

A framework to study learning in an internationally distributed course

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Abstract

This paper presents a framework for studying the various ways in which learning of computer networks is experienced by students who take part in an internationally distributed, computer-supported, project-based university course. The students' learning and their perceptions of their learning environment are studied in a phenomenographic research tradition (Marton and Booth, 1997), illuminated by elements of activity theory (Engeström, 1987). By studying the learning of the subject matter, the learning environment, and the complex relationship between the two, as they are experienced by the students, insights can be gained that can help to improve learning environments and thereby learning outcomes.

The purpose of the study

This paper presents a research framework for studying the complex interplay between the learning of a subject area and a learning environment. The framework has been developed to study learning situations, where students work in internationally distributed teams collaborating over Internet. It offers a way to analyse and interpret the learning that takes place and to identify critical factors in the learning environment that promote students' learning. Studies within the framework are useful when designing and redesigning computer-supported distributed project-based courses to better promote students' learning of the subject area. From such studies insights can be gained into how students go about collaborating, and how collaboration and learning relate to different elements in the course environment.

The research framework presented here is targeted towards the study of academic courses. Both the course content and the learning environment are here important and together contribute to how the learning takes place and what is learnt. The different actors in the situation, the tools that are used, the rules etc form together an environment in which the learning takes place and of which it is an integrated part. In a complex way the students' interaction with all these factors forms the basis for the environment as perceived by the students. Neither the course content nor the situation can be omitted, since the two are not experienced as separate entities by the students, and the students interact with both.

To address these questions, a phenomenographic research approach (Marton and Booth, 1997) is appropriate, since it focuses on the learners' relation to, or experience of, different phenomena, such as concepts within the subject area or other phenomena in the learning environment. The use of phenomenography is extended with elements of activity theory (Engeström 1987) to illuminate the students' perceptions of the learning environment as a whole.

As was briefly indicated above, the development of this framework is based on the needs within a research project, where learning in computer networks is studied in a project-based course. Third and fourth year students in computer science work in teams of six, three in Sweden and three in the US. The student teams, who never meet physically as a whole group, communicate over the Internet to jointly produce a software system that controls a motorised toy. This project will, throughout the paper, serve as a case study.

The aim of the framework is thus to analyse and describe learning as it takes place in an internationally distributed, computer-supported learning environment, and to gain insights in how the students experience the role of this complex environment, when they learn about a subject area, here computer networks. The strong focus on the learning environment, as it is experienced by the learners, can be derived from the underlying goal of the research project: To improve students' learning in computer science by influencing the ways in which the subject area is taught. To reach these goals, it is crucial to understand the role of the learning environment *from the students' perspective*, since changes in a course not related to the students' different experiences, risk becoming useless or even contra-productive. Research performed within this framework can contribute to new insights based on the students' experience of studying in distributed courses. Such understanding can help teachers and course designers to develop courses that promote good learning.

The remainder of the paper is structured as follows. Phenomenography, which offers the theoretical basis for this project, is described in the next section. The same section also briefly describes some elements of activity theory, and is followed by a section describing related research projects, encompassing elements of phenomenography and activity theory. I then describe the research framework that is developed, and present the project-based course that serves as a case study and an illustration in this paper. Finally, some implications of the framework are discussed.

Introduction to Phenomenography and Activity Theory

Phenomenography offers possibilities to address issues related to the students' varying experience of their learning and learning situation. The approach is described in the next sub-section. I will, in the following sub-section, discuss some elements of activity theory that serves as an intellectual tool for understanding the learning environment as a whole in this project. The descriptions focus on the features that are important in this project, and do not in themselves do justice to the richness of two approaches. After these presentations, I will briefly refer to some studies, where these approaches meet.

Phenomenography

With the study object of phenomenography being the relationship between a learner and one or a group of phenomena, the outcome becomes a description of this relationship as a set of qualitatively different ways in which the phenomena are experienced, or

understood, by some learners. Variation is in focus in phenomenography; the individuals are “carriers” of different ways of experiencing something or of fragments of a collective way of experiencing it. The results are then to be interpreted at a collective level, without relating a particular way of understanding something to a specific individual or groups of individuals.

With this as a point of departure individual learning is interpreted, or defined, as acquiring the possibility to see something in a qualitatively new way. Learning, seen in this way, is shaped both by the learners and the phenomena they study. The role of the researcher is then to analyse and describe this relationship from a second order perspective, that is, to reveal the variation in the ways in which the students experience some phenomena. Both the students and the concepts that they study are in this way present in the outcome, which is a description of the researcher’s understanding of the various ways in which the students understand some concepts.

