort over f net Ford Escort equals delta t. And same thing for the moving van, delta t. Delta p of van over f net. Moving van equals delta t. And since those two equations are equal to each other you can pull them together. And delta p over f net escort. Equals delta p moving van over f net. Moving van. Alright. Um... [pause] [mumbles] The force- I forgot which one I'm thinking of. So... [mumbles] [sighs] The net force- the force that the...I think that that's right. Newton's third law- by Newton's Third Law ... [sighs] the force f e. Escort- the Ford Escort on the moving van equal- would be equal and opposite to the force of the van on the Ford Escort.
C: Ok, delta- delta p of the Ford Escort... net Escort equals p over net- net van. Ok. Since this is a nonrelativistic you can move the mass of each. So it will be mass of Ford Escort..delta v Ford Escort. M v. Mass of Escort equals mass of moving van delta v. F from that. Moving van would be...initially moving at the same speed. So…um...(mumble) Um…where I'm going with this but... V is..moving van that. Let me give one equals one, which proves the equation is equal. 'Cause the delta- delta p f e is equal to the delta p of the moving van. But the forces are not equal because by the equals f equals m a...this takes place because of the Ford Escort. Acceler- acceleration is...it being experience is going to be equal and opposite to. I know this problem as I'm sure most people do. So by Newton's Third Law force is equal and opposite to each other. And-

Clark is really confused about Newton's third law and in what situations it can be applied. He started to think he cannot apply Newton's third law because of the different masses of cars. Then he does

correct himself soon after.

C: So Newton's Third Law doesn't really apply because, um, actually yeah, it does apply. But the amount of de- the amount of deceleration that the Ford Escort and the moving van experiences is equal, but the masses are different. And since the mass of the moving van is a lot larger than the Ford Escort the amount of force applied to the moving van is greater than the amount of the force applied to the Ford Escort. But…[mumbles] By that, um, the force of the moving van would be a lot larger because they would- the basic assumption right here is that acceleration- is their velocity would drop down to zero in collision. They would- they wouldn't just keep going through each other. Or they wouldn't keep going a certain direction at a certain speed. But that the accelerations would drop down to zero and because the truck was more massive than the Ford Escort the amount of force that would be required would be larger than the Ford Escort. No, no that's not right… The amount of force required on the Ford Escort is equal to the amount of force required on the van.

In last part, Clark tried to explain Newton's third law in his own words. Although it is not very clear, it can be understood that this explanation includes Newton's third law.

C: [pause] [sighs] one f equals f two and one two. Much that pushes back. The answer now is, um, the basic equation is used is f one on two is equal and opposite to f two on one.

Clark solved the problem correctly, but he was always in a dilemma. He was, therefore, exhibiting some profound conceptual difficulties with Newton's Law because he thought he could just use Newton's third law when the masses are equal. He has the p-prim, which states that since the truck is more massive, it requires larger force. He could not make links between the pieces pf knowledge. He cannot make certain connections correctly between the momentum principle and Newton's third law. Finally, after a long process, he got the correct answer by struggling back and forth between Newton's third law and the momentum principle. The idea of the momentum principle concept and Newton's third law concept is not clear in his mind.

During data analysis in phenomenographic research, the researcher will identify qualitatively separate categories that describe the ways in which different people experience a different concept. There can be a limited number of categories for each concept from the study. And these categories can be found in interview transcriptions (Booth, 1997). Sjöström's study (2002) stated that the analysis includes certain steps. These steps are as follows:

The first step is familiarization, which means the researcher becomes familiar to the material by means of reading through the transcripts. This step is important in making corrections in the transcripts. ***The second step*** is compilation of answers from participants to a certain question. The researcher should identify the most significant elements in answers given by participants. ***The third step*** is a condensation, or reduction, of the individual answers to find the central parts of a dialogue. ***The fourth step*** is preliminary grouping or classification of similar answers. ***The fifth step*** is a preliminary comparison of categories. ***The sixth step*** is the naming of categories. ***The last step*** is a contrastive comparison of categories. It includes a description of the character of each category and similarities between categories.

