A hybrid recommender system integrated into LAMS for learning designers

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Abstract. In the constantly evolving field of e-learning, the Learning Design (LD) sector constitutes a critical success factor, as it has the potential to preserve and disseminate effective pedagogical approaches and enhance the quality of the educational process. Recognizing the LD process as demanding in terms of time and expertise this paper answers the research question of how to leverage Recommender Systems (RSs) and reuse pre-existing LD solutions in order to support teachers in the LD process. In particular, this paper presents the implementation and the first evaluation results of Mentor. Mentor is an RS that supports teachers in finding pre-existing LDs, which cater better for their needs and preferences, so as to re-design them. Mentor is integrated into LAMS, which is a well-known tool for designing, managing and delivering sequences of learning activities. The first user-centric evaluation experiment results are presented and confirm the underlying assumption that Mentor can facilitate teachers in the LD process. Further results concerning the user's general perception and the perceived usefulness of Mentor are discussed.

Keywords: Learning design, recommender systems, social tagging, technology enhanced learning

1. INTRODUCTION

Design for learning has been proved to be a great challenge in the increasingly changing field of learning in the 21st century, which has the potential to support the development of effective and pedagogically sound learning environments. The Learning Design (LD) process refers to the whole necessary actions -like designing, planning, orchestrating- by which teachers manage to create sequences of learning activities that constitute a learning session. The educational and research community brought together by the field of LD proved to be very active. The Handbook of Research on Learning Design and Learning Objects (Lori Lockyer, Bennett, Agostinho, & Harper, 2009), compiles related research papers and provides an overview of the key concepts, the knowledge, the tools, and the applications that resulted from the study of the scope. The Larnaca Declaration on Learning Design (Dalziel et al., 2016) is another excellent source of information about the theoretical background, research and practice in the field.

Today, thousands of teachers have incorporated the LD process into their daily practice using corresponding tools. The major aim of our work was to facilitate the LD process for teachers recognizing the amount of time invested and the expertise that are required for the LD process. To achieve this aim our work relied on the principle of re-design through reuse, taking into account what Mor, Craft, & Hernández-Leo (2013) say "reuse can also be an act of design, if conceived in the right frame of mind". Following this principle, we propose and study a Recommender System (RS), named Mentor, that utilizes existing LDs to produce recommendations for teachers. Therefore, teachers do not begin to create an LD from scratch but by leveraging recommendations they re-design their colleagues' LDs through critical consideration of them.

Thus, this paper presents our current work on the research question: how to leverage RSs and reuse pre-existing LD solutions in order to support teachers in the LD process? The significance of our work for the educational community is reinforced by the belief that the adoption of LD tools and practices by teachers greatly depends on the teacher-friendly LD process (Leo, Harrer, Dodero, Asensio-Pérez, & Burgos, 2007). Additional benefits for the community stem from the reuse of LDs, such as the dissemination of best teaching practices. More precise sub-questions related to the primary research question are the following:

1. Could an RS be leveraged so as to make the LD process easier for teachers?
2. Could an RS be leveraged so as to reduce the amount of time needed for the LD process?

In addition to the aforementioned questions, this study sought to examine whether the proposed RS is able to facilitate the sharing of good teaching practices. Last but not list, this study investigates the issue of the quality in user experience with the proposed RS by measuring the user's general perception.

The remainder of this paper is structured as follows. Section 2 presents the background of the present study with respect to the RSs and the reuse of LDs. Section 3 provides an overview of related work. Section 4 introduces Mentor's design and implementation. Section 5 presents the first evaluation experiment that was conducted in order to handle the aforementioned questions and investigated issues. A detailed discussion follows in section 6 regarding the advantages and limitations of this study. Section 7 contains the conclusions of the paper and provides outlines for future work.

2. Background

2.1. Learning Design and Pedagogical Theories

Various disciplines of science (e.g. psychology, pedagogy and biology) have studied the complex internal biological and spiritual phenomenon of learning, trying to understand what goes on inside a learner's mind. As a result, several pedagogical theories have arisen that propose different explanations for how learning occurs based on which they suggest diversified approaches on effective teaching and learning practices. Some of the most well known pedagogical theories include cognitivism, social constructivism and connectivism (Pritchard, 2013), (Siemens, 2014), (Anderson, 2016).

