# Pedagogical Agents for Teacher Intervention in Educational Robotics Classes

Research plan for PhD studies

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# 1 Motivation and Background

## 1.1 Introduction

The aim of this document is to describe my PhD study project with the title *Pedagogical Agents for Teacher Intervention in Educational Robotics Classes*. The study is in the field of educational technology. The motivation for this study rise from the fact that teachers working in robotics classes face a major problem: how to keep track on individual students' or even small groups' progress in a class of 30-40 students. Our approach is to use a multi-agent environment to help teachers with this problem. The agent environment is based on having pedagogical agents to monitor students' interaction, robots' movements, and the construction and programming process of robots, and mobile interaction agents to deliver agents' observations to teacher's visualization agent.

This document is organised as follows. This chapter explains terms and definitions and en existing background with a core idea of the study. Chapter 2 specifies the research problem in the form of several research questions. Furthermore, Chapter 2 discusses about the methodolocial issues related to the questions. Chapter 3 presents the current state of the study including the schedule, courses and publications. Finally, Chapter 4 draws outlines for a financial plan of the study.

## 1.2 Terms and Definitions

**Agent:** An entity of software which can monitor progress, give instruction when needed, help organize students' work, and provide feedback for tutors.

**Educational robotics:** Construction kits designed to help learning in scientific fields such as mathematics, physics, engineering, and computer science.

**Empirical Modelling (EM):** A modeling approach for constructing computer based models that can assist in the understanding of a phenomenon. The approach has been developed at the University of Warwick since 1980's. The EM approach has an emphasis on experiment, observation and interaction during the development process and it offers an alternative approach to the goal of developing interactive artifacts to support experiential learning.

**The IPPE programming environment:** Programming tool for Lego Mindstorms robotics with a pseudo-like programming language near to the student's own natural language. The environment has been developed at the University Joensuu since 2001.

## 1.3 Background and Problem Definition

Educational robotics is successfully used for teaching in several school contexts. These small-scale computerized teaching tools have many advantages over the PC based tools which have traditionally been used to teach, for example, programming or engineering. Lego Mindstorms is one well-known example of educational robotics. This robot construction set is flexible and simple enough platform for building and programming even for novices. Educational robotics sets let room for student's own creativity by emphasizing active learner as the center of the learning process. However, in a typical classroom setting, especially at the elementary level, a teacher might have 30-40 children to teach. When using educational robotics in large classroom settings, students are usually divided into groups of 3-4 students. A typical educational robotics project follows an iterative cycle of building, programming, testing, and evaluation. It is characteristics that groups proceed differently, being in different phases of the cycle at the same time. This causes difficulty for the teacher to notice the needs for intervention. Our approach is to use educational agents to help the teacher to focus his/her attention in potential problems. The problem can be generalized as follows: *How could the robotics environment inform the teacher what students are doing and how they are progressing?* In this study, we develope an agent-enchanced educational robotics environment which aims to support the teacher to focus his/her attention in potential problems in the classroom.

## 1.4 PhD Project

My PhD project is to develop a multi-agent architecture for teachers' intervention educational robotics classes. The concept for agent-enhanced educational robotics system is based on the idea for adding new functionality to an existing educational robotics environment. In this case, the new functionality include four separate agent modules, which aim to help the teacher in his/her work in the classroom. Each of these modules implements independent, agent-like behavior (Figure 1). The first agent module is an intelligent agent which inhabit in the IPPE programming environment (*the IPPE Agent*). The main purpose of this agent is to observe the user's activity with the programming environment and build decisions based on the input data coming from the graphical user interface of the programming environment. The second agent module implements the similar observing behavior than the IPPE Agent, but it inhabits in Lego robots' RCX unit (*the LM Agent*). Third agent is a screen-based model of classroom setting constructed with the tools provided by Empirical Modelling environment. The model works as a *visualization agent* in the system. The third module is an *interaction agent*, which has the ability to move from one computer to another, for example from a students' computer to the teacher's computer to report a learner's problem observed by the other agents.

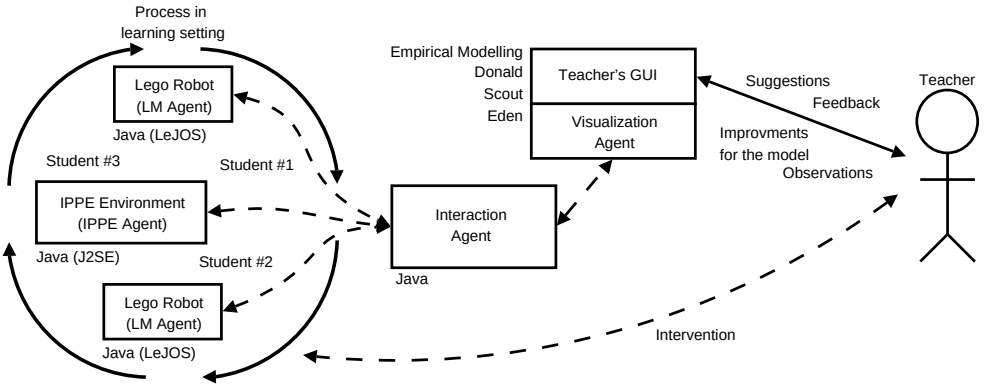


Figure 1: General concet of the agent environment

# 2 Research Questions

The aim of this study is to describe a prototype implementation of educational robotics environment which aims to support the teacher to focus his/her attention in potential problems in the classroom. The implementation is based on the concept described by Jormanainen et al. (2006a,b). The research problem of this study is *to develop a concept and appropriate tools with agent-based Empirical Modelling environment to support teacher intervention in educational robotics classes*. I will process this problem through three types of research approaches: *descriptive* (D), *evaluative* (E) and *formulative* (F). According to Glass et al. (2004), the descriptive approach contains descriptions of developed systems or methods. Furthermore, evaluative approaches evaluate an existing methods or processes with appropriate research methods such as field test or case studies. Formulative (or constructive (C) as Suhonen (2005) states) methods focus on formulation of new models, tools or algorithms. According Glass et al. (2004), constructive approaches are dominant in the field of computer science and information systems. To solve the research problem, I will use the following research questions during the research. The research questions falls to categories mentioned above as follows:

