Students’ Understanding of Computer Networks in an Internationally Distributed Course

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Abstract
The different ways in which some computer network concepts are understood by students who take an internationally distributed project-based course have been identified in an empirical, qualitative, phenomenographic research project. The students, who work in teams of six, three in each of the participating countries, collaborate over the Internet to produce a software system which controls a modified version of a toy. Their learning of computer networking protocols as well as the possibilities to generalize and to deploy the results in teaching situations are presented. The results are useful when seen in the light of the students’ learning environment, since relations between the learning outcome and the learning environment can be discerned.

1. Overview
An understanding of how the students understand the concepts taught are valuable for a teacher. With such an understanding as a background, he or she can design labs, develop projects, choose examples, and create lectures, that help a larger number of individuals to learn better. Literature studies indicate that relatively few studies on learning in distributed learning environments focus on the learning outcome. Instead, most published work concentrates on tools for collaboration, or on different aspects of the collaborative process. In this way the current study is uncommon, or possibly even unique.

This paper focuses on the various ways in which a technically advanced concept, Remote Method Invocation1, RMI, is understood in a student cohort. The results presented describe the learning outcome in a project based course, where university students in computer science study and work in teams. Three of the six team members are in Sweden, while the others are in the US. Each team should produce a software system to control a motorised, computerised toy.

Phenomenography as presented by Marton and Booth [4] is chosen as a research approach for this study, since, at the same time, it is open to the students’ different understandings, and offers a sound and well-researched framework for how to collect and analyse data, describe the results, and to deploy the results into the educational situation. It also offers the tools to judge to what extent the results can be trusted and generalized to other groups and situations.

Phenomenographic research aims at identifying, analysing and describing the different ways in which a phenomenon, in this study RMI, is understood within a group of students. The results of a phenomenographic research project are based on empirical data, normally collected through interviews, and offer descriptions of a small set of qualitatively different categories, each category summarizing and describing a particular way of understanding the phenomenon under investigation. The results are interpreted at a collective level, describing which understandings there are in a group, without relating a particular way of understanding the phenomenon to a specific individual or group of individuals. The results are then shaped by, and related to, both the learners and the phenomena they study. Learning is here defined as understanding something in a new way, or as simultaneously understanding something in new qualitatively different ways.

2. Different ways of understanding RMI
The task given to the students demands good skills in computer systems. Particularly, the assignment contains several computer communication tasks. The choice of how to tackle these tasks and the discussions about the relative advantages of different communication protocols and tools are important issues in the project. During the coding, many of the problems the students encounter can be related to computer communication. Due to the important role of computer communication within this project, computer network protocols, and particularly RMI, were selected as a main theme in this paper.

As a result of the analysis, three qualitatively different ways of understanding RMI have been discerned and categorized within the group of students. The aspects that differ between the three categories are: the framework, or scope, of which RMI is a part; how, or as what, RMI is understood; in what technical ways RMI is characterized; and in which level of abstraction RMI is described.

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1 RMI is used in computer communication, as a protocol (a set of rules) that provides programmers with a facility to supply data to code residing and executed on a remote machine, and to receive results through a “method” invocation mechanism in the Java language.
The differences are closely related and form three categories, as shown in the rows of table 1, where the rows correspond to the categories. An important, or critical, difference between the categories is, as indicated in the second column, the framework, or territory, in which the students understand the protocol to be used. The framework could be understood as a part of an environment that consists of two communicating computers (category 1), as a part of an internet (category 2), or as belonging to a world that goes beyond computers (category 3). The first category can be further analyzed into three different subcategories, differentiated by the roles of the two computers. The first column indicates “as what” RMI is understood by the students, while the following column presents the technical characterisation of RMI. The last column describes the different ways in which the students talk about RMI: as something concrete, in an abstract way, or from an outside perspective.

Data shows that only the three ways of understanding RMI, that are described in the rows, exist within the cohort. Each row then comes to describe a particular way of understanding RMI. These results are well in line with phenomenographic research results in general [4].

### 3. Applications of the results

To address the question of if some ways of understanding RMI are better than others, the categories discerned are compared to the different tasks in a programming development project [1]. RMI understood as related to two computers is useful for programming tasks with an interaction between two specific machines. RMI understood as a part of a network (category 2) relate to program design and selection of which tools or protocols to use in a particular project. Finally, the understanding expressed in category 3, where RMI is discussed from an outside perspective, is useful when discussing what properties protocols could have and thus to designing new protocols. It follows that the different ways of understanding RMI are relevant in different situations in a software development project and that none of the understandings are more valuable than the others, when seen in isolation. The task at hand determines the value of each way of perceiving the protocol. A teacher should then encourage the students to understand what is taught in different ways, by creating a variation, as proposed by Pang [5].

The outcome from this project is also set in relation to the complex, computer-supported distributed learning environment. Here focus is on the learning environment as it is perceived by the students. Changes made in a course, must, in order to improve learning, be experienced as useful by the course participants. A framework for analysing and describing the complex relationship between the students, the outcome of the learning, and the learning environment, as perceived by the students, is presented elsewhere ([2]) and will be applied during the continuation of this project. The results have direct applications in teaching situations in computer networks, both in teacher-led situations and in project work. Also in research about learning in computer-supported, distributed projects these results are applicable, and can be used when designing distributed courses where students collaborate at a distance using different technical tools.

### References


