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Benchmarking Study: Classical Learner Modelling Approaches vs An Ontology-Based Learner Model

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Abstract: In the field of technology-enhanced learning environment, while some researchers have been working on the learner modelling thematic for decades, the last few years have been marked by the multiplication of challenges related to the representation and selection of relevant information on the learner. Among the significant issues that arise when setting up a learning system is the question of how to present relevant learning content that meets learner's needs, and that also takes into account the learning context information. This present work aims to provide a context-aware learner modelling approach based on ontology. The proposed model incorporates the relevant characteristics of learners plus specific information about their learning context. In this paper, we also analyzed the prevalent approaches and provided a comparative analysis of our model with the most important works in literary. In conclusion, we showed different use cases that place in evidence the integration of learning context in the learner model, and that also stipulates our proposition as more comprehensive.

Keywords: Learner Model, Ontology, Learning context, Technology Enhance-Learning environment

1. Introduction

Nowadays, innovative technologies in education become the biggest challenges for the 20 century. Indeed, with the huge mass of university students, the imminent need of companies in terms of training and capacity building, technology-enhanced learning environments (TEL) remains an unavoidable solution.

TEL systems seek information about learners such as abilities, objectives, preferences, knowledge backgrounds and learning styles, so that they could be adapted to them. However, modelling the learner proved to be the best performance goal to perfect those systems. In fact, learner models are constructed from learner data usually gathered by an intelligent tutoring system through the learner's interaction with the tutoring system. Literature gives several points of view. Indeed, some authors consider the learner model as an explicit description of particular learner information to achieve the adaptation of learning content [1][2]. In other hand, there are others who To resolve this problem, we proposed in [3] a context-aware learner modelling based on ontology. The aim of this paper is present learning model with focus on the modelling process rather than the learner knowledge [5]. In this way, there is no unique learner model in the traditional sense, but a virtual infinity of potential models calculated "just in time" about one or several individuals by a particular calculation agent.

We note that the most important matter in the field of learner modelling is the absence of a standardized method for representing and exploiting the learner model component for distance learning system. In this fact, we propose to build the learner model by using ontologies as they play an essential role in distributing and representing knowledge. Furthermore, another constraint related to learner modelling is that the learner can train at every time, in everywhere and with any device. This constraint provides to add in the modelling other parameters that describe environmental contexts of the learner: noise level, brightness, the device context as the display, network, software, screen resolution... etc.

to present a comparative study of the most important works in literary against the LMONTO approach. Our objective is to

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prove the performance of our model based and differentiated by learner contextual Data.

1. Context-aware learner modelling

Learner model have a vital role in the personalization and adaptation of the content in distance learning systems.

There are several researches exploring the notion of the context. Indeed, Schilit [4], the inventor of the term «context-aware computing », defines the context by the location, the physical environment, the characteristics of the computing environment, the user profile and the identities of the surrounding objects and people. However, the most popular definition of the context is the definition of Dey which is widely referenced in the field of distance learning systems [5][6][7]. Dey defines the context by "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."[8].

For understanding the learning context, we propose (according to previous works) to present in (Table 1) a classification of information that is relevant to context-aware applications in distance learning system [3]

Table 1 - Context classification

Class	Characteristics
Computing context	• Network: static and dynamic network property; • Hardware: the device characteristics; • Software: document formats, operating system, software, etc.
Location context	the localization and the geometric information including people, environment and relationships between objects...
Time context	Includes information about the date (date of an activity day of the week, months or semester of the year, etc), time (the current time of learning, time interval or duration of an activity, etc) and period.[9]
Physical context	Describes the environment where the learner and the system are located. It includes measures for heat, light, and sounds[10].
Activity context	Determines the user's intention, objectives, actions, knowledge, objects and environment.
User context	personal data, prerequisites, profile information, interests, objectives, grade level ...
Social relation context	social relations, links, connections or affiliation between two or more persons.

We note that all those contextual information can be obtained in different ways: *Explicit* by users (i.e. forms, QCMs); *Implicit* by retrieving contextual information automatically from the environment, for instance, obtaining the location and type of learning device, or by *inference* from the analysis of the interaction between the user and the environment.

2. An ontology-Based Learner Model (LMONTO) : toward a new concept

In the literature, there are a large number of learner modelling techniques that represent the different characteristics of learners in online learning systems. Each technique can be more useful and beneficial than another depending on the possibilities and benefits which it offers.

