

# Academics' Experience of Teaching Open Ended Group Projects

## A phenomenographic study

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**Abstract—** An Open Ended Group Project (OEGP) is a distinguishable pedagogical tool, used by teachers in computing, engineering, and information technology courses. The tool contributes to the development of 'soft' skills essential for students' future career needs. This paper reports on a phenomenographic study that investigates the research question: What are the ways in which academics teaching Open Ended Group Projects experience teaching the course? Previous studies, using the phenomenographic research approach, have offered insights into academics' conceptions of science learning and teaching. However, there are no studies that investigate the experiences of teachers who use OEGP in their classes. This is the first study, that asks academics using an OEGP how they experience teaching these courses. Students enrolled in a course on computing education research conducted the small-scale study at Uppsala University, Sweden. In order to answer the research question, a theoretical sample was selected with a wide range of relevant population characteristics (e.g. background, prior experience, gender, and age). The semi-structured interview questions focused on understanding of OEGP, the learning objectives of OEGP, strategies for teaching these learning objectives, and the teacher's experience in teaching through OEGP. The results indicate that teachers see their role within OEGP as a coach and that the variation between experiences lies in what is intended to be coached. This variation is presented in a hierarchy (the outcome space). Categories focus on: the team, discipline, problem solving skills, learning and motivation. We also look at the first-hand experience of a student in an OEGP course and discuss the teachers' perceptions of students' experiences of OEGP. The implication for teaching is that a teacher needs to reconsider the way he or she teaches more often in OEGP than in regular courses. There are two reasons for this. First, teaching OEGP is based less on teaching content knowledge and more on teaching skills. Secondly, OEGP deals with a 'real problem', and aspects of the problem continuously change. Teachers are recommended to aim for reaching a higher category, indicating a deeper level of experience, and to use the experience of coaching OEGP in other courses as well. The importance of metacognition (reflection on action) and discussion with other teachers who have experience in teaching OEGP is highlighted.

**Keywords—**Open Ended Group Project (OEGP), teaching experience, phenomenography.

## I. INTRODUCTION

There are many different ways for a teacher to teach in a class. The most common way is to lecture [1]. At the

Department of Information Technology of Uppsala University, assignments, labs, seminars and projects are also used as instructional methods. At Uppsala University, the Open Ended Group Project (OEGP) course is distinctive in its instructional approach. It is used for teaching 'hot topics'. This means the topics discussed in the class can be new and yet undiscovered.

It might be hard for the teacher to instruct the student in such 'hot topics', because the teacher may not have the requisite content knowledge. This is in contrast to the teacher teaching the same course for many years, where the teacher has extensive experience in how to guide the students and has knowledge of the most common problems that the students encounter. In an OEGP course, the role of teacher changes from instructor to guide [2]. The teaching goal is to help the students to become active participants in their learning. This is different from just instructing and assessing knowledge using assignments and exams.

We are interested in how the teacher experiences teaching such project based courses. Using OEGP as a pedagogical tool is very different from traditional pedagogies. As a result, not only the teacher's role, but also the conception and the strategy of teaching is bound to be different when teaching the course. The learning outcomes and how to help the students to achieve their goals also need to be adapted to the OEGP course.

In order to investigate this area of interest, we propose a phenomenographic study to explore qualitatively different "ways of experiencing" [3] the phenomenon of OEGP. Thus, our research question is:

*In what ways do academics teaching Open Ended Group Projects experience teaching the course?*

Topics of particular interest are: the teacher's understanding of OEGP; how teachers try to help the student to learn better; and what teachers think of their role in such courses.

The outline of this paper is as follows. Section 2 covers related work. In section 3, we present the details of the phenomenographic approach that we used for the study. We show how we conducted, transcribed and analyzed interviews with teachers teaching an OEGP course. In section 4, we discuss the results of the data analysis. Finally, section 5 concludes the paper and highlights future work.

## II. RELATED WORK

We start by looking at definitions of OEGP courses. We then give an overview of other related learning environments, since they have some commonalities with OEGP. Moreover, the role of a teacher is expected to change when teaching an OEGP course, so the next sub-section addresses the expectations from teachers. Section D introduces phenomenographic research and identifies other phenomenographic studies which are similar to this study.