There are two key aspects in the relationship between LD and pedagogical theories. On one hand LD does not commit to a particular pedagogical theory but it can describe many different pedagogical methods. As Dalziel et al. (2016) stated, "*LD can be viewed as a layer of abstraction above traditional pedagogical theories in that it is trying to develop a general descriptive framework that could describe many different types of teaching and learning activities (which themselves may have been based on different underlying pedagogical theories)*". On the other hand, LD can be seen as a means to facilitate the dissemination and adaptation of effective teaching practices as it has the potential to encapsulate the pedagogical principles that guided the designer. Emerging online communities for sharing clearly point in this direction e.g. the LAMS Community, www.lamscommunity.org, for sharing LDs (Dalziel, 2013) as well as the Cloudworks, www.cloudworks.ac.uk, for discussion of teaching ideas among peers (Conole & Culver, 2010), (Galley, Conole, Dalziel, & Ghiglione, 2010).

In the light of the above, it seems reasonable that LD tools should provide teachers with tools, which facilitate them to implement various pedagogical theories. Considering the case where a teacher wants to implement a social constructionist approach, which acknowledges the social nature of knowledge. If there were no means of two-way communication, for example, it would prevent the dialogue and conversation and discourage the development of the constructionist approach. LAMS is an LD tool that supports the social construction of knowledge as it provides tools like (a) the Forum activity that provides an asynchronous discussion environment for learners, (b) the Chat activity that runs a synchronous discussion for learners (c) the Wiki tool that allows learners to make collaborative editing etc. Furthermore, it is evident that LAMS can support a variety of pedagogical approaches such as inquiry-based learning (Levy, Aiyegbayo, & Little, 2009), problem-based learning (Richards & Cameron, 2008), game-based learning (Dalziel, 2008) and collaborative learning (Papadimitriou, Papadakis, & Lionarakis, 2017).

In the context of our work, one of the pursued goals is to investigate for evidence that the recommendation technology can be leveraged in order to make real the potential of LDs to facilitate the sharing of good teaching practices. Moreover, we incorporate the proposed recommendation technology into LAMS, given that: (a) the LAMS community is one of the largest online communities for sharing LDs and (b) LAMS can support the implementation of various pedagogical approaches.

2.2. Reuse of Learning Designs

It is a common belief that reuse of Learning Objects (LOs) can be the driving force behind the scale and economic growth in the field of e-learning (Campbell, 2003; Littlejohn, 2003; Weller, 2004). New national and international initiatives, that explore ways of developing, sharing and reusing LOs among the educational community around the world, arise in response to the growing demand for access to education within the framework of a consensus effort for the economics of e-learning to remain viable and with improved cost-effectiveness (Littlejohn, 2004), (McCormick & Li, 2006), (Carey & Hanley, 2008), (Klerkx et al., 2010).

A Reusable Learning Object (RLO) is often referred to in literature as a small piece of learning material because in the past it was assumed that the large size of LOs was an obstacle to their being reused. Today, however, most agree that small LOs lack the pedagogical basis for reuse, which poses a risk of favoring a cut & paste approach to teaching based on a content transmission model preventing the development of pedagogically sound learning environments (Wills & McDougall, 2009). So while in the past LDs were considered as too large to be categorized as RLOs today they are recognized as very useful objects for reuse due to their underlying pedagogical structure (S Bennett, Agostinho, & Lockyer, 2005), (Agostinho et al., 2009), (Wills & Pegler, 2016). This belief has been the cornerstone for the implementation of various projects on the reuse of LDs. One of the first projects in the field was the Information and Communication Technologies (ICTs) and Their Role in Flexible Learning in 2000, which was implemented by the Australian Universities Teaching Committee (AUTC). The aim of the project was to produce high quality reusable LDs, which were spread through http://www.leamingdesigns.uow.edu.au in order to assist university teachers in adopting innovative uses of ICTs in educational practice.

The benefits resulting from reusing LDs are (Agostinho et al., 2009; Pegler, 2012), (Wills & McDougall, 2009), (Agostinho, Bennett, Lockyer, Jones, & Harper, 2013):

- Teachers can manage their time more efficiently when they stop reinventing the wheel.
- Reusing can improve the quality of teaching material.
- LDs' development costs are reduced.
- Reusing can be a way of supporting dissemination of best practices.
- Reusing can give teachers more confidence in their abilities and knowledge as a designer.
- Reusing helps foster collaborations beyond teachers, for example through peer review processes.
- Teachers gain access to a wide range of materials.
- It is assumed that the adoption of educational technology in teaching will be faster if teachers reuse educational courseware.

