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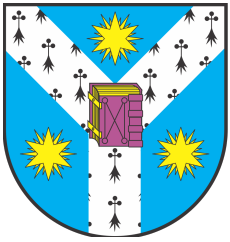

Towards Personalised Adaptive Learning: A Scalable and Interoperable approach using Semantic Web Technologies

Summary

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0.1 Contents

0.2 Introduction

One major positive—and perhaps debatable—change that the Internet era brought was widespread and unrestricted access to high-quality educational materials, albeit not in a formal sense. Coupled with continuous and diverse improvements in Information and Communication Technology (ICT), the means and process of learning are constantly evolving. With events like the COVID-19 pandemic, this evolution is accelerated, making activities involving e-learning, web-based learning, online learning, and distance learning a necessary part of formal and traditional education. These forms of learning propagate asynchronous learning where the main players (learner, teacher, and learning environment) are not necessarily defined by time and place through the use of networks, computers, and smart devices [9].

Transitioning from traditional forms of learning to other forms that are technology-based, network-supported, self-paced, and asynchronous necessitates the resolution of several issues. Access to learning systems does not always imply effective or satisfactory learning. This is because, learning, to a large extent, is a process that "can be recognised as individualistic, complex, and sometimes chaotic" [3] and exists in different stages. The quality of one-on-one interactions between teachers and students is one of such challenges that both traditional (classroom-based) and asynchronous forms of learning face. While this can be accomplished to some extent in a traditional educational system, it is a huge challenge in an asynchronous learning environment because environmental factors (which can affect learning) are numerous and diverse.

Personalised learning addresses this issue by replacing a one-size-fits-all learning paradigm with a scenario in which the learner

is at the centre of the learning process. This entails taking into account the learner's preferences, interests, goals, and abilities during the learning process to improve learning satisfaction while minimising disruption. According to Fischer [6], there is a fundamental need for systems that interact with users to deliver experiences that are tailored to the user's background, learning experience, and intended goals. This requires presenting information to users in the most appropriate form and at the most appropriate time, as well as at any time, place, or manner. Thus, personalisation in learning is tasked with meeting the learner's needs and preferences is dependent on the learner and use learner information (explicitly or implicitly) for further customisation.

When compared to a traditional learning environment, many factors can affect the learning process—and serve as personalisation criteria—in an e-learning environment. Cognitive traits, behavioural traits, skills, social factors, and affective states of the learner are examples of such factors [10, 8, 1]. Such data can be gathered using either explicit questionnaires or implicit methods (learner monitoring). Course designers and instructors are then faced with the challenge of balancing the time spent gathering such information with the actual learning process to avoid undue interference. The typical process is to model the learning environment with a few parameters that are relevant to the learners' context [5, 1]. This also reduces the effort required to provide learning resources to meet the widest range of possible needs.

The preceding paragraphs demonstrate that there are some issues and challenges associated with the transition from traditional to e-learning. The following are some of the challenges and gaps in current personalised e-learning in this context:

- A lack of personalised learning on e-learning platforms,

- A lack of reusable personalised content,
- A high student-to-teacher ratio, and
- The requirement to include more personalisation criteria.

0.2.1 Research Hypothesis

Rather than developing a personalised e-learning platform to support a few fixed personalisation parameters that, in most cases, cannot be applied to a different knowledge domain, an approach that can apply a set of possible personalisation criteria and can be interfaced with existing e-learning systems such as learning management systems, which do not include personalisation by default, can be used. Hence, the hypothesis that underpins this research can be stated as follows:

> *Different courses on an e-learning platform can be personalised by selecting and combining relevant parameters for each course in a reusable manner, and this personalised learning content can be dynamically presented to learners, meeting their needs and preferences.*

0.2.2 Research Objectives

To test the stated hypothesis, the goal of the research is defined as follows:

> *The e-learning initiative of the WASPEC program aims to demonstrate the selection and combination of relevant parameters for different courses in a curriculum, as well as how personalised learning content can be dynamically adapted to learners' preferences, needs, and ability to meet specified learning goals.*

The following objectives were established to achieve the research's stated goal:

- **RO1:** Conduct an extensive literature review on personalised learning, personalisation criteria, adaptivity and intelligence, and e-learning systems with multiple personalisation criteria.
- **RO2:** Using semantic web technologies and pedagogical agents, propose and design a model for incorporating multiple personalisation criteria on an e-learning platform. And demonstrate how the design model achieves personalisation and adaptivity in a dynamic and reusable manner.
- **RO3:** Implement a working prototype of the proposed model.
- **RO4:** Assess the final implementation, first using a heuristic approach (researchers and experts familiar with personalised learning), and then with learners (taking a personalised course).

0.2.3 Research Questions

The following questions arise as a result of the stated objectives of this research:

- **RQ1:** *How can relevant parameters be selected for courses when there is a set of multiple criteria for personalisation?*

From previous reviews, it was observed that most personalised learning platforms used a fixed number of parameters for personalisation because this was a feasible approach. Incorporating an excessive number of parameters will result in an impractical number of learning paths being designed [4, 7].

When incorporating multiple parameters, several approaches have been proposed for personalisation [4]. Thus, rather than approaching personalisation with a fixed set of criteria, courses should be personalised based on existing learning materials and the course instructor's or domain expert's decisions.

- **RQ2:** *How can personalisation and adaptivity be implemented in a reusable and dynamic manner on an e-learning platform?*

Personalisation is not included by default in the most-commonly used e-learning platforms, according to an examination of different e-learning platforms [2, 1]. And it is often difficult to apply the personalisation approach to a different domain in studies that implement personalisation and adaptivity through custom-designed e-learning systems without a complete redesign and implementation. As a result, personalised content can be created and shared with other systems using a personalisation approach that is independent of the e-learning system, as most widely-used platforms must be designed in accordance with some standards.