### A. Open Ended Group Project

In the academic world, a handful of authors use the term Open Ended Group Project (OEGP), whereas other authors use other terms to refer to similar projects. These different terms are included in the related work.

OEGP is an educational 'model' or pedagogic 'tool', which can be used effectively within undergraduate degrees [2]. There are many benefits to such projects. They help students develop 'soft' skills, such as collaboration, communication, and intercultural competences, which are essential in the real world and helpful for the future careers of students [4-6].

OEGP is a group project focusing on an open-ended problem defined in terms of goals [7]. The most important goal is to find out the objectives that students want to achieve by solving the problem. An open-ended problem is related to a need or desire to improve upon the current situation. There is an inevitable risk that participants may fail to benefit, or even change the situation for the worse. Putting students into teams and letting them face a problem, for which there is no right answer, helps them to integrate prior knowledge. However, the problem could also be too complex. In that case, OEGP could affect the student negatively by increasing the cognitive load to a level where it is too high for beginners. Moreover, it is important to give students enough time to reflect on the problem and the chosen solution [8].

### B. Other Learning Environments

OEGP is one type of learning environment. Three other learning environments related to OEGP are: constructivist learning environments, experiential learning, and problem-based learning.

#### 1) Constructivist Learning Environments

Constructivist Learning Environments (CLEs) consist of a problem, question, and various interpretative and intellectual support systems [9]. Examples of such intellectual support systems are: related cases, information resources, cognitive tools, conversational/collaboration tools and social/contextual support. The focus of any CLE is the question, the issue, the case, the problem, or the project that learners attempt to solve or resolve. A distinction is made between the problem context, the problem representation, and the problem manipulation space.

The goal of the learner in a CLE is to interpret and solve the problem or complete the project. In the process, learners may face many complex issues and need to collaborate with team members. These are similar to the goals in OEGP courses.

#### 2) Experiential Learning

Experiential learning [10] emphasizes that experience plays an important role in the processing of learning. It is different from rationalist and other cognitive theories of learning as it emphasizes acquisition, manipulation, and recall of abstract symbols. Experiential learning is characterized by interaction between the learner and the environment in the process of creating knowledge.

Experiential learning emphasizes the importance of experience when learning. Similarly, in OEGP learners need to recall the knowledge they had learned before to solve unknown problems, which means that prior experience is important.

#### 3) Problem-Based Learning

In problem-based learning, students work in small collaborative groups and learn what they need to know in order to solve a problem [11]. The teacher acts as a facilitator or guide throughout the learning process. Problem-based learning situates learning in real-world problems and makes students become active learners responsible for their learning.

According to Barrows and Kelson [12], problem-based learning was designed with several important goals designed to help students to:

1. construct an extensive and flexible knowledge base;
2. develop effective problem-solving skills;
3. develop self-directed, lifelong learning skills;
4. become effective collaborators; and
5. become intrinsically motivated to learn.

Many of these are also the goals of a course with an OEGP.

### C. Teaching in Different Ways

OEGP courses are different from other traditional courses where the teacher lectures and learning outcomes are assessed through exams. The students need to change their way of learning, and need to develop 'soft' skills. It seems logical that the teachers therefore need to change their way of teaching. According to various literature sources, there are many requirements for the teachers, that are different from those required for traditional ways of teaching.

The teacher's role changes from instructor to guide in OEGP courses [13]. The teacher does not impart concrete knowledge, but guides students to solve a real world problem. The teacher has to help students to become active participants in their learning. Also, the teacher helps students in making meaningful connections between prior knowledge, new knowledge, and the processes involved in the learning [14]. When the student is struggling, the teacher has to decide whether help is really needed or encouragement and/or reassurance will suffice.

OEGP allows for discussion of 'hot topics' [2]. However, this means that the teacher might not have the requisite content knowledge about the problem area. An example of such 'hot topics' can be seen in the collaborative course between Uppsala University and Rose-Hulman Institute of Technology. In this course, the students engaged in an open-ended project to investigate the Online Health Records (OHR) service. The project report [15] suggested extensions to increase the usability and accessibility of the service.