A crucial factor for the attainment of LDs' sharing and reusing is their representation in a semantic, formal, interoperable and machine-readable way (Koper & Miao, 2008). The quest of a specification as a containment framework that can represent LDs in the aforementioned way and express the underlying wide range of pedagogical approaches such as collaborative or active learning has lead progressively to the development of Instructional Management Standards Learning Design Specification (IMS LD) in 2003 (IMS Global Learning Consortium, 2003). Despite the overall convenience of reusing LDs and regardless of the fact that IMS LD is the only available specification that allows the representation of LDs and the expression of the underlying pedagogical approach, until now IMS LD has not been widely adopted either by practitioners or by institutions (Derntl, Neumann, Griffiths, & Oberhuemer, 2012). As Leo et al.

(2007) stated, apt to the point, the degree of IMS LD adoption by teachers' community in real context is associated with the extent to which teachers can design and author their own LDs using authoring tools compatible with the IMS LD. Thus, supporting teachers in the LD process seems to have the potential to encourage the adoption of IMS LD and can therefore lead the educational community to a further exploitation of LDs' reusing advantages.

Reusable LDs can be shared in a variety of contexts/ types of repositories -like Learning Management System (LMS), Learning Object Repository (LOR), Open CourseWare (OCW) and Learning Object Referatory (LORf) -. At this point, a significant question arises: what is the most appropriate context for sharing LDs?

The study of (Ochoa & Duval, 2009) answered that question through quantitative analysis of the following parameters:

- The typical size of a repository: It was found out that the size of repositories couldn't be expressed with an average value per repository type. What it seemed to be important is that the smaller repositories publish metadata in larger repositories in exchange for access to their federated search.
- The growth of repositories over time: The results showed that the different types of repositories are unable to keep their users over time. The problem lies in the fact that the user is not adequately compensated for his/her contributions in the repositories.
- The typical number of contributors in a repository: The survey showed that LMSs have comparative advantage. Integrating social networking into repositories will positively affect the number of users who contribute.
- The growth in the number of contributors over time: Only LMSs' users increase exponentially over time.
- The average number of LOs that a contributor publishes: In LMSs user's productivity is maintained until the course is completed.

Overall, the study concludes that LMSs, as course-based repositories, seem to be the best context for sharing LOs compared to LORs, LORFs and OCWs. In the case of LDs, LAMS is a course-based system 'inspired' by the concept and principles of IMS LD, that could be used as a context for sharing LDs. LAMS (Dalziel, 2003) is already widely used to create and execute LDs, consisting of sequences of learning activities which contain the required teaching materials. With regard to Greece, LAMS has been warmly welcomed by Greek teachers as a user-friendly application that can be leveraged in order to produce a high quality student-oriented learning environment according to the study of Papadakis, Dovros, Paschalis, & Rossiou (2012). Moreover, according to the pilot implementation of LD at the Hellenic Open University (HOU) there are clear indications of the students' positive engagement and beneficial impact on their learning experience (Pierrakeas, Papadakis, & Xenos, 2009).

Recognizing the benefits of reusing LDs and considering the research prompts for further support of teachers on reusing LDs (Wills & McDougall, 2009) and further development of tools and supports to aid teachers in the LD process (Agostinho et al., 2013), (Dalziel et al., 2016) our work has been focused on the implementation of a system capable of supporting teachers at all stages of an LD's life-cycle from its development, share and reuse to its adaptation and republication has been developed. To accomplish this goal an RS named Mentor, which is integrated into LAMS, has been designed and implemented. Our choice to integrate Mentor into LAMS and not into some LOR has been enhanced by the research of Ochoa & Duval (2009) discussed above and also by Agostinho et al. (2013), who mentioned the idea of embedding design support within the online environment of an LMS as an entirely new strategy to support the LD process that can offer guidance in situ and promote high quality learning. Additionally, in the Greek context, there are studies which indicate that LAMS is capable to support pedagogical approaches but entails an increased workload on the teachers' behalf (Papadakis, Paparrizos, & Rossiou, 2006) and that teachers need more support in the LD process within LAMS (Kordaki, 2011). In response to these findings, Mentor is integrated into LAMS and is expected to make the LD process easier and less time-consuming for teachers. Last but not least, it is noteworthy to mention that Mentor could also be applicable to other repositories of LDs, when these are IMS LD compliant, with minor changes.

2.3. Recommender Systems

RSs are intelligent applications that aim to support individual users in their effort to trace content which caters better for their needs and preferences (Resnick & Varian, 1997). RSs have been cited as a quality assurance mechanism in the reusing process (Clements, Pawlowski, & Manouselis, 2015), which played a decisive role in our decision to select an RS to support teachers. The term quality is used in the sense that the teacher finds an LD suited to the intended teaching context.

