A Tool Set Combining Learning Styles Prediction, a Blended Learning Methodology and Facilitator Guidebooks – Towards a Best Mix in Blended Learning

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Abstract

One of the challenges in the development in blended learning is to facilitate the individual learning styles of the learners. The alignment of a learning styles assessment with a learning methodology, a mapping between learning styles and social media, recommendations in a guidebook for facilitators and a checklist provide a tool set for a sustainable approach for a responsive learning environment. This paper analyzes how the different approaches, methods and studies interact to form an overall tool set to develop a learner-centered mix in blended learning. It proposes a tool set to adapt blended learning to the learning styles of the learners.

1 Introduction

Estimating user characteristics is essential for many applications that require adaptation [1]. To facilitate the individual learning styles of the learners the estimation of the differences in students' learning styles, approaches to learning and intellectual development levels [2] is crucial. The underlying principle consists of estimating the needs of the user in order to adapt the content.

In student modelling, Bayesian networks are used to estimate students' abilities at different levels of granularity. The underlying probabilistic model allows handling uncertainty in the assessment of students' knowledge and understanding [3], or users' plans and goals [4]. Küper and Kobsa [5] presented a plan generation approach for achieving the user's goals consedering their capabilities.

This paper proposes a set of tools and methods to adapt blended learning scenarios to the learning styles of learners. The tool set is made of four main components presented in the following sections. The first component describes an original probabilistic method to automatically estimate the learning style of a student based on Felder's index of learning style [6]. The second component presents a pedagogical methodology that structure activities taking into consideration domain tasks, blended learning activities, pedagogical objectives, and learning style requirements. Component 3 presents a Guidebook for tutors providing suitable scaffolding for different learning styles as well as online and face-to-face learning. Component 4 shows a customizable checklist for blended learning courses as results of a ranking-type Delphi study.

2 Estimation of Learning Styles Based on a Bayesian Network

The learning style is a cognitive characteristic of individuals that depends on the way they perceive and process mentally information. Often the style is represented using multiple dimensions estimated statistically. A review can be found in [7]. Every model suggests an instrument to measure the individual's style. They all share the same method: estimate the style, which is hidden information, from observable data representing the user behaviour. This section presents a Bayesian network to estimate the learning style of a student from observable data characterizing the blended learning material and the student's performance. We first present the structure of the network. Second, we describe the way we use this network to progressively estimate the style and reinforce the tables of probabilities.

The proposed Bayesian network is based on the Index Learning Style (ILS) established by Felder and Solomon [2]. Two types of nodes are used: i) observable variables that describe the learning task, the learning material, and the user behaviour; and ii) non-observable variables that represent the dimensions of the learning style. The dependencies between these variables are based on pedagogical assumptions. The pertinence of a learning material to achieve a given learning objective depends on the student's learning style. In other terms, the learning objective and the learning style have a causal influence on the choice of the learning material. The second assumption consists in considering that the student's learning behaviour and performance depend on the matching between the task, the learning material and the student's style. This means that the task, the learning material and the style together have a causal influence on the performance. Each of these observable variables describes different aspects [9] like the media used in the material, the type of pedagogical activity, the type of exercises, the learning objective, the performance, and the nature of the knowledge. In order to describe blended activities, we use a set of variables including collaboration, discussion, and tutoring.

The ILS considers that people's approaches to perceive and mentally process information can be classified according to four dimensions. This theory assumes that a student's learning style can be estimated by a belief measurement projected on four dimensions [2]. The first dimension represents the sensorial dimension. It measures the way (visual or verbal) the student prefer to perceive information (e.g. images, graphics, text or sound). The second dimension represents the progression dimension. It defines the way (global or sequential) the person prefers to progress in a learning task (e.g. linear constrained navigation or selective navigation). The third dimension represents the thinking dimension. It varies from reflective to active (e.g. practice, group work, experimentation, personal work, demonstrations). Finally, the fourth represents the reasoning dimension: ranging from intuitive to sensing (e.g. to progress from theory to practice or from examples to theory). These two last dimensions have a causal influence on the choice of the blended activities.

An initial set of data gathered from an empirical study [8] was used to calculate the conditional probabilities for each node. The resulting network is instantiated for every new student. The learning experiences of the different students are periodically used to reinforce the tables of probabilities of the network.

For a new student, we assign the most probable in the student's population i.e. style variables are set with the values corresponding to the highest probabilities in the initial network. This will be refined after the first learning activity. For subsequent utilisations of the system, style variables are set to the student's style estimated during

the last activity. A direct inference is, thereafter, performed in the network to calculate the conditional probabilities of the material variables. The values corresponding to the highest probabilities are selected. These metadata are used to compose a learning activity that is proposed to the student. Monitoring the student's behaviour during the learning task leads to measuring their performance. This is set as evidence in the network and a backward inference is performed to refine the student's style. After a certain number of iterations, the network converges to a stable estimation of the learning style.

