Participatory Learner Modelling Design: A methodology for iterative learner models development

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ABSTRACT

Learner models are built to offer personalised solutions related to learning. They are often developed in parallel to the development of adaptive learning systems and thus, linked to the system's development. The adaptive learning systems literature reports numerous accounts of learner model development, but there are no reports on the methodological aspects of developing learner models and the relation between the development of the learner model component and the rest of the system. This paper presents the Participatory Learner Modelling Design methodology, which outlines the steps for learner model development and their relation to the development of the system. The methodology is illustrated with a case study of an adaptive educational system.

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1. Introduction

The ability to personalise in order to adapt to the needs of a variety of students and accommodate their different background, skills and abilities is becoming an important feature of e-learning systems. To this end, a lot of research effort has been spent in the last 10 years in the area of adaptive learning systems and a variety of methods have been proposed to build learner models, which allow a system to personalise its interaction to individual learners. A recent review paper on the subject of learner modelling [19] outlines the different approaches for learner modelling used in the last decade.

Learner models are a type of user model, where the user is a learner. User models typically store information about a user (e.g. individual traits, goals, plans, preferences) and enable a system to adapt its behaviour to the individual user. User models are used in a variety of systems, such as Adaptive Information Systems and Recommenders, Mobile/Ubiquitous Systems, Adaptive Hypermedia Systems and Adaptive Educational Systems [15].

Several terms are used to indicate a systems' capacity to adapt to users. The most frequently used terms are personalisation and adaptation. The first refers to the effect the system has on the users, while the latter refers to the changes the system produces for different users based on their user models. In other words, from system design point of view, we think it is important to separate the purpose, i.e. personalisation, from the mechanism that achieves that purpose, i.e. adaptation. The adaptation is typically achieved through the utilisation of user models, which are the focus of this paper; consequently,

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throughout this paper we use mostly the term adaptation. The two terms, however, are deeply interlinked as the purpose of building user models into provide personalised interaction.

The process of creating a user model, and consequently a learner model, and keeping it up-to-date includes three stages [80]:

1. what is being modelled? (nature)
2. how is this information represented? (structure)
3. how is the model maintained? (user modelling approaches)

User models can be built for individuals or groups of users. Early user modelling research focused on groups and used stereotypes available *a priory* for this purpose; later on, most research focused on individual user models; however, research on group models continued (e.g. [72,10]) and grew over the last decade (e.g. [91,52,8,62,86,42]).

In the last decade, there have also been growing developments in the direction of user models inter-operability [17], including: a general user model ontology for uniform interpretations of distributed user models [45], generic user models that can be used to define user models for a variety of applications [56], cross-system user modelling where a user model from one system is re-used in another [1]. These developments are possible when the user modelling process is independent from the domain [56]; cross-system user modelling allows re-use of user-models in applications that deploy similar user information, such as web-based recommender systems.

For many adaptive systems, however, the user models are still tightly linked to the system that uses them in general, and the user interface and adaptation modules in particular. This is notably the case for educational systems where a participatory design [35,66] is used.

At the same time, there has been a shift from building systems as a whole to separating the different components of the system. The movement towards service-oriented architectures [49] and component-based development [30] emerged from the need to separate the development of the various components of a system from the development of the system as a whole, and led to challenges in assembling different components and services.

Particularly within the educational technology research, there is a move towards grid technologies, which enable sharing of learning resources in heterogeneous and geographically distributed environments [76]. This paradigm promotes the focus on stateful services and on flexibility in the way they are combined [3]. Unlike stateless services, stateful ones keep a record of the previous transactions; the interested reader can find more details on stateful services in [37].

Moreover, there is increasing focus on user involvement in product or service design, not only in the initial development phases, but throughout the development process [71], as well as involving the user in the design of particular components of the system [6].

The separation between the development of the learner model component and the development of the system is known to be a difficult issue [55] because the development of the learner model component needs to be coordinated with the development of the system. Despite the advances in the learner modelling research area, the literature is lacking in methodological frameworks for the development of learner models and the interplay between the learner model and the system development.

In this paper we focus on learning applications with a strong link between system and user model development. Moreover, we are particularly focusing on user-centred participatory design [66], where the users are involved in the development of the system and of the user model component. Consequently, this methodology is appropriate for adaptive learning systems which are built with the involvement of users.

A case study illustrates how the methodology works in practice. The case study refers to the development of an adaptive educational system for teaching mathematical generalisation in classroom settings to children of 11–14 years old. More details about the design of the entire system can be found in [70], while details about feedback elicitation are given in [63]. The case study is representative of adaptive learning systems, and in particular of exploratory learning environments, and illustrates how the methodology facilitated the integration of complex requirements in the development of the learner model component in parallel to system development.

The rest of the paper is organised as follows. Section 2 provides an overview of the learner modelling process, previous literature on learner modelling and adaptive systems development, and on iterative and participatory design. Section 3 describes the specifics of our methodology and the interplay between system development and learner model development. Section 4 illustrates, through a case study, how our methodology provides a structural systematic approach to learner model development in the context of participatory design of a complex adaptive educational system. Section 5 discusses our methodology, including its generality and the lessons that we learned from its use, that we believe other researchers will find useful.

2. Background

This section presents an overview of the literature in relation to: (a) learner modelling, (b) adaptive educational systems development with a focus on the learner model development and relation to system development, and (c) iterative participatory design.