Another view from Orgill (2002), in terms of analyzing data, is that researcher examines the transcriptions of participants, looking for not only similarities, but also differences between them. During this process, the researcher develops initial categories that describe different people's experiences of the given phenomenon. After covering multiple aspects of that phenomenon, the researcher develops the categories that explain all kinds of variations in the data. Then, based on initial categories, the researcher reexamines the transcripts to determine whether the categories are sufficiently descriptive and indicative of the data. This second review of the data modifies, adds or deletes category descriptions, and the next examination of the data is reviewed for internal consistency of the categories of description. This process of modification and data review continues until the modified categories seem to be consistent with the interview data.

Credibility of Phenomenographic Analysis

In quantitative research, the issue of reliability are related to sample size and the instrument for data collection, whereas in qualitative research, there are issues of credibility of the research results in a different sense. The main issue of credibility in a phenomenographic study is the relationship between the data obtained from interviews and the categories for describing the ways in which people experience a certain phenomenon. The researcher has to show a way to describe similarities and differences that should be supported by the data from transcriptions. Having excerpts from the interviews to support the categories can provide this. In general, the validity of phenomenographic research is based on three factors. The first is the logic of the system of categories emerging from the analysis. The categories must be logically separate and exclusive. The second factor is the correspondence between the results and what is known from previous study in the field. The last is the probability of the categories to be considered (Dahlin, 1999). For reliability, two or more researchers can be asked to analyze the same data independently and compare their findings (Martin et al., 1992).

What is the difference between phenomenography and phenomenology? One can say that it is similar to phenomenology in that it is another theoretical framework in qualitative research. Sometimes, phenomenography is confused with phenomenology, but phenomenography is different from phenomenology. On the other hand, as referred at the beginning of this paper, one can choose a theoretical framework based on the purpose of his or her study. Let's explain the differences with an example by using Ornek's study (2006). In the study, students' thoughts, experiences, beliefs and feelings about a physics course that students took were investigated. Therefore, the study needed to be framed and required the use of a qualitative research method. Besides phenomenography, which is the theoretical framework of the study, there are other frameworks which could be used in this

study, such as phenomenology or ethnography; however, they would not be suitable for the study. The following reasons and features of these methods will ascertain why they are not appropriate for the study.

Like phenomenography, phenomenology is also a field of knowledge that is acquired by having experience as the subject of the study (Walker, 1998). They have many similarities, but also have differences. Morton (1981) describes that the aim of phenomenology is "to describe either what the world looks like without having learned how to see it or how the taken-for-granted world of our everyday existence is 'lived.'" The differences and relationship between phenomenography and phenomenology are shown in Table 2 which is adapted from Barnard et al. (1999). As is seen in Table 2, phenomenology is a different approach and should not be confused with phenomenography, even though both aim to discover human experience and awareness. Phenomenology is interested in individual experience, which was not the aim of Bernard's study, whereas, phenomenography is interested in having collective meaning. Also, phenomenology is interested in a first-order perspective in which the world is described as it is, rather than a second-order perspective in which the world is described as it is understood.

Table II: *The differences between phenomenography and phenomenology (Barnard et al., 1999).*

Phenomenography		**Phenomenology**	
1.	The structure and meaning of a phenomenon as experienced can be found in pre-reflective and conceptual thought.	1.	A division is claimed between pre-reflective experience and conceptual thought.
2.	The aim is to describe variation in understanding from a perspective that views ways of experiencing phenomena as closed but not finite.	2.	The aim is to clarify experiential foundations in the form of a singular essence.
3.	An emphasis on collective meaning.	3.	An emphasis on individual experience.
4.	A second-order perspective in which experience remains at the descriptive level of participants' understanding, and research is presented in a distinctive, empirical manner.	4.	A first-order perspective.
5.	Analysis leads to the identification of concept tions and outcome space.	5.	Analysis leads to the identification of meaning units.

In addition, the most important difference, which makes it not be appropriate for the study, is that phenomenology takes a dualistic ontology in which the object and the subject are considered separately and independently. For example, a textbook and a reader are separate entities according in this approach. That is, there is a textbook in itself and a reader (Walker, 1998). Here is another example that is related to the study. The goal for the study is to investigate how students experience the physics course. Therefore, the physics course cannot have meaning in itself without having students who are experiencing it. It always has meaning to students, and it cannot be independent.