Based on the analysis of different learner modelling techniques, we decided to describe the learner model using ontological technology.

Recently ontology have been widely used in the field of the intelligent learning environments[11][12][13]. According to Winter[14], the ontological technology offer great potential to learner modelers who have traditionally struggled with issues of re-use, portability and tight coupling with learning applications. He has granted the advantages of using ontological technology to learner modelling and mention that the ontology-based learner model offers a set of benefits such as reusability, portability, flexible access and information integration due to inference mechanism, the availability of effective design and reasoning tools.

In fact, a multitude of learner modelling approaches based on ontologies was proposed. Sheeba and Krishnan [13] proposed a student profile that describes the best way a student prefers to learn. It includes information on student's characteristics such as background knowledge, learning preference, styles, interests, goals, etc.

Panagiotopoulos and Kalou[15]propose a student model and enhance it with semantics via an ontology to be exploitable effectively within an ITS. The ontology schema consists of two main taxonomies: (a) student's academic information and (b) student's personal information. As for[11], he developed a learner ontology that is exploited as a guideline to offer semantic contents to certain categories of learners from content ontology keeping in view his ability, knowledge, prior performance and results in current assessments.

Moreover, some related works proposed a student model ontology comprising student personal data, learning styles, and student performance[16][17][18]. Now a day, searchers developed the learner model ontology according to the learner capacities and cognitive level in the computing environment for human learning systems[19][20]. These models based on an accurate description of learners and their behaviours, knowledge, skills, and interactions[21].

Based on the analysis of these learner modelling approaches, we had decided about the characteristics that will be presented in our model. Furthermore, based on the analysis of different modelling learner techniques presented in [15], we choose to describe the context-dependent learner model by using ontology written in OWL (Web Ontology Language) created by the W3C (Web Ontology Working Group) Consortium[22]. To build L-MONTO, we used the Protégé 5.2 ontology editor [23].

The proposed approach evolves from the existing learner models cited in section 2. However, it integrates other information which seems to be useful and ensures a better representation of the learner.

As shown in Fig.1, L-MONTO incorporates the relevant characteristics of learners plus specific information about their learning context. It is described according to four mains categories of information : Personal Data, Cognitive Data, Activity Data, and Contextual data.

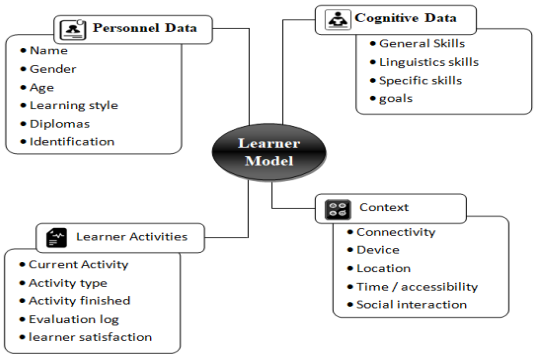

Fig. 1 - Learner Model Structure[24]

Our proposed learner model as represented in [3], [24]was building by the ontology as shown in "Fig. 2," including the different characteristics of a learner.

The focus of this perception is not restricted to modeling the learner characteristics but encompasses both permanent learner characteristics and specific information about learning context. Moreover, the developed ontology is based on the existing learner models cited above with the integration of other information which seems very important for the best representation of the learner.

3. Benchmarking Study: L-Monto Vs previous learner models

In this section, we present a comparative study of the different learner models presented in[11], [19],[13],[14],[15], [16], [17],[18], [20],[21]that have been described above.

For prove the performance of our model L-Monto, we propose a benchmarking study based on a binary matrix. In fact, we attribute 0 for an absence of the characteristic of a specific type of data for learner model ontology, and 1 if it exists. So the binary matrix well be as it shown in Table 2.