- **(D)** What is pedagogical modelling?
- **(D)** What is technical modelling?
- **(D/C)** What kind of agency architecture could support the modelling?
- **(D/C)** How we could implement such a system?
- **(E)** How this system works?

To answer the questions in category C, I will design and implement a concept and a framework for the agent environment. The environment is based on ideas we have presented in

Jormanainen et al. (2006a) and Jormanainen et al. (2006b). From technical point of view, it is necessary to develop an extensible application framework and strong wireless communication protocol between agent entities. The questions in the category E will be answered by using appropriate qualitative research methods. Furthermore, I will answer questions in category D by reviewing literature and describing existing methods and tools in fields of concretization and Empirical Modelling.

# 3 Schedule

The research started at the spring semester 2005 and the estimated duration will be about four years. I have defined the steps for the research, and the schedule of studies has been planned according to these steps (Table 1). The aim is to complete the PhD thesis at the end of 2008. Currently, I have a position in the International Multidisciplinary PhD Studies in Educational Technology (IMPDET) program (IMPDET, 2005). The program provides online courses and summer schools for PhD student in the field of educational technology. However, this program does not cover costs nor provide a scholarship for the studies.

The research also entails a period abroad. I am currently visiting Advanced Learning Technologies Research Centre at Massey University, New Zealand. The purpose of my visit here is to co-operate with Prof Kinshuk and his research group. My PhD work is a part of a larger project studying the usage of intelligent and mobile agents to observe the activities in different kind of learning settings.

Table 1: Schedule for studies.

| **Time period** | **Action** |
|---|---|
| 6/2005 – 8/2005 | Fundamentals of EM and agent technologies (literature review) |
| 9/2005 – 12/2005 | Review of existing tools and techniques |
| 6/2005 – 12/2005 | Definition of the concept |
| 1/2006 – 12/2006 | Definition and implementation of the prototype |
| 1/2007 – 3/2007 | Empirical studies (part 1) |
| 3/2007 – 5/2007 | Evaluation of the results |
| 5/2007 | Licentiate thesis and degree ready |
| 6/2007 – 12/2007 | Improvments for the environment |
| 1/2008 – 5/2008 | Empirical studies (part 2) and evaluation |
| 6/2008 – 11/2008 | Finishing the thesis |
| 12/2008 | The public defence |

The research will contain two parts of empirical studies as follows:

**Empirical studies part 1:** The aim is to study the concept and implementation of the prototype. I will run experiments at Joensuu at the first quarter of 2007.

**Empirical studies part 2:** In this study, I will examine the complete application and functionality with the school Kids' Club (Eronen et al., 2005) groups in Finland.

## 3.1 Publications and courses

During the PhD studies the aim is to get two peer reviewed conference papers accepted each year. Furthermore, the aim is to get four peer reviewed journal paper accepted during the studies. Currently, the following articles have been published:

[1] Beynon, M., Harfield, A., Jormanainen, I., November 2005. Varieties of Concretization: an illustrative case study. In: *Koli Calling 2005 - Fifth Koli Calling Conference on Computer Science Education*. Turku Center for Computing (TUCS), pp. 153–156.

[2] Jormanainen, I., Zhang, Y., Sutinen, E., Kinshuk, 2006. Agency Architecture for Teacher Intervention in Robotics Classes. In: *The 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006)*. IEEE Computer Society, Los Alamitos, CA, pp. 142–143.

[3] Jormanainen, I., Moroni, C., Zhang, Y., Kinshuk, Sutinen, E., 2006. Implementation of Intelligent Agents with Mobility in Educational Robotics Settings. In: *The 4th IEEE International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE 2006)*. To appear.

Beside these articles, the following manuscript has been sent for reviewing for the First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning.

[1] Jormanainen, I., Zhang, Y., Kinshuk, Sutinen, E., 2006. Pedagogical Agents for Teacher Intervention in Educational Robotics Classes: Implementation Issues. Unpublished manuscript.

The research will contain also laudaur-level courses on computer science and educational technology (total 60 ECTS). I will select about half of the courses from the Department of Computer Science (CS) and rest from the IMPDET program. Topics of the courses include for example research methodology, scholarly communication, project management, philosophy of computer science, individual project works, and seminars. Courses that I have already done and courses under the progress at the moment cover 40 ECTS points out of required 60.

# 4 Funding

The funding for the PhD studies can contain several sources and instruments. Table 2 summarizes the fundings from the beginning of my studies until the end of March, 2007.

Table 2: Funding during the studies

| **Time period** | **Type** | **Source** |
|---|---|---|
| 1/2005 – 8/2005 | Salary | The Development Project for Technology Education (ESF) |
| 9/2005 – 12/2005 | Salary | Department of Computer Science, University of Joensuu |
| 1/2006 – 3/2006 | Student aid and loan | |
| 4/2006 – 3/2007 | PhD Scholarship | Faculty of Science, University of Joensuu |


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