The strong focus on the content of the subject area, with the related potential to influence education within that field, has been promoted by several authors (for example: Adawi, 2002, in physics; Berglund, 2002a, in computer networks; Booth, 1992, in programming; Cope, 2000, in information systems; Pang, 2003, in business economy) as a key feature of phenomenography. The discussion in Berglund (2002a), concerning students’ learning of a particular network protocol, can serve as an illustration. In this paper I argue that a teacher, understanding the different ways in which the students perceive the phenomenon she teaches about, can use these insights as a tool to improve her teaching.

In the phenomenographic tradition issues related to the learning environment and its role in learning are normally relegated to the background, since research in this tradition focuses on and explores different aspects of the relation between the learner and what is learnt about. As we express this in Adawi et al. (2002) “the analysis deliberately strips away contextual features of the data in order to focus clearly and exclusively on the phenomenon”. For the current project, where learning within the subject area is studied in, and as a part of, a particular learning environment, the use of phenomenography alone as a guide for the research is not sufficient. For this reason, I propose a phenomenographic approach, informed by elements of activity theory, as a unifying framework.

Activity Theory

The elements of activity theory, as they are employed in this project, serve as a framework for describing, analysing and explaining human activities, as learning, as integrated parts of an environment. The theoretical aspects of activity theory are based on the interpretations of Engeström (1987) as well as other researchers in this tradition (Kaptelinin et al., 1995; Kuutti, 1996; Bellamy, 1996; Nardi, 1996; Bannon, 1997). Activity theory is briefly presented here and is further developed Berglund (2002b) with a focus on the needs of this phenomenographic research project.

With an activity theoretical approach, learning can be understood as being integrated in a larger system that considers the socially based nature of human activity. Activity theory serves here as a “clarifying and descriptive tool rather than a strongly predictive theory” (Nardi, 1996, p. 7).

An activity system basically describes the interaction between a *subject* (in this study: a student, or a group of students), and an *object* (a programming task, or a computer science concept to understand). The activity, as a whole, is directed towards an object,

which is transformed by the interaction into an outcome. This transformation of the object is the motive for the existence of the activity. The subject interacts with the object through *tools*, both physical (a computer) and intellectual (abstract computer science concepts). The activity is, however, larger than the tool-mediated relation between a subject and an object. It is an integrated part of a collective activity, consisting also of the *community* that shares the same object (other students taking the same course, university staff). The relation between the subject and the community is mediated by *rules*. The term rules must be understood in a broad sense, including aspects as diverse as the legal systems, cultural or social rules for interacting between humans, as well as the rules, or habits, that have developed within the current activity. The relationship between the community that together share an object and the object itself is mediated through a *division of labour*. The relationships between the components are frequently presented graphically, as shown in figure 1.

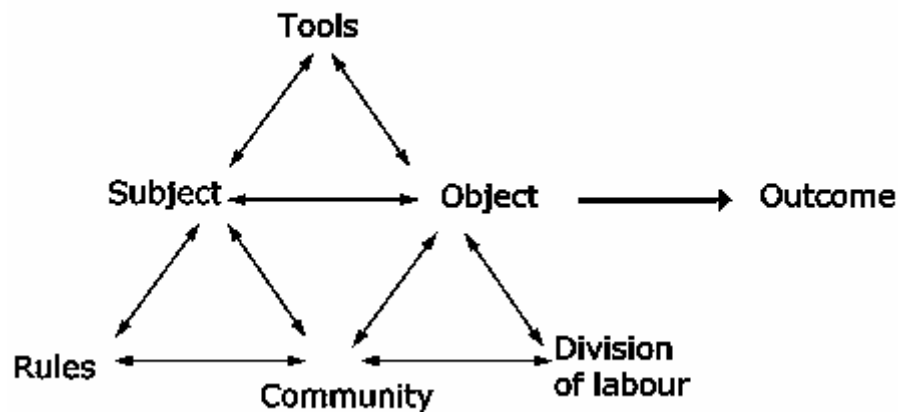


Figure 1. A graphical representation of an activity system

An activity is continuously constructed and reconstructed by the individuals within the system. The activity becomes in this way more than the sum of individual discrete actions, and the individual becomes inseparably intertwined with the activity. As the object is what motivates the existence of the activity, the activity in its turn gives the researcher “meaning to seemingly random individual events” (Engeström, 1993, p. 65), that is, an activity is a context, in which the participating individuals and the different events are integrated parts. With this approach, it is impossible to study a part of the activity separated from the whole system. The activity is the context and is taken for the unit of analysis. This does not imply that the activity is a homogenous and harmonious entity. On the contrary, with its multi-voiced character and its embedded history, it contains different, often contradictory, expressions and events that serve as a ground for inner conflicts. These conflicts, in their turn, are important forces in the development of the activity.

