PhD student work, Work−in−progress
A phenomenographic view on the socio−cultural activity theory in research concerning university students' learning of computer science in an internationally distributed environment

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Abstract

This PhD student paper discusses a possible approach for studying students' learning about computer networks in a course that is jointly taught by two universities as an internationally distributed course. Since the students are working in virtual teams, consisting of six students, three in Sweden and three in the US, with a technically advanced assignment, the environment in which the learning takes place has a significant influence on the learning. An approach to studying the students' experience of their learning as well as their experience of the context of the learning, combining phenomenography with activity system, is proposed. While the experience of the learning is studied with a phenomenographic approach, an activity system seen "from within" through the eyes of a learner is used to analyse the experienced context.

Introduction

Phenomenography has proved to be a fruitful approach for studying students' experience of learning in higher education. It has, however, been criticised for not paying sufficient attention to the context of the learning.

In my research, studying students' learning in an internationally distributed course, that is students' learning in a particular environment, the context becomes important. Since this context is an integrated part of the students' experience of their learning, as well as a factor that is expected to influence the outcome of the learning to a large degree, I need to analyse the context as it is experienced by the students. My choice is to use a phenomenographic perspective on the context seen as an activity system, a choice that I argue will give me the possibilty to analyse the students' experience of their learning in the experienced context.

Background to the project

Information and communication technology (ICT) is a priori an essential ingredient in computer science education at university level. It is both the study object per se and an important tool for learning.

Some key issues facing the future computer science professionals involve globalisation of the knowledge base, and increased specialisation and distribution of expertise with resulting need to collaborate in a culturally and linguistically complex environment. This is coupled with rapid changes in techniques, which demands life−long learning within the profession. Future professionals must be capable of collaborating internationally in order to maintain their roles within the professional community.

Knowledge construction in remote collaboration and the creation of virtual environments in which the cooperation becomes fruitful and productive are thus important when considering the education of future computer science professionals. These processes must be understood in order to be able design suitable instructional environments.

The question I am addressing in my research is in what ways students, who take part in international collaboration as part of courses in computer science, experience their learning and collaboration. The question can be analysed into a number of aspects which relate to

- how the collaborative learning situation is experienced and tackled
- how ICT is experienced as support for peer learning and peer teaching
- how the situation is seen as a contribution to future professional life

Further, these can be examined in the light of the outcomes of learning in the specific course context in the field of computer science.

The setting

The study is performed within the Runestone project (Daniels et al 1998, Daniels, Berglund, Petre 1999, Last et al 2000.)

The main objective as seen by the two universities is, of course, the students learning within the field of computer science. Another important aim for the project is to introduce "international experience into undergraduate Computer science education in a way that has value for all participants". The students attending this course, third and fourth

year computer science students at Uppsala university, Uppsala, Sweden and Grand Valley State University, Allendale, MI, USA are jointly, in groups of 5 − 6 students, 2 −3 at each university, solving a technically advanced computer science project. The goal of the project is to produce a software that can control a Brio labyrinth. This task demands skills in computer networks, distributed systems, network programming, C/C++ and Java, as well as software engineering. The students use various forms of communication, mainly e−mail and chat. There are other research projects carried out on data from the Runestone project, at University of Texas at Austin, Austin, TX, USA, and at Open University, Milton Keynes, UK. These projects emphasise other aspects of the course as group dynamics.

The software development project

During the project the students should design and implement a software that gives an end−user the possibility to "play" with the labyrinth as described in the course information.

On the Web−page related to the course (http://www.csis.gvsu.edu/class/brio/BrioProject/BrioProjectOverview.html), the project is described in the following way:

> This project involves designing and implementing a distributed, real−time system to navigate a steel ball through a board by tilting the surface of the board via positioning motors. The board and ball are a modified version of the well−known Brio Labyrinth game. A monochrome digital video camera focused on the board is available to aid in navigation. The user interface is presented through a web browser. Users who play the game specify a path for the ball to follow, then get feedback on the result of their run.
>
> This project has elements of real−time control (the Brio game), low−level distributed systems (multiple CPUs to gather data, drive motors), and high−level distributed systems (web interface, network programming), in addition to some demanding requirements on the language used to implement portions of the project (dynamic code loading, security).

The descriptions above indicates that the software consists of several more or less independent modules, that might (or might not) be distributed over several different computers. These software modules have to communicate to create a whole, that can be understood and used by an end−user.

