Pedagogical based Learner Model Characteristics

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Abstract

The personalisation and adaptation of content creation, distribution and presentation aim to increase learner quality of experience, improve the learning process and increase the learning outcomes. This paper introduces a novel Learner Model that is integrated by the NEWTON project into the NEWTELP learning platform in order to support personalisation and adaptation. The NEWTON's Learner Model includes a multitude of learner characteristics, including pedagogical, disability, affective and multi-sensorial.

1. Introduction

Personalisation is a key factor in modern education, as the differences between learners are now widely recognised by both researchers and educators alike. Personalisation is also one of the biggest current trends in the e-learning industry [1]. There is an increasing need for personalised and intelligent learning environments as learners differ in levels of knowledge, motivation, and have a variety of learning styles and preferences [2]. Personalised learning can support individual learning and further engage learners in their studies. Gaps between slow and fast learners are consistently emerging, and teaching to cater for these differences between students is being noted as one the most challenging aspects by science educators [3], [4].

There is a call for personalisation to be implemented into modern pedagogies, in order to meet the needs and interests of different types of learners [5]. In the Technology Enhanced Learning (TEL) domain, personalisation is one of the key features, and can assist in bringing the focus of the learning experience to the learner instead of the teacher [6]. The personalisation is based on a Learner Model which represents the necessary learner characteristics in the context of a learning system. Various authoring tools that provide support for personalisation rules definition in order to provide personalisation based on the information represented in the Learner Model have been proposed [16].

The HORIZON 2020 NEWTON[1] project provides an European learning platform (NEWTELP) that delivers personalised and adaptive technology-enhanced educational content and learning activities, addressing the individual learner needs in order to increase the learning outcomes and learner quality of experience. A Learner Model implemented in the NEWTELP platform supports the personalisation and adaptation. The NEWTON Learner Model includes various demographic, pedagogical, disability, affective and multi-sensorial learner characteristics. This paper introduces the NEWTON Learner Model and the learner characteristics modelled by it.

The paper is organised as follows. Section 2 proposes the theoretical background of the study and existing pedagogical and affective based characteristics considered in the Learner Model by different e-learning systems. Section 3 presents the NEWTON Learner Model and its characteristics that support personalisation and adaptation. Section 4 concludes the paper and presents its perspectives.

2. Literature Review on Learner Model Characteristics

2.1. Pedagogical based Characteristics

The Public and Private Information (PAPI) for Learners [7] is a standard that divides the learner information into six categories: (1) contact information (e.g. name, postal address and telephone number), (2) relations information (e.g. classmates, teammates, and mentors), (3) security information (e.g. public keys, private keys and credentials), (4) preference information (useful and unusable I/O devices, learning styles and physical limitations), (5) performance information (e.g. grades, interim reports, and log books), and (6) portfolio information (e.g. accomplishments and works).

[1] http://www.newtonproject.eu/

The Chinese E-Learning Technology Standards (CELTS-11) [8] is a specification for Learner Model that includes seven categories: (1) individual information (e.g. name, gender, date of birth, phone number and e-mail), (2) academic information (e.g. major, grade and learning plan), (3) relationship information (e.g. the relation of the learner with tutors and other learners), (4) safety information (e.g. password), (5) predilection information (e.g. learning resource types such as picture, animation, audio, video, text), (6) performance information (e.g. the learner's knowledge and mastery of the learned knowledge), and (7) show reel information (e.g. accomplished work and projects of the learner).

Robson and Barr[9] identified five types of learner information to be included in the Learner Model: (1) educational records and high level competencies (e.g. language skills and certifications), (2) competencies (e.g. skills, knowledge, abilities, outcomes, objectives) and level of competence, (3) data in Affective, motivational, and social dimensions, (4) goals (e.g. learning goals and mission/task goals), and (5) physical adaptations (e.g. location, device capabilities, ambient light, and accessibility data).

The Felder–Silverman learning style model (FSLSM) [10] characterises each learner according to four dimensions: (1) sensing (learn facts and concrete learning material) / intuitive (learn abstract learning material), (2) active (learn best by working actively with the learning material) / reflective (think about and reflect on the material), (3) visual (remember best what they have seen) / verbal (get more out of textual representation), and (4) sequential (learn in small incremental steps) / global (learn in large leaps).

According to these main refinement works that provide a general vision of the information considered for user/learner profile/model, one can notice that there are four main types information considered: (1) demographic data such as learner name, his/her postal address, his/her gender, his/her number, etc., (2) grouping data like student mentors, his/her teammates, his/her grades, his/her certifications, (3) student preferences such as media presentation and language skills, and (4) learning activity based information including for example learner's knowledge level, his/her learning goals, and skills.

2.2. Affective based Characteristics

Learner's affective characteristics, such as motivation, engagement and emotions were also recognised as important aspects to be considered for a successful learning process [11]. Affective characteristics such as motivation, engagement, interest, joy, surprise, boredom and frustration have a huge impact on decision making, managing learning activities, timing, and reflection on learning [12]. A Learner Model should take into consideration these changing learner's affective characteristics. Current research attempts to address these factors by developing different Learner Models [13].