#### *D. Phenomenographic Research*

In a phenomenographic study, researchers are interested in learning about people's experiences [16]. Participants with a wide range of experiences are interviewed and the researchers adopt a second order perspective to understand how people experience the situation they are in. Interviews allow the participants to express their thoughts in their own words and the goal is to capture the rich variation in the experiences. During the data analysis phase, the researchers try to find similarities and differences in the participants' accounts of their experiences. Categories are then created to reflect the variations in the experiences. These categories are refined iteratively by the researchers as the data analysis continues.

Outcomes are represented analytically as qualitatively different meanings or ways of experiencing the phenomenon [16]. These outcomes are "categories of description" to distinguish the empirically interpreted category from the hypothetical experience that it represents. The categories are typically ordered in a hierarchy in relation to each other, with some categories considered as more advanced or powerful ways of experiencing a phenomenon [3].

Phenomenographic studies about academics' conceptions of science learning and teaching are available [17, 18], as also how computing academics experience teaching [19, 20]. Phenomenography has also been used to explore teachers' experiences of student learning successes and failures in computer science [21, 22]. However, no specific studies about teachers' experience of teaching OEGP were found. This paper offers a fresh perspective on the topic.

### III. METHODOLOGY

From a phenomenographic perspective, experiences and understanding are not "hypothesised to reside within individuals" [16], but are the result of a relationship between an individual and his task and context. Therefore, it is important to study not only the understanding of the individual as such, but also the relation to the task and context. This research focuses on OEGP within the department of Information Technology of Uppsala University, Sweden. The rationale for this choice is that the researchers are most familiar with this domain. The context comprises one Swedish university and two American universities. The OEGP task is for both bachelor and master students.

The participants for this study were selected based on their experience in teaching OEGP courses. A theoretical sample was selected with a range of relevant population characteristics as broad as possible (e.g. background, prior experience, gender, and age). As befitting a small-scale study, four teachers were interviewed: two from a Swedish university and two from American universities. They were each interviewed for 45 to 60 minutes.

The teachers from America were given the choice to do the interview using e-mail or video conferencing and the teachers from Sweden were interviewed using video conferencing or in person. Although it would be ideal to get all the data in the same format, the interviewees were offered the opportunity to choose what they were most comfortable with. Making the interviewees feel more comfortable was seen as high priority

by the researchers, as a comfortable setting for the participant may increase willingness to talk openly and honestly. The same consideration was given for the use of a camera during the videoconferences. As any information about gender or race (visible in video recordings) would not be needed for this study, a decision was taken not to use video during the online interviews. This would guarantee anonymity and increase comfort level. The disadvantage to this approach was that the body language of the participant was not visible. All interviews were conducted in English.

The interviews were conducted in three phases. The first phase consisted of closed questions to gather demographic data, e.g. "How long have you been teaching through OEGP?" The main section focused on four topic areas:

- the teachers' understanding of OEGP;
- the learning objectives of OEGP;
- the strategies for teaching these learning objectives;
- the experience of teaching through OEGP.

This part of the interview was semi-structured, using a list of questions to be asked during each interview. The questions are given below:

- What is your understanding of an OEGP?
- What are the learning outcomes of this OEGP course?
- How do you make students achieve these outcomes?
- How do you see your own role in teaching these learning outcomes?
- What does it mean to you to teach (these learning objectives) through Open Ended Group Projects?

If the interviewee used ambiguous terms, such as "understand", further clarification was asked for. The interviewer was not to evaluate the answers, as right or wrong, but should be interested in getting the interviewees to express themselves clearly. In the final phase, the interviewee was asked if there were any further comments. Finally, we thanked the interviewee for participating.

Each interview was recorded. The most significant answers of the interview were transcribed. The interview was conducted in English but not all of the participants were native English speakers. Therefore, there could be grammatical errors. We decided to transcribe these errors to maintain the authenticity of the transcripts.

In phenomenography, transcribing only the most significant answers of the interview is a part of the bracketing process. When transcribing, details such as examples are left out in order to capture only the parts related to the research question. The first two authors of this paper performed the data reduction process individually, choosing what parts of the interview were 'most significant', and ensured reliability and validity through inter-judge communicability [23].

A preliminary grouping of the significant answers was done in the first phase of the data analysis. The list of categories was iteratively refined and categories of description were

formulated. The categories of description mirror qualitatively different meanings or ways of experiencing teaching the OEGP course and are represented in the final outcome space [3, 17].