An informal finding during interviews performed 2000 indicate that students choose different technical solutions to data communication issues: TCP, UDP or RMI1 . The preliminary finding also show that the students did not have the experience of using any of these solutions in larger projects.

In the project they need to analyse which technical data communication solutions that could be used for the project, choose one or many solutions, learn the specific details of this solution and implement it. This is made by the group, and needs negotiations between the group members at all stages.

The focus of my research is though:

> ***What do the students learn about these data communication issues and how do they go about learning in this environment?***
>
> ***and***
>
> ***What is the significance of the experienced context for learning?***

Data collection

Data is collected in various ways in the Runestone project in order to serve the needs of the different researchers: interviews, logged e−mail messages, logged IRC chat sessions, saved web−pages, questionnaires etc. The interviews are the most important source for my research.

I have interviewed eight students at each site in Uppsala and Allendale on two occasions during 2000, once at the beginning of the course, and at the end of the course. The interviewees where chosen to represent a broad spectrum of backgrounds, study results, ages etc., with the aim of getting a large variation in the descriptions of experience obtained. Interviews mainly emphasised on their experience of learning in this course, being taught in a non−traditional environment. These interviews are currently being transcribed and analysed.

During spring 2001 I will perform interviews again, this time focusing on variations in their experiences of learning the technical issues of data communication that are a main component in the project.

Theoretical framework

The aim of the research is to investigate the variation in the ways that the students experience essential aspects of their learning in this international collaborative environment. The research is performed using a phenomographic approach (see for example Marton & Booth (1997)), combined with the socio−cultural activity theory (see for example Engeström (1987)).

By combining these two perspectives, I can study the variations in the ways in which the students experience their learning of computer science in the context as they experience it, in the internationally distributed project−oriented

course that they are taking.

Motives for choosing the two perspectives phenomenography and activity theory

An important objective for using a phenomenographic approach is my interest to have a strong emphasis on the actual content of the learning, in this case computer science, or, more specifically, data communication. Phenomenography also gives me a possibility to see the variation in the experience of learning at a collective level, as viewed by the collective of individuals who were interviewed. At the collective level, the individual learner "disappears" from the results of the investigation, but his or her various expressions of learning remain as data.

The learning that I study takes place in a certain environment, a course given in an internationally distributed environment. This means that the study partners of each individual student are living both in the neighbourhood (and frequently also physically present) and at a long distance, in another country. A collaboration in this environment makes many factors, that normally are not present in locally taught university courses, important: time differences, different mother tongues, cultural differences, different student populations, lack of personal contact etc.

The students' experiences of the environment for the learning are thus important factors for their experience of the learning (Adawi, Berglund, Ingerman, Booth (2001, in preparation)), and for the outcome of the learning, and needs to be studied.

I have chosen to describe the context of the learning, the course and its surrounding factors as an activity system using the framework of activity theory (see for example Engeström 1987). An activity system is an integrated whole, consisting of subjects aiming to the transformation of an object using tools and taking other factors: rules, the community and division of labor into account.

An activity system is, according to Engeström (1993) the context. Here, the activity system is the learning environment, centred around the course with the subjects (= students) aiming at learning. I will use the activity theory to understand the context, as it is experienced by the students, in which the learning takes place.

Phenomenography

Remains to be written. The text should mention variation, the field of study (computer science), the experience of learning, theq collective level.

Activity Theory

Activity theory aims giving a framework for describing, analysing and understanding activities or systems (like hospitals, universities, university courses). (see for example Engeström, Miettinen, Punamäki, 1999, Nardi, 1993) Activities are seen as a relation between subject and object, mediated by tools.

Activity theory has so far mainly been applied in analysing work settings, human computer interaction (HCI) etc. , that is, complex systems where several individuals interact in a system rich in technology, rules of conduct etc.

The activity theoretical viewpoint has, according to Engeström (1993), three basic principles for describing human behavior and discourse:

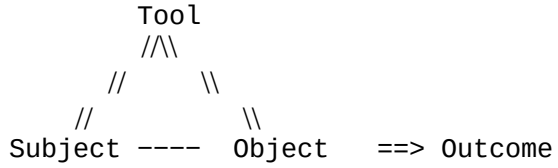
> First, collective activity system can be taken as the unit of analysis, giving context and meaning to seemingly random individual events. Second, the activity system and its components can be understood historically. Third, inner contradictions of the activity system can be analysed ...

