Pedagogical Adeptness in the Design of E-learning Environments: Experiences from the Lab@Future Project

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Abstract: The concept of e-learning is increasingly being used to describe the deployment of information and communication technologies (ICT) to support educational activities in various spheres of life. As a result, ICT is being heralded as a catalyst for innovations in teaching and learning. For developers of educational technology, this perspective highlights the need to produce computer-based tools that are pedagogically adept and functionally relevant to the context and purpose of use. In practice, this entails exploiting the connectivity of psychological and pedagogical concerns whilst taking into consideration technology capabilities. These design challenges highlight the need for well-harnessed methods and techniques for incorporating pedagogy into systems design. The paper outlines methods and techniques used to abstract pedagogically and contextually adept design requirements for an e-learning environment for supporting teaching and learning in European high schools.

Introduction

Advancements in the design of information and communication technologies (ICT) for educational use have had great influences on teaching and learning practices due to their capabilities to facilitate innovations in methods for executing these processes. However, producing effective educational tools requires understanding the nature of activities and relationships that exist in the proposed context of deployment (Mwanza, 2002). Towards this end, pedagogical theories and theories of human activity can provide insights into the operational structure of teaching and learning practices in the targeted context of deployment for an e-learning environment. Given these considerations, we describe our approach to abstracting design requirements for an e-learning environment.

The paper begins by describing the empirical context in which this research was carried out. This is followed by an outline of the theoretical and pedagogical framework in which this work is grounded. Thereafter, the research method used to operationalise theoretical concepts during requirements abstraction is presented. The paper concludes by reflecting on contributions of theories to the design of e-learning environments.

Context and Pedagogical Framework

The context for this study is an ongoing research and development project - the Lab@Future project (http://www.lab@future.net), which is funded by the European Union (EU) as part of the Information Society Technologies (IST) programme. The Lab@Future project is focused on leveraging educational use of ICT by exploiting advancements in virtual reality, 3D and mobile technologies to produce innovative tools for supporting teaching and learning activities in participating European high schools. This premise is based on the rationale that implementing these technologies into real and computer generated objects interfaced with mechatronic systems, augmented virtual reality, mobile technologies and 3D multi user environments, will achieve this objective. However, it was recognised that developing effective ICT tools for educational use requires good understanding of pedagogical and contextual practices. In order to achieve this remit, human activity centred design methods and techniques grounded in the framework of *activity theory* (Leont've, 1978) were used to conceptualise teaching and learning practices in the targeted environment of deployment. The conceptualisation of pedagogical perspectives was considered from the point of view of the *theory of expansive learning* (Engeström, 1987). These theoretical perspectives are described as follows.

Activity Theory and Theory of Expansive Learning

Activity theory presents a collection of basic ideas for conceptualising both individual and collective practices as developmental processes of the context in which human activities normally takes place (Engeström, 1987, Leont'ev, 1978). The idea of studying human activities as developmental processes is crucial for identifying changes and contradictions that exist in an activity. Therefore, contradictions serve as the means by which new knowledge about the activity being examined emerges (Engeström, 1987). According to Leont'ev (1978), the *concept of activity* entails a complete system of human practices. Engeström (1987) conceptualised a representational model to portray the various elements of an activity system as shown in Figure 1.

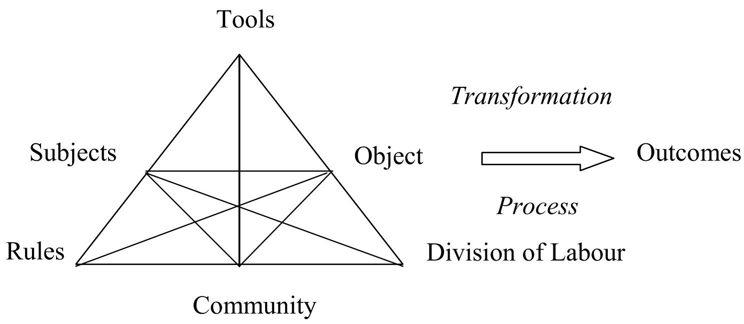

Figure 1: The Activity Triangle Model (Engeström, 1987)