The two research approaches used together

An extensive literature survey has indicated that only a few research projects use phenomenography and activity theory within the same project. Significant work in this context includes that of Åberg-Bengtsson (1998) concerning children learning graphs, Gordon (1998) concerning students’ learning of statistics, Coupland and Crawford

(2002) concerning ICT-based tools in learning mathematics, Hultén and Booth (2002) concerning learning within a collaborative project-based distance course. These studies, all combining the research approaches in different ways, use phenomenography for different aspects that are close to or perceived by the learners, while the role of activity theory is to analyse and/or describe a context for this learning. Hultén and Booth (2002) takes a stand similar to the one presented here: They adopt a phenomenographic approach illuminated by elements of activity theory, while Åberg-Bengtsson (1998), as well as Gordon (1998), choose to let the two approaches serve as different lenses, that in this way illuminate different aspects of the learning. Coupland and Crawford (2002), finally, propose a predominantly activity theoretical approach, where results from methods inspired by phenomenography serve as data for the activity theoretical analysis.

The focus on a particular situation, seen as a whole, in activity theory implies that the actions taken or performed by individuals within the activity form an important basis for the data used in the analyses. In a phenomenographic study, on the other hand, aiming at revealing the different ways in which something is experienced, or understood, the learners' own accounts play important roles. This is clearly expressed by Ekeblad and Bond (1994) as the difference between an *externalist* perspective, which leads researchers to observe events and to analyze them from within their theoretical and methodological frameworks, and an *experiential* perspective, in which the researcher seeks to see events as the actors experience them. A discussion about discrepancies and similarities between these two approaches that "methodologically [...] present complementary analytic lenses with distinct and different foci" (Gordon & Nicholas, 2002) is available elsewhere (Berglund, in preparation).

The research framework presented here serves as a tool to study the experience of learning in the perceived context by adapting an experiential perspective on the students' learning environment. Hence the phenomenographic foundations are kept in the proposed approach, also when the context of the learning is studied, and possible conflicts between the approaches are, as will be shown, avoided in this way. The use of phenomenography is "extended from focusing mainly on the variations in the relations between the student and the object of his/her studies, to include also the variations in the relations between the students and phenomena contextual to the study object." (Berglund, 2002b). Elements from activity theory are used to guide the researchers understanding of the learning situation, of which the network protocols, and the students' relation to them, are important parts.

The Proposed Research Framework

In the previous sections, phenomenography has been described as a research approach that aims at analysing and describing the variation in which a phenomenon or a group of phenomena are experienced by a student cohort. Phenomenographic results offer descriptions of the various ways in which something (as a learning environment or concepts learned about) are perceived or understood *from the learners' perspective*. In this way the perspective offers closeness both to the learners and the concepts they learn about. Here, when studying students' understanding of concepts within a particular subject area, these features of phenomenography are useful. Activity theory offers possibilities for a researcher to describe and analyse activities, as complex entities with many actors, such as a university course or (as in many examples in literature) a medical clinic. Activity theory takes an externalist perspective, with the terminology

introduced by Ekeblad and Bond, and serves as a clarifying tool, when studying an activity as a whole.

In this project my focus is on how a distributed course with its particular learning environment influences and is a part of the students' learning. For this analysis, the experiential perspective is appropriate, since it offers the researcher the opportunity to analyse phenomena as they are experienced by the students, and it can be supported by the tools offered by activity theory. With an aim of the research project, to offer guidelines for improvement of the learning environment, in order to support learning, it is crucial that the learning environment as it is understood by the learners, can be analysed. In this way, a course organiser is offered insights about the students' perception of their learning and their learning environment, insights that can serve as a basis for a further development of a course.