Table 2 Binary matrix of benchmarking study

	Learner characteristics	Yago	Sarwar & al	Sheeba & al	Winter & al	Panagiotopoulos & al	Rezgui & al	Labib & al	Nguyen & al	Pramitasari & al	Sani & al	L-MOnto
Personal data	General information	1	1	1	1	1	1	1	1	1	1	1
	Learning style	1	1	1	1	0	1	1	1	1	1	1
	Preferences	1	1	1	0	0	1	1	1	1	1	1
	certifications	1	1	0	0	1	1	1	1	1	1	1
	Identification	1	1	0	1	1	1	1	1	1	1	1
	motivation	1	0	0	0	0	0	0	1	0	0	1
Cognitive Data	Prerequisites/ background	1	1	1	1	0	1	1	1	1	1	1
	performance	1	1	1	1	0	1	1	1	1	1	1
	Language skills	1	1	0	0	0	1	1	1	1	1	1
	Technical skills	1	1	0	0	1	1	1	1	1	1	1
	Specific skills domain	1	0	0	0	1	1	1	1	1	1	1
	Level-Learner	1	1	1	0	0	1	1	1	1	1	1
	Learning goals/Objectives	1	1	1	0	1	1	1	1	1	1	1
Activity data	Learner Activity	1	1	1	0	0	1	1	1	1	1	1
	Current Activity	1	0	0	0	0	0	0	0	0	0	1
	Activity type	0	1	0	0	0	0	0	1	0	0	1
	Prerequisites Activity	1	1	0	0	0	0	0	0	0	0	1
	Learner Disabilities	1	1	0	0	0	0	0	0	0	0	1
	Learner errors and misconception	0	0	0	0	0	0	0	0	0	0	1
	Learner outcome	1	0	0	0	0	0	0	0	0	0	1
	finished Activity	1	0	0	0	0	0	0	0	0	0	1
	Knowledge gained	1	1	0	0	0	0	0	0	0	0	1
	Learner satisfaction	0	0	0	0	0	0	0	0	0	0	1
Contexual Data	Device	0	0	0	0	0	0	0	0	0	0	1
	Location	0	0	0	0	0	0	0	0	0	0	1
	Time	0	0	0	0	0	0	0	0	0	0	1
	Acces Date	0	0	0	0	0	0	0	0	0	0	1
	Acces frequency	0	0	0	0	0	0	0	0	0	0	1
	Duration session	0	0	0	0	0	0	0	0	0	0	1
	Social interaction	0	0	1	0	0	1	1	0	0	1	1