Learner's affective characteristics can be grouped into two main dimensions related to: motivation and emotions. These can be measured and assessed using either objective or subjective methods. Objective metrics of motivation can be derived through analyses of data that relates to student's navigation behaviour such as time on task, number of repeated tasks, and number of help requests [11]. They can also be assessed by using external equipment, such as video camera recordings, heartrate monitor bracelet, Electroencephalography (EEG) headset and following eye-tracker movements. Subjective metrics include scores of questionnaires regarding motivation and engagement, and similar, questionnaires can be used for emotion recognition. Furthermore, an observational assessment can be carried out to evaluate the emotional state of the learner.

A number of adaptive learning systems have incorporated an Affective Learner Model [2], [17], [18]. Cocea and Weibelzahl [14] studied data from a web-based interactive environment, HTML-Tutor, to predict whether a learner is disengaged. They defined interest as being a determinant of engagement, as people tend to be more engaged in activities they are interested in. The study focused on two types of tasks, reading and problem-solving activities, with results pointing out similarities between blind-guessing and uninterested guessing.

Looi [15] based their study on the ARCS Model, inferring three aspects of motivation: confidence, confusion, and effort. This research focused on identifying the learner's focus of attention and inputs related to learners' actions, such as time spent on task, time spent reading the relevant text, the time for the learner to decide how to perform the task, the time of starting/finishing the task, the number of tasks the learner has finished with respect to the current plan (progress), the number of unexpected tasks performed by the learner (unrelated to the learning plan), and the number of times learners have used the help files.

Rogaten et al. [13] criticised the lack of affective changes (attitude) and behaviour in research, and proposed to breach this gap by studying an Affective-Behaviour-Cognition model of learning gains using longitudinal multilevel modelling, which included data from 80,000 students. Their focus was on finding out whether any specific student or course characteristic can predict learning gains or highlight a potential dropout.

3 NEWTELP Platform

NEWTON is a large-scale EU Horizon 2020 project that aims to develop, integrate and disseminate innovative technology-enhanced learning (TEL) methods and tools, and to create new or inter-connect existing state-of-the art teaching labs. Moreover,

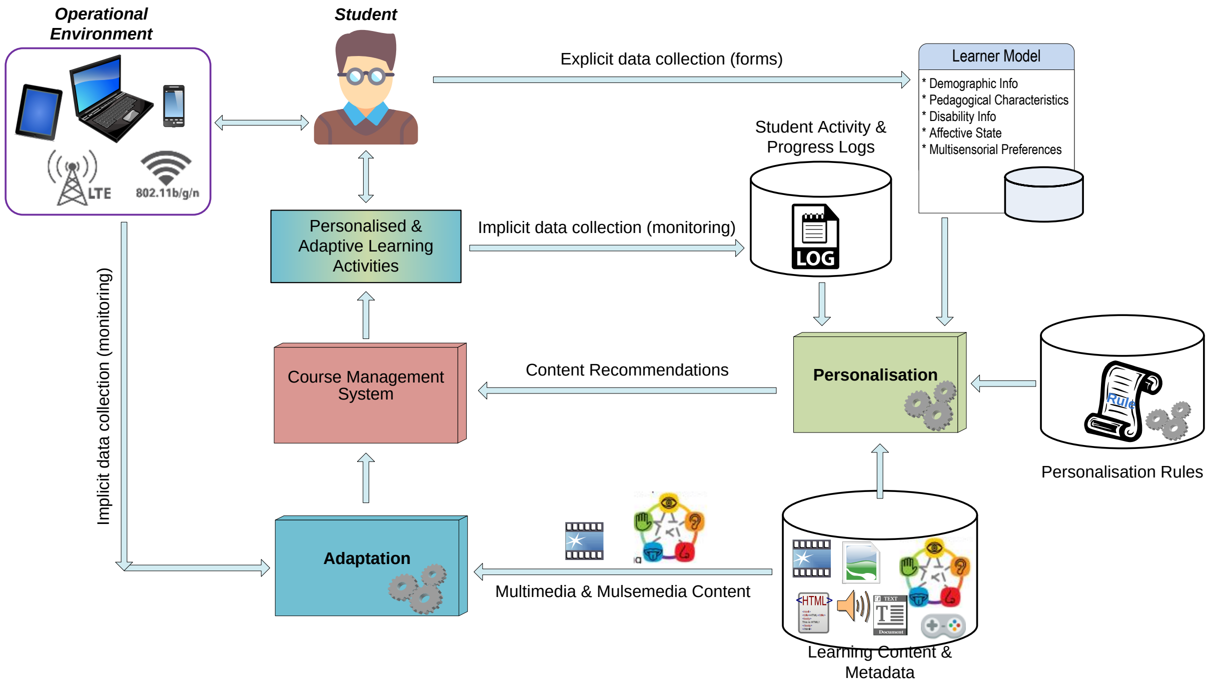

Figure 1. NEWTON learner modelling, personalisation and adaptation.