#### IV. WAYS OF EXPERIENCING OEGP

In the interviews, teachers were asked to answer questions about their experience with OEGP. In phenomenographic research, the results presented are experiences on a collective and not on an individual level [3]. Before the results are explained in depth, a definition of ‘experience’ is given based on the answers of the participants. The teacher’s experience is what she/he intends to teach. The outcome space is then presented and illustrated with quotes from the interviews.

The data analysis revealed that OEGP was experienced as:

- A. coaching teamwork;
- B. coaching to see the breadth of computer science;
- C. coaching students to experience the complexity of problems;
- D. coaching learning;
- E. coaching internal motivation.

As can be seen in the categories, they all “experienced OEGP as coaching...”. Coaching was seen as “scaffolding and directing”. As teachers themselves did not know the solution for an open-ended problem, when the students encountered problems doing the OEGP project, the teachers offered their knowledge based on experience.

One teacher remarked: “*Throw them in the water and hope they don’t drown. And if they crawl out of the water, make them reflect on how they survived*”. For these reasons, the ‘coaching’ aspect is part of every category. What varies is what the teacher intends to coach the students in. This variation is explained in the following sections.

##### A. To experience OEGP as coaching teamwork

In category A, teachers want to coach their students in collaborating and communicating in a real project. The objective is to learn how to work together in a team. According to teachers, “*They [the students] are not very good at communication. They have no experience in collaboration*”. The students should learn how to work in a team, because it helps the student to prepare for work in industry. Communication skills are also stressed.

*The better employee more than anything knows how to communicate.*

##### B. To experience OEGP as coaching to see the breadth of computer science

Students often think that computer science is only about finding a technological solution. In category B, teachers coach students to expand their view of computer science.

*Education should be more than learning knowledge – it should be more than how to solve technical problems.*

Students tend to think that in their future job, they only have to program code. Teachers want to show the students that this is not the case in industry. Ideally one should aim to program something that is beneficial to society, and in order to do so, the programmer must understand society. In the interviews, this was described as:

*It is not possible to just identify a technical problem to solve. And I think that you really start with the context. And understanding the context to identify relevant technical problems to solve.*

##### C. To experience OEGP as coaching to experience the complexity of problems

In category C, the goal is to coach the students in “*strategies to handle wicked problems, problems that are complex or complicated*”. The students are given a problem for which “*the teachers themselves don’t know the right solution*”, so that there is no ‘easy’ way to solve the problem. The students must learn themselves that the problem is not well defined, because “*if you’re out there, problems will not be so well defined*”. There is no single path that leads to successful results. Instead, the students must learn to understand the problem as a whole and try out different solutions for successful results. The following quote illustrates this aspect:

*We’re losing the art of brainstorming and having to think for longer than you think you might have to for a particular problem to solve it. And so in an open problem a lot of times you run into walls: that there just doesn’t seem to be a quick answer. And to see students to go through that, and you kind of want the students to go through that in a controlled environment where they still have the help of the professors, but they still can kind of work on their own to start to think objectively for themselves. And to get those problem solving skills we try to teach that, but you know, we can’t because we’re not giving the right kind of problems. And I think an open ended problem is really one of the best ones to get them to get creative like that.*

On the way to solving problems, students experience that some paths are more successful than others.

*As a teacher you can always prevent them from doing the mistake by telling them ‘do this instead’ before they have done the mistake. But I think mistakes can be fruitful.*

##### D. To experience OEGP as coaching learning

In category D, teachers want to coach students to learn. Learning in this context concerns questioning: When am I learning something? What am I learning? How do I turn knowledge into action? The teacher helps the student understand that learning is not always visible.

*One of the problems is that, those people who learn for the exam they have a tendency to think that you can only learn what is visible in this course too. And then they miss out the learning opportunity.*

The teachers mention that: “*the main challenge is for the students to really see their learning*.” The teacher wants the student to see when they have learned something, and what they have learned. In doing this:

*The hard part is just to make sure that even when they don’t think they’re learning something, making everything that they did learn as visible as possible.*

#### E. To experience OEGP as coaching internal motivation

In category E, the teachers want to coach the students in finding motivation. Students should find out why they should learn and what motivates them. In industry, motivation can be based on the promise of promotions or the threat of being fired. In OEGP the teachers try to teach the students that they can be motivated through external motivators, such as doing well for a client. They can also find internal motivation within themselves.