Ethnography is another theoretical framework for framing the study and analyzing data in terms of answering the question of "what is the culture of a group of people?" (Patton, 2002). It is the analysis of social processes by means of involvement in day to day experience (Richardson, 1999). Its focus is to describe cultures, and thus the ethnographic researcher participates in every educational experiences that relates to their inquiry. For this reason, ethnographers may observe students for long periods and report their interpretations of students' behavior. They listen to students and have heard/recorded their statements. Moreover, they have a questioning attitude towards to students' statements (Richardson, 1999). The researchers can talk with them anywhere and everywhere. There is no a formal or semi-structured interview. Also, the researcher has immersed him or herself in the student experience being studied. This is the negative aspect of ethnography; the researcher should try to be neutral. Since the interview is a primary source of data in phenomenographic research, the researcher should prompt students to discuss their thoughts in detail to remove or reduce incorrect interpretations that the researcher might have from his or her own conceptions. In contrast to phenomenography, observation is a primary source in ethnography, and the researcher does not consider his or her own conceptions whether related or not. Therefore, it is not suitable to use ethnography as a theoretical framework for the study.

Benefits of Phenomenographical Studies in Education/Science Education

There are certain benefits to using the results of phenomenographic study in education research. Phenomenographic studies in education probe how students experience understanding and constructing of new knowledge. In universities or institutes of higher education, students are usually encouraged to develop conceptual understanding (Entwistle, 1997). The goal of teachers or instructors is to assist their students in developing conceptions that are consistent with those of experts in different areas, such as physics. However, in general, students have multiple, different and alternate conceptions for a phenomenon which may not be

consistent with experts' conceptions. Marton (1986) claims "a careful account of the different ways that people think about phenomena may help uncover conditions that ease the transition from one-way of thinking to a qualitatively better view of reality" (p. 33). Therefore, "phenomenographic information about the different conceptions that students hold for a particular phenomenon may be useful to teachers who are developing ways of helping their students experience or understand a phenomenon from a given perspective" (Orgill, 2002).

Another possible advantage of phenomenographical research is that "students may become aware of contradictions in their own reasoning and become more open to alternative ideas as they reflect on their views and understandings of their world experiences" (Marton, 1986).

As a result, educators can benefit from these studies designed to improve or develop their teaching strategies or their curriculum by understanding students' conceptions and thoughts about the course.

Acknowledgement

I would like to thank to Dr. Donna Enersen, an instructor at Purdue University, in the United States, for her tremendous help.

References

Barnard, A., McCosker, H. & Gerber, R. (1999). Phenomenography: A qualitative research approach for exploring understanding in health care. *Qualitative Health Research, 9,* 212-226.

Booth, S. (1997). On phenomenography, learning and teaching. *Higher Education Research and Development, 16,* 135-158.

Dahlin, B. (1999). Ways of coming to understand: Metacognitive awareness among first-year university students. *Scandinavian Journal of Educational Research, 43,* 191-208.

Entwistle, N. (1997). Introduction: Phenomenography in higher education. *Higher Education Research & Development, 16,* 127-134.

Linder, C. & Marshall, D. (2003). Reflection and phenomenography: Towards theoretical and educational development possibilities. *Learning and Instruction, 13,* 271-284.

Martin et al. (1992). Displacement, velocity, and frames of reference: Phenomenographic studies of students' understanding and some implications for teaching and assessment. *American Journal of Physics, 60,* 262-269.

Marton, F. (1986). Phenomenography - A research approach investigating different understandings of reality. *Journal of Thought, 21,* 28-49.

Marton, F. (1981). Studying conceptions of reality - A metatheoretical note. *Scandinavian Journal of Educational Research*, *25*, 159-169.

Orgill, M. K. (2002). Phenomenograpy. Retrieved January, 2008 from http://www.minds.may.ie/~dez/phenom.html

Orgill, M.K. (2002). Phenomenograpy. Retrieved September, 2003 from http://chemed.chem.purdue.edu/chemed/bodnergroup/frmaeworks/phenomenography.htm

Ornek, F. (2006). Modeling-based interactive engagement in an introductory physics course: Students' conceptions and problem solving ability (Doctoral dissertation, Purdue University, 2006). *Dissertation Abstracts International*, *68*, 02.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). California: Sage Publications, Inc.

Richardson, J. T. E. (1999). The concept and methods of phenomenographic research. *Review of Educational Research*, *69*, 53-82.

Sjöström, B. & Dahlgren, L. O. (2002). Applying phenomenography in nursing research [Electronic version]. *Journal of Advanced Nursing*, *40*, 339-345.

Walker, C. (1998). Learning to learn, phenomenography and children's learning. *Educational and Child Psychology*, *15*, 25-33.