The *Activity Triangle Model* or *activity system* representationally outlines the various components of an activity system into a unified whole. Participants in an activity are portrayed as *subjects* interacting with *objects* to achieve desired *outcomes*. In the meanwhile, human interactions with each other and with objects of the environment are mediated through the use of *tools*, *rules* and *division of labour*. Mediators represent the nature of relationships that exist *within* and *between* participants of an activity in a given *community* of practices. This approach to modelling various aspects of human activity draws the researcher's attention to factors to consider when developing a learning system. However, activity theory does not include a theory of learning, instead, activity theory oriented pedagogical concepts are incorporated in Engeström's (1987) *Theory of Expansive Learning*.

The pedagogical stance of the activity-theoretical concept of *expansive learning* differs from traditional types of learning in that:

(a) The contents and outcomes of learning are not merely knowledge in texts and the heads of students but new forms of practical activity and artefacts constructed by students and teachers in the process of tackling real-life projects or problems - it is 'learning what is not yet known'.

(b) Learning is driven by genuine developmental needs in human practices and institutions, manifested in disturbances, breakdowns, problems, and episodes of questioning the existing practice.

(c) Learning proceeds through complex cycles of learning actions in which new objects and motives are created and implemented, opening up wider possibilities for participants involved in that activity.

This perspective on teaching and learning highlights the potential impact of new tools as vehicles for transforming activity procedures.

Method used to Abstract Design Requirements for Lab@Future

In order to implement these ideas, we operationalised the activity triangle model shown in Figure 1 by working through a list of open-ended questions presented in the Eight-Step-Model (see Table 1) (Mwanza, 2002).

The Eight-Step-Model		
Identify the: -		***Question to Ask***
Step 1	*Activity* of interest	What sort of activity am I interested in?
Step 2	*Object-ive*	Why is the activity taking place?
Step 3	*Subjects*	Who is involved in carrying out this activity?
Step 4	*Tools*	By what means are the subjects performing this activity?
Step 5	*Rules* and *Regulations*	Are there any cultural norms, rules or regulations governing the performance of activity?
Step 6	*Division of labour*	Who is responsible for what, when carrying out activity and how are the roles organised?
Step 7	*Community*	What is the environment in which this activity is carried out?
Step 8	*Outcome*	What is the desired *Outcome* from carrying out this activity?

Table 1: The Eight-Step Model (Mwanza, 2002)

The *Eight-Step-Model* (ESM) is a requirements abstraction tool incorporated within the Activity-Oriented Design Method (AODM) – a requirements capture methodology grounded in activity theory (Mwanza, 2002). In order to gather data, ESM based open-ended questions were used in interviews and ethnographic studies involving project partners responsible for each focused subject, also teachers, students and technical assistants in participating schools. Gathering requirements data using the ESM tool enabled us to elicit human activity centered teaching and learning scenarios that are relevant to the targeted environment of application for the Lab@Future system. Teaching and learning scenarios (Carroll, 2000) were abstracted as story-like descriptions or narratives of user practices. Scenarios were later elicited into user roles so as to envision current and future relationships between subjects involved in teaching and learning activities. Information about user roles and activity elements was later used as the basis for producing a conceptual model of user practices and mediating relationships as shown in Figure 2.