If the students find what motivates them, the goal is to teach the students self-motivated leadership. A quote that illustrates this well is:

*At the same time, from a learning perspective, all of the sudden people, students are put in a position where what they're learning both from failure and success, is not just tied to the products they product and the quality of the products they produce, but the quality of that relationship with their stakeholder. Which is kind of the hook in the first place: I want to do something real. I want to deliver something for these other people, not just my teachers. So it's an internal motivation.*

### V. DISCUSSION

In this section, for each category of experience we describe the focus (or nature) of the experience and its dominant aspect. As this study focuses on teachers' experiences, we also focus on teachers' views on students' experiences. To enrich the context of the study we add the perspective of a student who experienced the OEGP course.

#### A. Categories of experience

The outcome space presented earlier is summarized in table 1. The summary shows the hierarchy in the categories identified by the researchers, as well as the focus and dominant aspects of the categories.

In category A, teachers see their goal as coaching the student about teamwork. The focus is on team building. The students are expected to first learn that collaboration and communication is necessary for teamwork. A student cannot do what she/he wants to do when creating knowledge and solving the problem with team members. The dominant aspect of the teachers' experience is the team, as in every project students face problems with collaboration and communication in teamwork.

TABLE I. OUTCOME SPACE INCLUDING THE FOCUS AND DOMINANT ASPECT OF CATEGORIES

Outcome space		
To experience OEGP as ...	Focus	Dominant Aspect
A. Coaching teamwork	Team building	The team
B. Coaching to see the breadth of computer science	Disciplinary vision	The problem
C. Coaching students to experience the complexity of problems	Problem solving	
D. Coaching learning	Learning	The mindset
E. Coaching internal motivation	Motivation	

In category B, teachers experience OEGP as coaching students to see the breadth of computer science. The focus is on the discipline with the dominant aspect related to understanding the problem. By talking to users, the students start to learn that the problem or knowledge is not just technical. Sometimes societal or political changes are more important to successful implementation than technical changes. An open-ended problem covers many different aspects. In university projects, it is often easy to uncover the technical assignment behind the given context, leading to students separating context from technical problems. In order to ensure that students relate context and technical problems, the problem has to resemble 'real life' issues. Students learn that computer science is not just solving technical problems but requires both the skills of teamwork and understanding of the context.

In category C, students learn that there are many different paths that one can choose to solve a given problem. The teachers focus on problem solving and the dominant aspect is the problem given to the students in the OEGP course. The first path that the students choose to solve the problem might not always be the correct path. Then, the students need to adjust and change direction. This situation provides an opportunity to promote problem-solving skills. For example, in many contexts with societal and political changes, new ideas and new aspects to the problem and to solving the problem continuously appear.

In category D, teachers experience OEGP as coaching students to learn. The focus is on what students learn and the dominant aspect of the experience is developing the mindset of the student. Students start to think about what "learning knowledge" is and about how the OEGP influences them and changes their personal skills. The student concentrates on questions such as: What should I do in order to solve the problem? What am I learning now? When am I learning? Do I learn only if I read a book or am I also learning if I speak to users?

Category E shows that teachers experience OEGP as coaching students for internal motivation. The teachers' focus is on motivating students to learn with the dominant aspect of the experience dedicated to the mindset of the student. If students know what they learn, they should think about why they learn. If students know why they learn, they can motivate themselves to learn, instead of working for reward or due to pressure. That is one of the reasons why it is important for teachers to step into a coaching rather than an instructing role. Students can learn better when learning motivation is internalized. The difference between being able to learn and being motivated to learn is whether students can move forward and learn on their own.

#### B. Perspective on students' experiences

The first author has experienced the OEGP course firsthand. This experience provides insights for the context of OEGP. Furthermore, the topic of students' perspective came up during some interviews and we describe these aspects of the interviews with teachers.

### 1) Learning how to learn

According to the first author, this course has been very helpful in learning how to learn, which matches one of the teachers' view of what students have to learn: *"This whole notion that it's all about technology and it's all about what I know... What you all are learning now is going to be ancient history in 10 years. ... So you better learn how to learn"*.