3 Blended pedagogical design methodology

In the context of this tool set, we define the domain model as a set of dependent pedagogical artefacts that include domain tasks, domain skills, learning objectives, learning activities, and metadata of learning material. This model is represented in the form of an ontology. This is made of three layers: domain, pedagogy and content structure. To build such a model, we established a methodology that composes of few phases ranging from needs analysis to content packaging. Each phase creates or enriches the ontology. The domain layer contains a hierarchical structure of tasks; and for each task, the required skills. In addition to classical pedagogical learning activities such as information presentation, practice, and exercises, the pedagogical layer contains other types of activities such as project based learning, collaboration, discussion, tutoring. These activities can be online or face-to-face, individual or group work, synchronous or asynchronous. They might require live sessions or offline-developed material, need assistance from instructor, coach or peers and might require tools.

As part of the UP2UML European project, a metadata schema has been created in order to store this information in the ontology. Some of these metadata are used during content creation (title, scenario, description…); the others, such as the **nature** (blended, self-paced), **delivery mode (**online, face-to-face), **synchronization** (synchronous, asynchronous), **actors** (group, individual, system, instructor, tutor, coach, organization, peers, class), **narrative** (live, offline) control the delivery mode. These metadata serve also as observable variables (or nodes) in the Bayesian network. They are used to adapt the activity to the learning style of the learner.

In order to assist the training designer, we created reusable patterns of blended activities. Three main patterns have been specified:

- Course pattern: made of activities related to organization, planning, meetings, exams…
- Project pattern: made of activities related to setting up, running and assessing project activities
- Practice pattern: made of activities related to setting up, running, and helping with practical (or laboratory) activities

Each of these patterns is structured as three sequences of activities:

- start: a sequence of activities to start a series of other activities that have relationships
- execute: a sequence that allows completing the series of activities
- terminate: a sequence that ends the series of activities

Figure 1 shows the course pattern example.

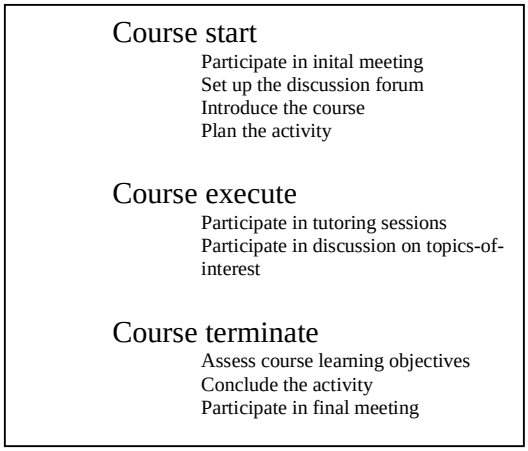

Figure 1: course blended activities pattern

The resulting ontology represents a rich body of information and knowledge related to teaching the concerned domain. It is used in different ways. The first utilisation is to guide the creation and structuring of the content material for teaching. The second utilisation is to support an adaptive system to tailor pedagogy to learning styles. Third, parsing tools allow to extract a guidebook that can be used by facilitators in blended learning courses.

4 Guidebook for Tutors

Guidebooks are a formalized way of describing blended activities. They provide instructions for course facilitators or tutors on how to conduct a course using the available course material. Guidebooks may contain different syllabi based on the same material. In particular the proportion of self-paced and blended activities may vary as well as the pedagogical approach [11]. It assists facilitators in providing suitable scaffolding for different learning styles as well as online and face-to-face learning. Its main function is to outline the options for face-to-face activities under special consideration of different learning styles of the learners. By prescribing the setting and possible usage of the material, guidebooks aim to guarantee a constant standard for the course across facilitators.

Interviews with trainers and providers of blended learning in ongoing research provide a diverse picture. The provider group went so far to actually use the guidebook to instruct the tutors in detail which materials to use when and how to conduct the sessions. Trainers on the other hand pointed out that a guidebook would take responsibility from the trainers. Both groups agree though that a guidebook can help to provide constant quality for the delivery of the face-to-face sessions.

The following guidebook structure was developed and has been used for the test of the course as part of the UP2UML project. It has two main parts, the structure itself and the information for the tutors. The structure reflects the pedagogical design methodology, dividing the course into the course pattern as outlined above. The “course start” as well as the “course execute” list the standard activities for this part of the course. The “course execute” part branches out to self-paced learning and blended activities and from there into detailed activities. The information part provides the three main types of information required by the tutors and respectively the learners regarding practice, projects and assessments and which information is required in regard to these activities.