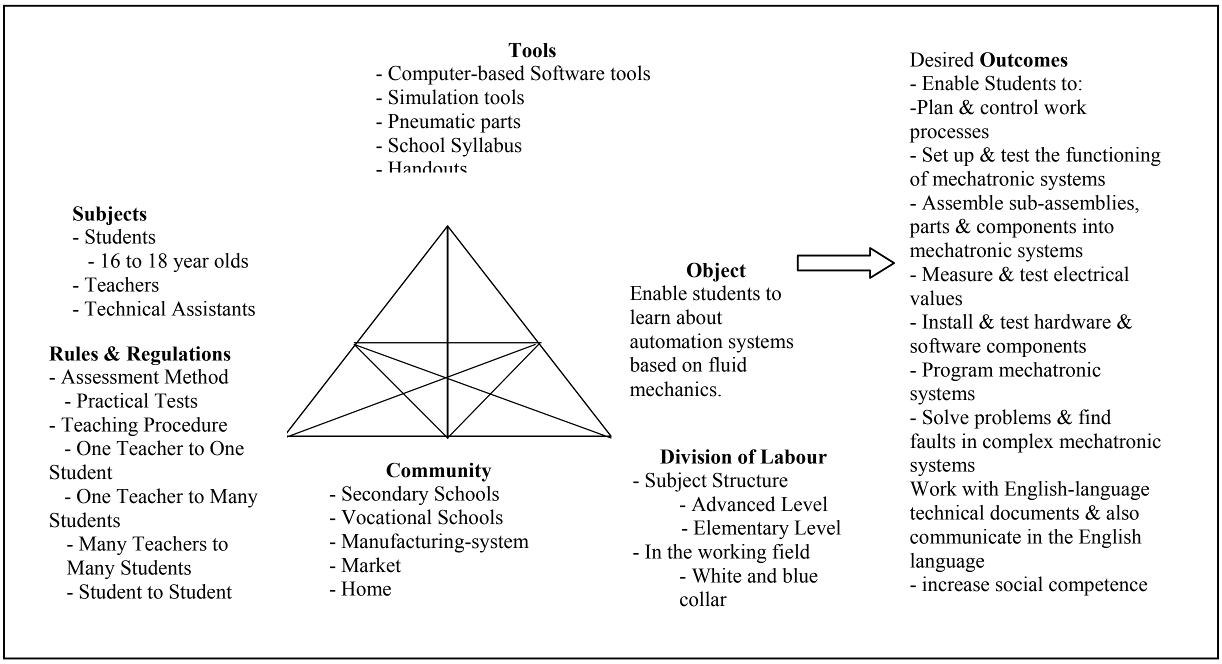

Figure 2: Activity System for the subject area of Fluid Dynamics

Figure 2 shows a conceptualisation of teaching and learning activities in one of the subject areas used as test cases for the design of the Lab@Future project.

Reflections and Conclusion

The potential impact of the outlined pedagogical framework on the design and evaluation of an e-learning environment is clearly huge. Therefore, the main contributions of activity theory and the theory of expansive learning to the Lab@Future project can be considered from the point of view of the following design implications. Theories provided: -

1. A framework for systematic gathering of targeted contextual information about the conditions and specific priorities of the four case studies. E.g. learning scenarios were constructed on the basis of contextual information gathered from focused subjects in the case studies using the 'Eight-Step-Model' (Table 1 - Mwanza, 2002) - a tool developed from the framework of activity theory.
2. A descriptive and analytic language for mapping out components and relationships that exist within the anticipated learning and teaching activities. E.g. the basic model of human activity (Figure 1 - Engeström, 1987) was used to describe and represent the structure of teaching and learning activities in the focused subject areas (see example in Figure 2).
3. A basis for formulating prescriptive principles for the design of the Lab@Future e-learning environments. The key pedagogical principles derived from the theories are:
   a) Technology based support for learning activities need to be integrated with the existing instructional practices and motives of the teachers and the life activities and motives of the students.
   b) The Lab@Future system shall support learners to expand their customary ways of learning by engaging in explorations, experimentations and creation of new knowledge objects and social practices.
4. A basis for formulating the criteria for evaluating and validating the usability and usefulness of the Lab@Future e-learning environment. E.g. the new system shall be evaluated and continuously improved not only from the point of view of fulfilling the general pedagogical principles outlined above and the predetermined requirements, but also from the point of view of identifying unexpected contradictions and innovations that emerge as a result of introducing the new system.

This paper has illustrated how theoretical and pedagogical perspectives can be incorporated into the systems development process of abstracting design requirements for an e-learning environment. The method outlined in this paper emphasis that focus should not be put on interface design alone, instead, we should aim to address the whole context of use and forms of interaction which are embedded both in tasks and in the users' understanding of their activities. In practice, the human activity centered approach described in this paper enables the systems developer to combine focus on producing conceptual models that facilitates understanding of teaching and learning practices in context, and, also to generate design principles that are grounded in pedagogical theory.

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