### 2) Preparation for future

The OEGP course has provided good preparation for the first author for larger (individual) assignments, such as a thesis. However, every year a few students start the OEGP project at Uppsala University and do not finish it.

A teacher explained this aspect in the interview: *"One of the problems is that, those people who learn for the exam they have a tendency to think that you can only learn what is visible in this course too. And then they miss out the learning opportunity. ... Almost every year there are a few students who quit. Not everyone is mature enough to understand, to take this opportunity. Sometimes this minority demotivate the others"*. Students need to find internal motivation within them to succeed in the course.

### 3) Recognition of role of teacher

For a student, it takes some time to realize that the role of the teacher in OEGP is different. Until the students realize that the teacher will not tell the students exactly what to do, some students are left in a state of not knowing what to do. Not all students manage to get out of this awkward situation. During an interview, a teacher gave this example: *"Some years it's been a really bad year. ... Then most of the students didn't understand it and didn't get it. Then we had many students who really never got going. And the reason for that... it was a combination of different things."*

## VI. CONCLUSION

This article has given an overview of research on academics' ways of experiencing teaching OEGP courses. The results of the phenomenographic analysis indicate that teachers see their role as a coach and that the experienced variation lies in the intention underlying the coaching. This variation is presented in a hierarchical outcome space that focuses on the team, discipline, problem, learning, and motivation. The resulting categories are inclusive, meaning that the higher levels by definition include the lower levels of experience. Also, the categories are valid at a collective level and do not, in themselves, describe individuals [3].

Different categories might have emerged if there would have been other researchers or if more data were collected and analyzed. The research conducted for this study is small scale, since it only consists of data from four interviews. It is possible that other dimensions of variation related to the phenomenon have not merged in this study. However, the categories we have identified reflect the possible ways the participants have experienced the phenomenon of OEGP. The results are valid in the given setting and are available to other researchers working on data from other settings.

The five categories, which this research identified, have their own meaning and value. But whilst a hierarchy is

proposed, it needs to be stressed that teachers contribute significantly when they guide students to learn the importance of teamwork (as in category 1). However, we recommend teachers should always aim for reaching a higher category. Therefore, it seems important for teachers to think they can improve their teaching in order to reach a richer way of experiencing the teaching of an OEGP.

There are two reasons why a teacher has to reconsider the way he or she teaches more often than in regular courses. Firstly, OEGP deals with a 'real life problem' and therefore aspects of the problem continuously change. Secondly, the teaching is not based on content knowledge but on the experience of the teacher. As a result, it is expected that the teacher needs to continually adjust the support given to the students. Future research could question whether every teacher is capable of teaching an OEGP, or whether additional training is needed.

Reflecting on practice [24] allows a teacher to adapt her/his behavior in action and on action. In-action reflection allows a practitioner to constantly reflect and adapt behavior to events happening during the process. On-action reflection leads to reflection and changes to behavior after the process is done. Both in-action and on-action reflection are essential techniques for teachers in OEGP courses. Another recommendation is for teachers to discuss their experience with teachers who have experience in teaching OEGP.

The OEGP course aims to guide students to have their own motivation as the highest goal. Being motivated to learn is a powerful force in learning. The goal of many of these skills is to be better prepared for work in industry. Research must be done to find out whether students who have successfully completed an OEGP course are actually more successful in industry than students doing more traditional courses.

Teachers might even use the experience of coaching OEGP in other courses as well. Further research is needed to investigate the applicability of OEGP in more traditional courses, in other domains, and in other departments.

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## REFERENCES

- [1] P. S. Westwood, *What Teachers Need to Know About Teaching Methods*: Aust Council for Ed Research, 2008.
- [2] I. Newman, M. Daniels, and X. Faulkner, "Open ended group projects a 'tool' for more effective teaching," in *Fifth Australasian Conference on Computing Education*, Adelaide, Australia, 2003, pp. 95-103.
- [3] F. Marton and S. Booth, *Learning and Awareness*. Mahwah, NJ: Laurence Erlbaum Associates, 1997.
- [4] M. Daniels, Å. Cajander, A. Pears, and T. Clear, "Engineering education research in practice: Evolving use of open ended group projects as a pedagogical strategy for developing skills in global collaboration," *International journal of engineering education*, vol. 26, pp. 795-806, 2010.