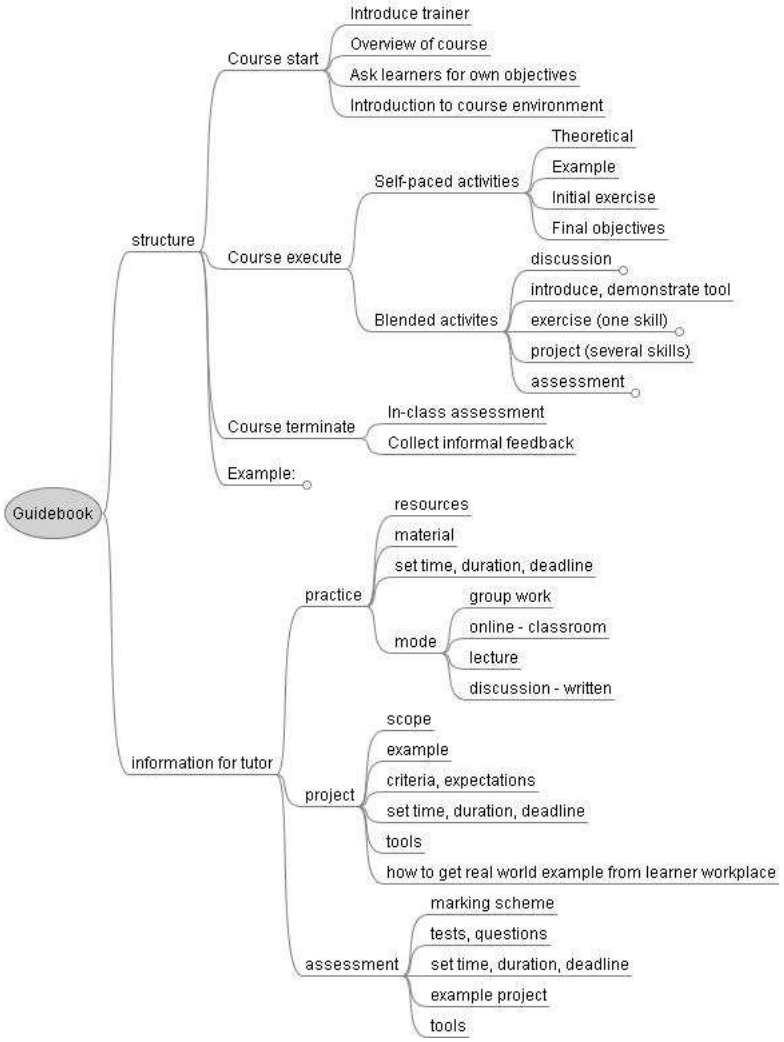

Figure 2: Guidebook structure and tutor information

Figure 3 shows an example for a guidebook, following the previously described guidebook structure.

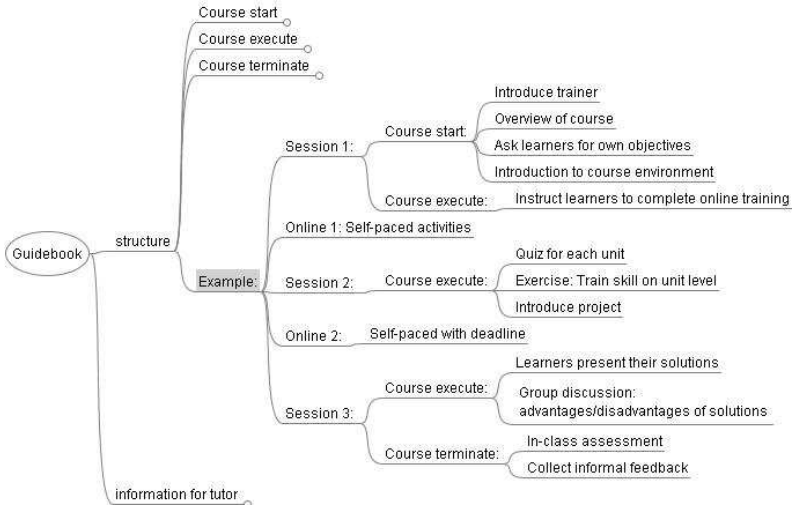

Figure 3: Guidebook structure example

The student's learning style is constantly assessed through the monitoring of the activities. Therefore it can also be applied for the selection of self-paced or blended activities and the tools most suitable for the student.
According to a recent Delphi study the mix of methods and media is an important aspect of blended learning is [12]. To accommodate the needs of today's learners a mapping of social media tools and learning styles [13] has to be considered. Baird & Fisher outline in a recent publication a mapping between social tools for Gardner's multiple intelligences [14]. These can be applied to the guidebook structure and thus improve the quality of the learning for different learners. A similar approach for other learning style concepts can easily be adapted.

5 A Checklist for Blended Learning

A three-round ranking-type Delphi study following the study design described in [15] with stakeholders of blended learning [12] gives an indication what different stakeholders consider important for successful blended learning. The study asked what works best in blended learning and included sub-panels of learners from SMEs (small and medium-sized enterprises) from the IT and the tourism industry, a control group with learners from large companies as well as trainer and providers.
Both SME sub-panels selected the following aspects of blended learning into the final "Top 10".

- Cost efficiency
- Accessibility
- Self-paced learning
- Efficiency
- Time flexibility
- Results measurement

The learners from IT SMEs also selected these aspects:

- Support mechanisms (IT)
- Content design (IT)
- Learner-centred (IT)
- Quality (IT)

The learners from IT SMEs also selected these aspects:

- Workplace-related learning
- Feasibility
- Geographical independence
- Individuality

Detailed descriptions of the aspects can be found in [12]. Keeping in mind that a Delphi study will give an indication rather than a representative result, the list outlines the selection of a panel of experts for blended learning in SMEs nevertheless and can serve as a quick method to check the fit for a specific learner group.

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