NEWTON project aims to build a large Pan-European learning platform that links all stakeholders in education, supports fast dissemination of STEM learning content to a wide audience in a ubiquitous manner, enables content reuse, supports generation of new content, increases content exchange in diverse forms, develops and disseminates new teaching scenarios, and encourages new innovative businesses.

The NEWTON Technology enhanced Learning Platform (NEWTELP) developed as part of the NEWTON project integrates and deploys a multitude of novel and emerging mechanisms and TEL methodologies including: interconnected fab labs and virtual labs, multi-modal and multi-sensorial media distribution, augmented reality, gamification, game-based learning, and self-directed learning pedagogies (e.g., flipped classroom, online problem-based learning, and e-practice testing).

Figure 1 illustrates how the NEWTELP learning system integrates learner modelling, personalisation and adaptation of content creation, distribution and presentation with the aim to improve the learning experience and the learning outcomes.

3.1 NEWTON Learner Model Characteristics

The novelty aspect of the NEWTON Learner Model is that along with demographic and pedagogical characteristics, the model also includes disability, affective and multisensorial characteristics in order to construct a more realistic learner model.

Table 1 summarises the demographic, pedagogical and disability learner characteristics defined by the NEWTON Learner Model. The pedagogical characteristics include demographic data (e.g., student name, gender, age, etc.), grouping data (e.g., college/ school name the learner is enrolled, education level such as primary school, secondary school or university), learning preferences (e.g. preferred language, media presentation type, learning style that can be retrieved using questionnaires such as Index of Learning Styles (ILS), etc.), and course or learning activity-based information (e.g. knowledge level, completed tasks, assessments, accessed material, etc.). The learner disability information includes the disability type, the specific disability name, the disability level and any other relevant details.

Table 2 summarises the affective and multi-sensorial characteristics defined by the NEWTON Learner Model. The learner affective based characteristics include the learner motivation, described as student interest and self-efficacy when conducting the learning activity and his/her emotions that include both learning emotions and a subset from DEQ (Discrete Emotion Questionnaire). The multi-sensorial characteristics are related to what multisensorial devices are available to the learner, as well as learner preferences regarding multi-sensorial aspects such as visual, olfactive, haptic and air flow.

The information stored in the NEWTON Learner Model is collected explicit from the user (e.g. through forms embedded into the platform), or it is provided by the learning system administrator when a user account is created. Some information is also collected implicit through logging and monitoring of learner's interaction with the learning platform.

Table 1. Learner demographic, pedagogical and disability characteristics defined in the NEWTON Learner Model.

Category	**Sample Characteristics**
Learner demographic data	Student image, name, student ID, email, gender, age
Learner grouping data	School name, education level, course, study year, working group
Learning preferences	Language, media presentation, learning style
Course or learning activity-based information	Knowledge Level, learning goals, skills, interests, learning performance
Disability information	Type, specific disability, level, details

Table 2. Learner affective and multi-sensorial characteristics defined in the NEWTON Learner Model.

Category	**Sample Characteristics**
Motivation	Interest, self-efficacy
Emotion	Engagement, anxiety, boredom, sadness, happiness, anger, enjoyment
Multisensorial preferences	Device availability, preferences for visual, olfactive, haptic, air flow

3.2 NEWTON Personalisation and Adaptation

The NEWTELP performs personalization and adaptation of content delivery and presentation to address the individual learner needs including their physical disabilities, to improve the learning process, and to increase the learning outcomes and learner quality of experience.

The personalisation aims to improve the learning experience by using the information stored in the Learner Model to provide learners with content that is relevant, suitable and useful (e.g., based on their disability, interaction preferences, multisensorial preferences, affective states, etc.). The NEWTELP learning system also aims to support the students in achieving the learning outcomes by identifying the knowledge gaps (e.g., difference between learning goals and student's competences for particular topics), and recommending a set of relevant contents to address the gaps.

The NEWTELP complements the content personalisation, with adaptation technology to further support the users and improve the learning experience. The adaptation focuses on overcoming technological limitations, by providing the learners with content adapted to their operational environment/context (e.g., network characteristics, device types, etc.)

4. Conclusion

The paper introduced the novel NEWTON Learner Model that includes various learner characteristics such as demographic, pedagogical, disability, affective and multisensorial characteristics. A literature review of most common characteristics considered by other learning systems that have built a Learner Model is provided. The learner characteristics modelled in the NEWTON Learner Model are the basis for the personalization and adaptation mechanisms implemented in the NENEWTELP). NEWTELP performs both course-level personalisation (e.g., by tailoring and recommending learning contents based on information from the Learner Model), and content-level personalisation (e.g., by having personalised learning loops and feedback inside of an educational content such as virtual labs or educational games).

5. Acknowledgment

This research is supported by the NEWTON project (http://www.newtonproject.eu/) funded under the European Union's Horizon 2020 Research and Innovation programme, Grant Agreement no. 688503.

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