Extending the Use of Phenomenography

Marton and Booth (1997) define the research object of phenomenographic research:

[...] unit of phenomenographic research - a way of experiencing something - which [...] is an internal relationship between the experiencer and the experienced. (p. 113)

Taking this as the point of departure for my phenomenographic research framework, the issue of relating this to, or extending it with, the experienced context becomes crucial (Berglund, 2002b).

An activity is, as described earlier, a theoretical entity, discerned and described by the researcher, aiming at studying the context, with the subjects (in this study: students) and the object (what is learnt about), as integrated parts. Someone, a subject, cannot experience the complete whole at a particular point of time, since, as Marton and Booth (1997) point out, different parts or aspects of the world are in focus of the attention at different times. A student can for example have his or her focus at a particular moment on an aspect of a concept within the course content, for example a networking protocol, while another issue, such as concerns about the grade, are relegated to the background. Later, focus can shift to be on the grading, with the network protocol residing in the background. The students' relations to these phenomena within the activity are thus dynamically changing.

Both the learning of the course content, here network protocols, and the experience of other phenomena related to the course, for example grading, are important for a researcher to describe and analyse, in order to understand the students' experience of their studies in a particular setting. Both are needed to understand the complex relationship between the learning outcome and the experience of the learning environment.

In the framework presented here, the students' experience of these phenomena, whether directly related to the learning objectives or not, are analysed in the phenomenographic tradition. The outcome of a phenomenographic analysis is sets of categories of description, where each set describes the experiences of a particular phenomenon found within a group, and each category describes a certain way, in which the phenomenon is understood. These categories and the relations are then further analysed based on elements drawn from activity theory. The outcome of the "pure" phenomenographic analysis is thus not the entire final outcome of the research project. Besides its role as an outcome in itself, it serves as a material for analysing the learning *in a particular*

situation as it is perceived, or experienced, by its participants. The final outcome of the analysis consists thus of a description of the students' experience of learning of the subject area in this particular course setting. Such an outcome is a description from the learners' perspective that in its turn can serve as a vehicle for the design of similar distributed courses, since it can be used to relate the students' experience of learning to the course setting.

A Phenomenographic Analysis of an Activity

As was briefly indicated above, the analysis is performed in two steps. First, the variations in the students' experience of different phenomena in the learning environment are analysed and described in the phenomenographic tradition. As a second step the analysis is advanced by means of some intellectual tools related to activity theory. Here the outcome space of the phenomenographic analysis is associated to the activity. The aim of such an association is to create the potential to capture, analyse and describe the variation in the experience of an activity by its participants, that is, to describe the activity as it is experienced by its participants¹.

As a starting point of the analysis, each category of description is associated by the researcher with a particular component of the activity. This association demands of the researcher that he or she "goes inside" the activity and explores it from the participants' perspective. Taking this perspective, an insider perspective, as a tool for delimiting and understanding an activity, is well in line with the reasoning of Nardi (1996), who argues that "a commitment to understanding things from the users' perspective" (p. 95) is a practical methodological implication of activity theory, and Engeström (1987) who is explicit on the importance "of (a) gaining a preliminary *phenomenological insight* into the nature of the discourse and problems as experienced by those involved in the activity and (b) of *delineating* the activity system under investigation" (p. 324, italics in original).

Through such associations each component of the activity comes to have some phenomenographic categories related to it, indicating the variation in how this particular component is experienced by the subjects of the activity. As will be demonstrated in the example in the next section, the various categories related to a particular phenomenon can be associated to different components, and the categories at each component can, as a consequence, contain descriptions of various phenomena.

In this second step, the activity system, now describing the various ways in which an activity is experienced by its participants, is further analysed. The basis for this analysis is found in Adawi et al. (2002), where we introduce different levels of analysing and describing the concept of context within phenomenographic research:

(1) The *experienced context of the individual* that describes the relation between a phenomenon and its context, is discussed as follows in Adawi et al: During a "phenomenographic interview, some aspects of the phenomenon come into focus, while others remain in the background. The phenomenon is thus experienced against and interwoven with an experienced context, what we can refer to as the *experienced context of the individual*." (italics in original)

(2) The *experienced context of the collective* describes the interplay between utterances of different individuals. "When analysing the interviews, the researcher finds that light is shed on some utterance made by one interviewee by reading it against the background of the context deduced or assumed by the researcher from reading an interview extract by another interviewee. Switching between these two perspectives

allows the researcher to let an aspect of a phenomenon as experienced by one participant interplay with an expression of an experienced context that originates from another participant.” (ibid.)