To address the tutor-to-student ratio issue, some tasks must be automated. Such tasks can be delegated to pedagogical agents, with course instructors handling the more intricate and complex responsibilities.

0.3 Organisation of Chapters

This thesis addresses personalised adaptive e-learning, with special emphasis on LMS, to accommodate learner needs and preferences, resulting in more satisfying learning experiences. WASPEC, a learning platform that supports multiple personalisation parameters, with semantic web technologies and pedagogical agents,

is also presented, along with its design, implementation, and evaluation. The thesis is divided into seven chapters, which are summarised below:

Chapter 1, *Introduction*, sets the tone for the rest of the thesis by providing a general introduction and background to the research, its context, and scope. The main question that motivates this research, as well as the hypothesis that seeks to answer it, are defined here. The research's aims and objectives are also stated, followed by the main contributions. This provides a comprehensive overview of the thesis in order to provide the audience with a sense of the big picture that this research seeks to address.

Chapter 2, *Personalised E-Learning: A 21st Century Challenge*, provides a review of the literature on the main concepts underlying personalised e-learning and its evolution. To begin, it provides an overview of the major learning theories (behaviourism, cognitivism, and constructivism) and their impact on the transition from classroom-based learning and traditional e-learning to personalised e-learning. Second, it depicts the goals, benefits, and challenges of personalised learning. Finally, it examines several personalisation criteria used in personalised learning environments. The chapter's main goal is to introduce the problem that this research is addressing.

Chapter 3, *Designing a Personalised E-learning Platform*, expands on the previous chapter's literature review, establishing the tone for the design of the WASPEC learning platform. It examines various approaches to designing personalised e-learning systems, highlighting the challenges associated with the approaches summarised.

Chapter 4, *The Design of WASPEC*, describes the design and architecture of the novel approach to personalising content on learning management systems that incorporates semantic web

technologies, standardisation, and pedagogical agents. The chapter describes the principles and ideas underlying this semantic rule-based approach to personalisation, as well as the ontology that underpins it. Following that, the process of selecting and combining personalisation parameters, as well as the metrics that enable this, are discussed. Finally, the various levels and procedures of personalisation that take place during the learning process are described.

Chapter 5, *Implementing WASPEC*, describes the development of a prototype system using the approach described in the previous chapter. The technologies and tools used in the WASPEC implementation, including Moodle, an LMS, are detailed here. The chapter concludes by examining the difficulties encountered in implementing WASPEC.

The results of validating the approach proposed in this thesis are presented in **Chapter 6**, *Evaluation Methodology*. It describes the experiments used in the evaluation process, the first being an evaluation from the perspective of a course instructor, and the second involving students taking a personalised course on the WASPEC learning platform. The findings are discussed in detail, and the chapter concludes with a general discussion of the proposed system. Finally, the platform is compared to other platforms of its kind.

This thesis is concluded in **Chapter 7**, *Conclusions and Future Directions*. The chapter provides an overview of the research's objectives and contributions, as well as a reflection on the extent to which the goals stated in Chapter 1 were met. Finally, future work ideas and improvements to this approach are discussed.

0.4 Summary of Contributions

Through the development of an interoperable e-learning approach, this study contributes to meeting the challenges of personalisation and access to educational content. This makes it easier to share personalised learning content and ensures efficient scalability. This study contributes to personalised adaptive learning through the design, implementation, and evaluation of the WASPEC platform. The principal contributions are enumerated below:

1. **Design and development of an ontology to support multi-personalisation of learning content in the e-learning domain**

   An ontology, E-learning Ontology for Multi-Parameter Personalisation (EOMPP), was created to support reusability and interoperability between different e-learning platforms. The relationships between personalisation parameters and metadata standards describing learning materials were defined by EOMPP. It also described relationships in an e-learning system between a knowledge domain and learner characteristics.

2. **Definition of metrics for selecting and combining relevant parameters based on existing learning content**

   Two metrics were defined to determine relevant parameters for each course based on its content. These dynamically applied metrics assist a course instructor in selecting relevant parameters. The metrics determine the appropriate and dynamic combination of these parameters in real-time adaptivity in the different levels of personalisation once relevant parameters have been selected.

3. **Development of an ontology-driven model to support multi-personalisation and adaptivity of learning materials on an e-learning system with pedagogical agents**

   Despite having a wide range of functionalities, most e-learning systems, such as learning management systems and virtual learning environments, do not support personalisation and adaptivity by default. WASPEC's model consisted of highly modular components that allowed for flexibility in personalisation without disrupting the core functionalities of the e-learning system.

4. **Implementation of the WASPEC platform for adaptive and reusable personalisation Moodle was extended to create an e-learning platform to test the approach proposed by WASPEC.**

   The proposed ontology, metrics for selecting and combining relevant parameters for personalisation, and pedagogical agents were all included in this platform.

5. **Assessment of the WASPEC learning platform**

   Two experiments were carried out to evaluate WASPEC. The first goal was to assess how well the system fulfills its basic functionality from the perspective of course instructors. The second step was to test the hypothesis with students in real-world learning scenarios. The findings indicate that this approach provides novel and valuable insights into personalised adaptive learning in e-learning systems.

6. **Contribution to the body of knowledge on personalised learning**

Several reports, reviews, and papers based on this research have been presented, published, and peer-reviewed by experts in the fields of personalised e-learning and adaptivity.

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