An activity system is continuously constructed and reconstructed by the individuals within the system. However, the activity system as such is more than the sum of individual discrete actions. The individual actions are continuously influencing the activity system and are a part of the system itself. As the activity system is evolving it thereby affords new actions by individuals, actions that are a part of the system. Hence the individual and the activity system are inseparably intertwined.

An activity system is mainly defined and motivated by a shared idea about its object, which can be seen as the "raw material", that is transformed to an outcome or a result, that can be "glimpsed on the horizon". The object, in the case of a hospital can be patients (seen as ill persons), that get better or possibly even are cured, or in the terms of activity theory: are transformed to the an outcome of cured patients. The activity system is object−focused[2] (or, to use Engeström word: object−oriented) since the system, and all its parts are oriented toward and focused on this transformation of the object.

The collective of participants in the activity system are the subjects, who interact bi−directional, with the objects using mediating tools. The interaction is asymmetric − the subjects are active (Engeström, 1987), while objects mainly are passive.

A minimal activity system can be drawn in the following way (Kuutti, 1997):

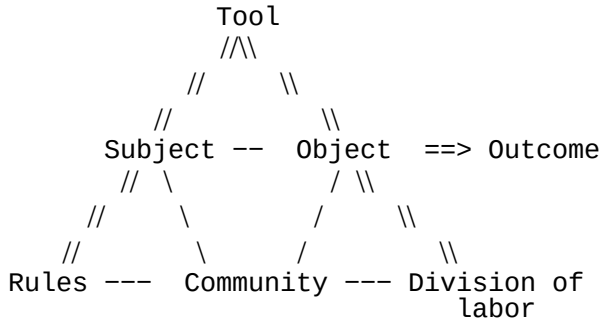


The tools that can be abstract or concrete are "at the same time both enabling and limiting" to use the words of Kari Kuutti (Kuutti, 1997). The tools contains the historically collected experience of the activity and affords (Gibson, 1979) the use of this experience in the new situation within the activity system that continuously evolve. In

the case of a hospital tools could be different instruments used during a surgery, but also skills and experiences of different professionals in the hospital, as well as the patient's understanding of his own problems.

The minimal activity system, the relation between the subject and the object, mediated by the tool, is simple, even too simple to be useful if not being part of a larger whole. This structure has to be embedded (Kuuttti): The participants, the subjects are part of a community sharing the same object. The relationship between the subject and the community is mediated by rules, implicit or explicit. The community has a division of labour related to the transformation process. In the hospital example the subject is often one of the staff, who follows legal rules for their activities (keeping a "journal"), as well as conventions (carrying certain clothes) and social rules. Thus the rules mediate the relationship between the subject and the community. There is a division of labor in a hospital among participants sharing the same goal (curing the patients). Doctors, nurses, laboratory personnel, secretaries all have their given duties.

The complete activity system, that according to Engeström is "object−oriented, collective and culturally mediated" (Engeström, Miettinen, 1999) can be drawn like this:



Another example from Kuutti (Kuutti, 1997) will tie the pieces together.

A software development team (a community) transforms a half−ready program (object) using computers, pens and their experience (tools) into an application (outcome). They follow laws, habits and rules set up (rules) and have all different tasks (division of labor).

The process of transforming objects into outcome is a long−term process, that might be without a clear beginning and a clear end (Engeström, 1987) .

The long and complex activity consists of smaller entities, actions, that have consciously planned, immediate and well−defined goals. The actions get their meaning from the activity, and could not be understood without the context of the activity. A typical action in the hospital could be giving a patient a specific injection to cure a certain decease. This action gets its meaning in the activity, the hospital, explaining why pricking someone is a useful and good thing to do, although it hurts, and would, without the context seem meaningless. In a different activity, a nursing school, the same action could have another interpretation: In this school school students prick each other to learn their profession.

Even at the hospital there are different activities that could explain the action of pricking: In an era of cut−backs, the hospital might need to take patients who want and are willing to pay for vaccinations before going on a holiday trip. In the light of this activity, the vaccination could be performed to bring an income to the hospital.

Actions consist of chains of operations. Operations are routinely made and are in a normal situation made without conscious decisions, like the nursing fetching the syringe in order to give the injection.