(3) *The experienced context of the researcher* describes the researcher’s relation to the object of his/her research, and is discussed by us in the following way: “It can be claimed that when engaged in a phenomenographic study on learning the researcher stands in the same relation to the object of research as the learner stands to the object of learning. The object of research is embedded in a context, and this context can be said to be what lends meaning to the object.” (ibid.)

In this paper the use of these distinctions, that are based on who is experiencing the context, are extended to also encompass the concept of an activity.

At the *individual level*, case studies are made, where individuals are studied in the light of the activity. Relations and tensions in the different ways in which an individual experiences an activity give the researcher, as well as the universities organising the course, a “feel” for the individual in the activity.

At the *collective level*, the inner tensions of the activity are described and analysed. As stated earlier, the tensions within a system are its source of development and change. Analysed in this way, the tensions between and within the *experienced* components are discriminated and discerned, offering a way to understand the dynamics of the learning processes in the group.

At the *researcher’s level*, a further phenomenographic analysis can be performed by returning to the interview excerpts that now, through the categories, are related to this component. These interview excerpts can be analysed again with the component and the earlier analyses as a background. The new analyses can be structured to reveal aspects related to the component of the activity in question, and to those phenomena that originally, through different aspects, fed into the description of the component. By performing this analysis, the researcher can gain insights into the learners’ experience of a particular component of the activity.

Analyses at these three levels, taken together, offer to researchers and course organisers intellectual tools for understanding the learning experience in a real situation as seen from the participants’ perspective. With these insights, improvements in existing courses, as well as outlines for new courses, can be made, based on an analysis of the students’ experience of their learning and the learning situation. In this way, changes are based on the participants’ experience, instead of on a view from the outside.

Using the Research Framework

The aim of the work presented here is, as was mentioned in the introduction, to develop a framework to study the learning that takes place in an internationally distributed course. Thus, as a background, I will here briefly describe the course that students are taking (adapted from Berglund, 2002a). Following that discussion I will give one example from the currently on-going analysis, illustrating the phenomenographic outcome space and tentatively associate it to an activity system.

Of course, one phenomenon alone, however well selected it might be, does not constitute a basis for analysing the context of the learning. Instead, the aim of the example, taken from the on-going analysis, is to illustrate how the first step of the research framework, as it is presented above, can be applied. In the second step of this on-going research, a phenomenographic outcome space describing the students’

experience of several more phenomena, selected to illuminate different aspects of the students' learning, will be analysed (Berglund, in preparation).

The Course Setting

The course, which forms the basis to this work, lasts for half a semester and corresponds to half-time studies for the students. It has been taught jointly since 1998 by Uppsala University, Uppsala, Sweden, and Grand Valley State University, MI, USA, with approximately 100 participants per year. The students, who are in their third or fourth year of studies in computer science, work in teams of six, three from each university, with a technically advanced group project. The assignment given to the teams is to develop a software system to make it possible for an end-user to control a wooden toy (a Brio-labyrinth) that has been modified, mechanized and computerized for the purpose (See figure 2). That is, the student should in a joint effort produce one software system, which could work on the adapted hardware, either in Sweden or in the US. The task, that within itself contains data communication solutions, is regarded as hard and demanding both by students and teachers. To produce a solution the team has to work together as a unit, using different internet-based tools for their communication.



Figure 2. A Brio labyrinth and a modified version with a camera and motors added (from Berglund, 2002a). The aim of the game is to move a steel ball on the board from a starting point to a final point. The knobs are used to tilt the board and in this way move the ball

Grading in the project-based course

Grading in general, and particularly how grading should be performed in project courses, is a part of the on-going debate within universities teaching computer science, a discussion that is further presented in Berglund and Booth (2002). Issues of debate include to what extent the grade should mirror the group or the individual, and the importance given to the outcome in comparison to the work process. In an internationally distributed course, such as this, additional concerns stems from the different grading systems (pass/fail in Sweden, A - E in the US) and possible cultural differences, such as different perceptions of the importance of being graded (Pears et al., 2001).

The students' experience of being graded has thus been chosen as an issue for a pilot study and is presented here in brief, to illustrate the first step of the analysis in the framework.