- [5] C. Laxer, M. Daniels, Å. Cajander, and M. Wollowski, "Evolution of an international collaborative student project," in *11th Australasian Conference on Computing Education (ACE '09)*, vol. 95, M. Hamilton and T. Clear, Eds., ed Darlinghurst, Australia, Australia: Australian Computer Society, Inc., 2009, pp. 111-118.
- [6] M. Daniels, L. Barker, Å. Cajander, C. Laxer, and D. Moore, "Managing cross-cultural differences in an open ended group project course," in *35th ASEE/IEEE Frontiers in Education Conference*, Indianapolis, IN, USA, 2005, pp. T4D22-23.
- [7] ITS Education Asia. (2015). Defining problems - "closed and open ended problems. Available: <http://www.itseducation.asia/define-problems.htm>
- [8] A. Hauer and M. Daniels, "A learning theory perspective on running open ended group projects (OEGPs)," in *Tenth Australasian Conference on Computing Education (ACE '08)*, 2008, pp. 85-91.
- [9] D. H. Jonassen, "Designing constructivist learning environments," *Instructional design theories and models: A new paradigm of instructional theory*, vol. 2, pp. 215-239, 1999.
- [10] D. Kolb, *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice Hall, 1984.
- [11] C. E. Hmelo-Silver, "Problem-based learning: What and how do students learn?," *Educational Psychology Review*, vol. 16, pp. 235-266.
- [12] H. Barrows and A. Kelson, "Problem-based learning in secondary education and the problem-based learning institute," *Springfield, IL: Problem-Based Learning Institute*, 1995.
- [13] A. Kolmos and H. Algreen-Ussing, "Implementing PBL and project organized curriculum," in *Das Hochschulwesen. Forum Für Hochschulforschung,-praxis Und-politik*, 2001.
- [14] J. Copley, "The integration of teacher education and technology: a constructivist model," *Technology and Teacher Education*, Charlottesville, VA: AACE, vol. 681, 1992.
- [15] C. Anil, M. Lofvars, L. Ames, E. Björling, A. Moregard, E. Campbell, et al. (2013). Project Earth. Extending access to medical records and test results in health care [Online]. Available: <http://docplayer.se/12075761-Rose-hulmaninstitute-of-technology-uppsala-university.html>
- [16] F. Marton, "Phenomenography — Describing conceptions of the world around us," *Instructional Science*, vol. 10, pp. 177-200, 1981.
- [17] G. S. Åkerlind, "Variation and commonality in phenomenographic research methods," *Higher Education Research & Development*, vol. 31, pp. 115-127, 2012/02/01 2012.
- [18] M. Prosser, K. Trigwell, and P. Taylor, "A phenomenographic study of academics' conceptions of science learning and teaching," *Learning and instruction*, vol. 4, pp. 217-231, 1994.
- [19] A. Carbone, L. Mannila, and S. Fitzgerald, "Computer science and IT teachers' conceptions of successful and unsuccessful teaching: A phenomenographic study," *Computer Science Education*, vol. 17, pp. 275-299, 2007.
- [20] R. Lister, A. Berglund, I. Box, C. Cope, A. Pears, C. Avram, et al., "Differing ways that computing academics understand teaching," in *Ninth Australasian Conference on Computing Education (ACE)*, Ballarat, Victoria, Australia, 2007, pp. 97-106.
- [21] A. Pears, A. Berglund, A. Eckerdal, P. East, P. Kinnunen, L. Malmi, et al., "What's the problem? Teachers' experience of student learning successes and failures," in *Seventh Baltic Sea Conference on Computing Education Research (Koli Calling 2007)*, Koli National Park, Finland, 2007, pp. 207-211.
- [22] P. Kinnunen, R. McCartney, L. Murphy, and L. Thomas, "Through the eyes of instructors: A phenomenographic investigation of student success," in *Third International Workshop on Computing Education Research (ICER)*, Atlanta, GA, USA, 2007, pp. 61-72.
- [23] C. Cope, "Ensuring validity and reliability in phenomenographic research using the analytical framework of a structure of awareness," *Qualitative Research Journal*, vol. 4, pp. 5-18, 2004.
- [24] D. A. Schon, "Educating the reflective practitioner," *San Francisco: Jossey-Bass*, 1987.