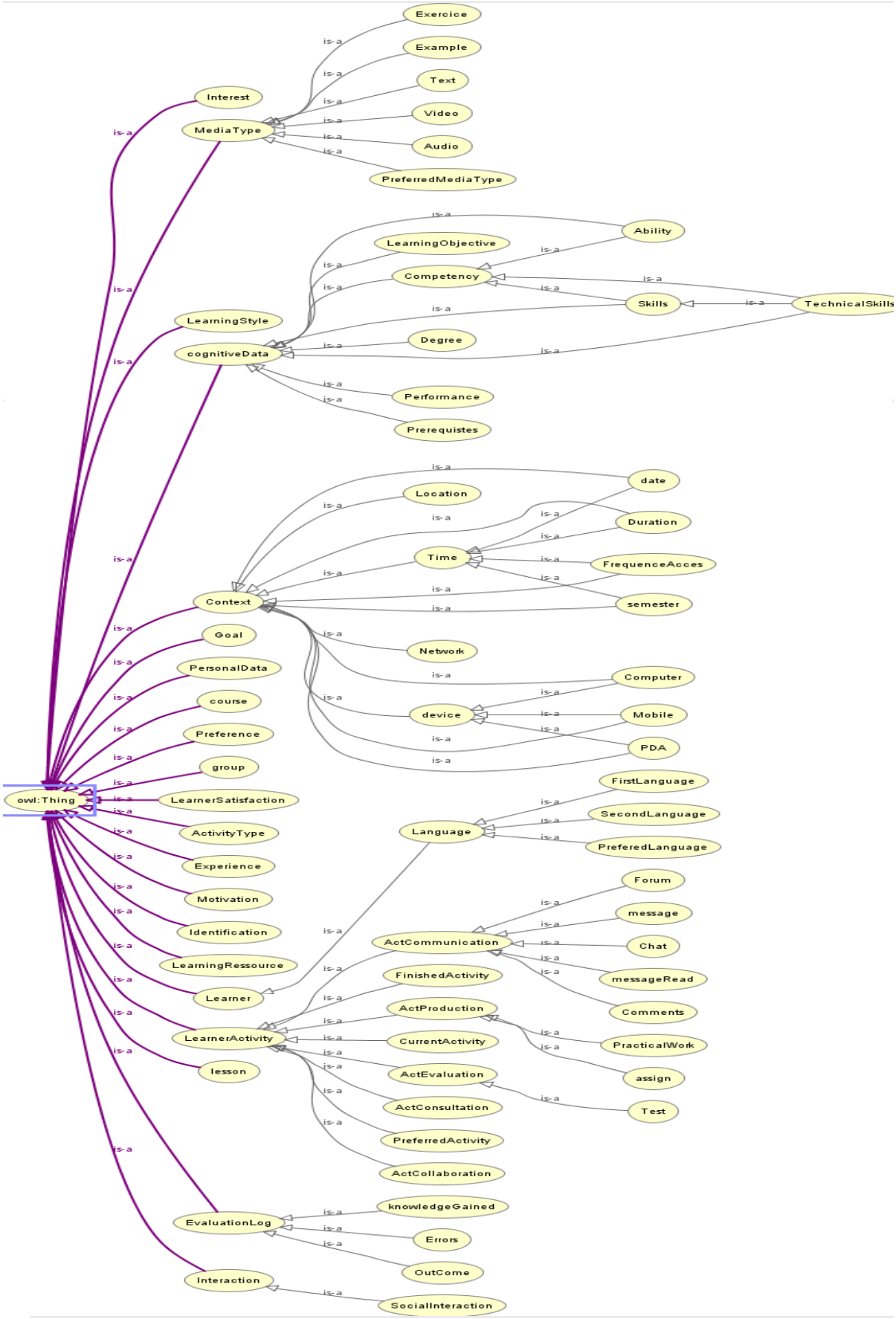

Fig. 2 - Learner Model Ontology [3]

The bellow matrix shows the difference between the eight models and our model according to the features that can describe a learner. From the table, we observe that the proposed model is similar to all the models presented above regarding to learner's general information, prerequisites and background. Nevertheless, it differs greatly in several aspects. The first aspect is the activity data; most of those information are absent in the majority of other models, such as activity type, current activity, finished activity, knowledge gained, Learner errors and misconception, learner outcome and learner satisfaction which we consider very important for identifying the specific needs of each learner. The second aspect concerns the contextual data, the comparison results observed in the table shows that only the models proposed by [21], [18] and [17] introduce the representation of social interaction. Besides, all these learner models do not represent both the information related to the time that contain information about the accessibility of the learner to the environment nor the location and the device's characteristics used by the learner during learning Activity.

4. Discussion

Nevertheless, such contextual data may appear to be specially required for making decisions about the educational content to be presented and how it can be shown to the learner.

As a case study, there are different fictitious scenarios that proof how important the contextual data is as a basis for providing the learner modelling. The first one concerns the use of the 3G internet connection by the learner. For example, consider a situation where a student at the university who did his studies and internship in two different cities. He is not forced to attend school regularly during the week to take his courses. Simply, he can just use his phone and the internet as an alternative. Instead of that, we need likely information about his device and the kind of internet connection that he working with. That's how we can avoid the fact that the student feels unable to choose the learning device to use, also, the system can't propose an appropriate form of content learning for him.

Another scenario is where an employee takes a train every day to go to his work (the trip takes around 2 hours). Next to his work, he is enrolled in an online formation. So he spends the journey accessing the online learning system. In order to predict how much he is concentrated and can surely benefit from the course, the system must gather some contextual information, like, his location and level of noise around him.

Besides, there are some pedagogical approaches such as the Connectivism approach which requires collaboration between learners. Thus, the learner model should include information about learner social interaction. Based on that information, we will detect which learners are the most active and most communicating and those how are the least communicating. Therefore, in this sense, this collected data enable the implementation of support strategies for supporting learners and encouraging them to communicate more. So, they will be more integrated into the course.

By considering the above use cases, we may conclude that the information provided by the works cited in matrix 1 are insufficient and cannot be used in such situations to represent the learners.

5. Conclusion

In this paper, we have presented a literature review of different learner modelling approaches based on ontologies. Besides, we have granted a comparative study between the different proposals dealing with learner modelling which gives us a general view of the different learner's characteristics that can be included in the proposed LMONTO. The proposed model is constructed based on the most relevant learner model approaches and specifications. Moreover, for a better representation of learners, we have encompassed both the learner characteristics and the learning context.

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