A phenomenographic approach on activity systems

Studies have been carried out where phenomenography and activity theory are both involved. Of particular interest is the thesis by Åberg−Bengtsson (Åberg−Bengtsson, 1998). She has studied how pupils in the age 7 − 10 learn, interpret and construct graphical representations of numerical data during group work in school. Phenomenography has been used for the unravelling of which aspects of graphs that are crucial the students' understanding, while the context of the learning has been studied in a socio−cultural perspective using activity systems.

Combining the two approaches in the context of university students learning computer science in a internationally distributed course seems challenging as well as promising to me. They are different in character. Activity theory is object focused, which means that object and the outcome of the activity are essential aspects. Its main use has been to describe and analyse large systems. Phenomenography, on the other hand, starts by looking through the eyes of the learner, to get a subjective perspective, in order to reveal variations in the experiences of learning. In short, one could say that while activity theory, as it normally is used, gives a view of the learning as seen from the outside, phenomenography looks at learning from the inside.

By combining them, I intend to study the experience of "learning in a context". In other words, the view in my research is the view of a learner, "from the inside": **The experience of learning in the experienced context.**

In her study, Åberg−Bengtsson studies pupils learning of graphics, using a phenomenograhic approach. She sees their learning in a context of the school, described as an activity system. She argues that the object of the system (a school) is learning. Thus, it is the object node of the activity system that her study is focused on. Engeström and Escalante (Engeström, Escalante, 1993) argue that the object has a multifaceted character and that its character constantly is changing. Åberg−Bengtson reason in a similar way, when she says that the pupils' understanding of the field of study tends to become something that is used to solve more advanced problems within the field as the

learning goes on. The learning, once being "set", moves towards the role of a tool.

Engeström and Escalante further argue that the object manifests itself, not only differently on different occassions, but also in different ways for different participants in the activity. Objects are never understood "alone". We understand them by means of other objects, containing and expressing social norms, historical development etc. Thus, objects have two different roles, object (in the AT sense) and tool (also the AT sense). A tool can turn into an object − being the end in itself or a object can turn into a tool, when stable and established.

Would this approach give me the tools to study learning in context "from the inside"? As I understand Åberg−Bengtsson, she has not done this. She has used the activity system to get an "outside view" of the environment in which the learning takes place, and the phenomenographic research on learning to get an "inside view". However, this does not exclude that her approach could be further developed.

Another possible approach is to regard the field of study, that is the subject content of the studies, mainly as a tool, but to a certain degree playing the double roles of tool and object. When studying students at a university level, this seems like a reasonable approach: Their knowledge of the field of study could already be assumed to be important. This understanding presents experiences, methods, tools etc that mediates the learning of something new within the field.

I argue for a development of the above positions: I plan to get an "insiders' view" of learning in an experienced context. The activity system that describes the context should be based learners' experience of the learning, as well as of the tools, the rules, the community and the division of labour. With such an approach, the activity system will be based on the subjects' experiences and will describe the experienced context.

Questions concerning this approach for discussion:

If this is a reasonable approach, several "new" questions arises.

- To what extent can I use the approach inspired phenomenography to describe and analyse, at a collective level, those nodes within the activity system that are not directly related to the learning, that is, other nodes than "object" and "tool"? Would this be useful to do? What can I learn about the learning in this way?
- A large activity system, like the course I study, can be seen as constituted of several interacting systems (Engeström, 1987). What more, if anything, could I learn about the students' learning by analysing in this way?
- One of the objectives with making this analyses is to find possible conflicts with the systems, both within different nodes and between nodes. (for example Engeström, 1987) Such conflicts are both sources from which development springs, and sources for problems and obstacles of different kinds. Can these conflicts be productively described on a collective level

Notes

1 The three concepts TCP, UDP and RMI are three technically different computer network tools, that are used in this project.

2 I will use the term "object−focused" instead of the more frequently used term "object−oriented" in this paper, since the term "object−oriented" to a computer scientist denotes an "object−oriented computer−related activity", as for example object−oriented programming or object−oriented design. The basic unit of analysis for a computer scientist is the "object" in "object−oriented" programming or other computer−related activities (see for example Budd, 2000). Since I will discuss issues of related to computer science in this paper I prefer to avoid using the term for two conceptually different ideas.

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