A phenomenographic analysis of the experience of being graded is presented in Table 1 (adapted from Berglund and Booth, 2002). The analysis is based on transcribed semi-structured interviews with 14 students in the US and Sweden, selected to represent a

variation in backgrounds, earlier study results, gender, age, motivation to take this course etc. During the interviews a large number of topics related to the project and the course were discussed (Berglund, 2002a), with an introductory question to each topic followed by further questions to shed light on the answers given and for clarification. The analysis is performed by the author of this paper, in dialogue with other researchers both within learning and computer science. A brief summary of the results concerning grading will be given here, while detailed discussion about phenomenographic study and its results is available elsewhere (Berglund, 2002a; Berglund, in preparation).

Three categories, describing the students' experience of being graded, have been discerned in the material. The first category describes a perception, where getting a good grade is an aim in itself, since it opens possibilities in the labour market, or serves as a sign of recognition of a good work. Focus is on the individual and his/her relation to the grade. In the second category, the group is in focus. The grade is not an important feature of the project. Instead the honour of the group, in front of other groups, or the role of the individual, as a good group member is in focus. Finally, in the third category, grading is perceived as an obstacle. It is a set of rules that has to be followed even when they are counter-productive. For example, there is a conflict between preparing a good weekly report, a time-consuming activity, that influences the grade, and to spend the same time working towards the long-term goals of the project.

Table 1. A tentative phenomenographic outcome space describing the experience of being graded.

	Way of experiencing grading
1.	Getting good grade is a goal in itself
2.	The group is more important feature of the work than the grade
3.	Grading is an obstacle

A tentative association of the phenomenographic outcome space of the students' different experiences of being graded to an activity system is illustrated in Figure 3, where each category has been associated with a component in the activity system. The category "getting a good grade is a goal in itself" (category 1) is associated to the object component of the activity, as is illustrated in the figure, since the good grade here is perceived as an object. In category 2 the experience of finding the grading as an unimportant feature is described. Instead, the group is in focus. Consequently, this category has been judged as related to the community. Grading as an obstacle that hinders learning and work is described in category 3. Experienced in this way it has the role of a rule that governs the work.

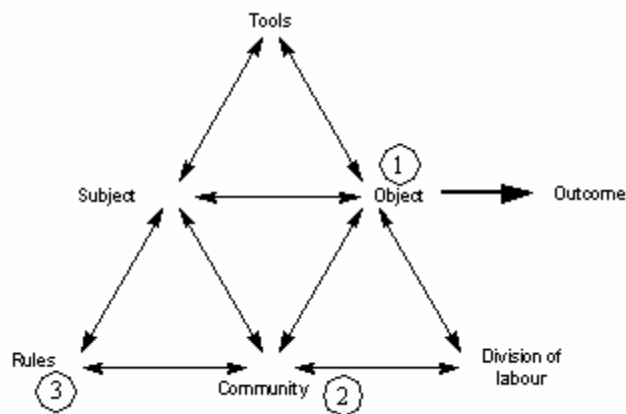


Figure 3. An association of the categories describing the experience of being graded to the components of an activity system. The circled numbers refer to the categories described in Table 1.

In the on-going work, the phenomenographic analysis is extended to several more phenomena. These are in the same way associated with the components of the activity system, creating a system where the components model the students' experience of the activity. The activity, described in this way, is then further analysed in the second step as it is discussed in an earlier section of this paper.

Conclusions

This paper presents a framework for analysing the variation in the ways in which learning in complex computer-supported situations is experienced by the students. It is basically an application of phenomenography to encompass the context of the learning, as well as the learning of the subject matter. Elements from activity theory are drawn upon to enlarge the scope of phenomenography. Researchers, as well as course organisers, gain insights into how courses are experienced by the participants, by applying this framework in relevant research. In this way tools are offered that can help to make course changes that are perceived as improvements by the course participants. With the predominantly phenomenographic approach, focus is kept on the content of the learning giving the ability to relate the learning outcome to the experience of the learning environment.

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¹ It must be stressed that this analysis is a further development of the phenomenographic research approach, that that “experience” at a collective level (in the phenomenographic sense of the word) is in focus in this part of the analysis. A “pure” activity theoretical approach would differ in several aspects: its selection of data, its aim, its study object, and its intended outcome. The elements of activity theory here serve as tools in the phenomenographic analysis, and should not be understood as an activity theoretical analysis on its own right. Still, for the sake of simplicity, the normal terminology from activity theory is kept in this section when discussing the presented framework.