RSs traditionally use two basic approaches to produce recommendations, known as Content-based (CB) and Collaborative filtering (CF) (Zhou, Xu, Li, Josang, & Cox, 2012). In the first case the production of recommendations is based on correlations between the descriptions of the items and the profiles of the users, so that the respective systems recommend an item to a given user according to the degree of correlations (Pazzani & Billsus, 2007). CF algorithms take into account users' evaluations of the items so that they can deduce similarities among users or items, the recommendation produced can be based on the degree of similarity between different users (user-based algorithms) or on the degree of similarity between different items (item-based algorithms) (Ricci, Rokach, & Shapira, 2011). Users' evaluations can be gathered indirectly by recording users' behavior, for example which items they visited or downloaded or directly by asking users to rate the items (Bobadilla, Ortega, Hernando, & Gutiérrez, 2013).

Individual implementation of CB and CF techniques to produce recommendations was associated with problems like the cold start problem (Bobadilla, Ortega, Hernando, & Bernal, 2012), (Sobhanam & Mariappan, 2013) or the over-specialization problem (Ricci et al., 2011), which can be seemingly surpassed through hybrid implementation modes of the two approaches (Gunawardana & Meek, 2009). This led to the Hybrid approach (Burke, 2007), which is currently followed by sophisticated RSs. Other well-known recommendation techniques that may also be incorporated into hybrid RSs are the following:

- case-based: provides recommendations based on similarity of the items in the case-base (database) with the user defined query, so as to provide recommendations for a target user by retrieving items whose descriptions best match the user’s query. Items are represented in a structured way using a well-defined set of features and feature values.
- demographic: provides recommendations based on a demographic profile of the user.

In this paper, a hybrid recommender approach is proposed.

At the same time, a new trend, aiming to improve the algorithms used in producing recommendations is the utilization of Social Tagging Systems (STS). In STSs, which are becoming more and more popular these years, users create or upload content, they annotate it with words of their own choice (tags), and share it with other users. Therefore, a new suggestion for RSs is the enrichment of item descriptions by utilizing the tags produced in STSs (Milicevic, Nanopoulos, & Ivanovic, 2010), (de Gemmis, Lops, Semeraro, Basile, & Degemmis, 2008). The proposed RS leverages social tags in order to enrich the LDs’ description.

3. RELATED WORK

According to framework introduced by Leo et al. (2007) pre-existing LD solutions can be classified into four categories based on their granularity and completeness: (i) Exemplars: are defined as ready to run (complete) Units of Learning that contain all the requisite data for being executed by an LD player. (ii) Templates: are incomplete exemplars that include all the elements of an exemplar, but these elements need to be refined (completed) in order to be executed. (iii) Chunks: are portions of exemplars that are not executed by an LD player unless they are assembled in a lego-logic. (iv) Components: are incomplete chunks at different levels of granularity and diverse degrees of completeness. Then, teachers can implement different types of design processes (i.e. refinement, assembly, modification) to adapt the above elements to their own preferences and needs and thus obtain their own LD.

In terms of the aforementioned framework we focus on providing teachers with Templates as a head start in order to release them of authoring LDs from scratch. Each Template could trigger a process so that through creative interventions of the teacher, to whom it is addressed, it can lead to a new LD, which satisfies his/her own unique needs and preferences.

Studying the projects in the field of LD it was found out that technologies in various forms have been developed to support the LD process -including online repositories and communities (Conole & Culver, 2010), toolkits (Conole & Fill, 2005), patterns collection (Mor & Winters, 2007) and microworlds (Laurillard et al., 2013)- relying on the fundamental conception that the better a design is the greater the opportunities for effective learning will be (Sue Bennett, Agostinho, & Lockyer, 2015).

The "Integrated Learning Design Environment" (ILDE), which has been developed in the context of the Metis European project, is a masterclass in LD community platforms (Hernández-Leo, Asensio-Pérez, Derntl, Prieto, & Chacón, 2014) (Chacón-Pérez, Hernández-Leo, Mor, & Asensio-Pérez, 2016). ILDE integrates multiple free and open source LD tools that enable teachers to co-create LDs, covering the complete LD's lifecycle - from conceptualization to authoring and to implementation-. ILDE enables teachers to share their LDs with other community members by defining different access rights. No recommendation tool has been integrated into ILDE in order to support sharing. Community members can only explore the list of shared designs by tags that may describe the LD's discipline or pedagogical approach.

The Learning Designer environment is an interactive microworld for the domain of LD, in order to support teachers in higher education in creating, adapting and sharing LDs with respect to pedagogical principles (Charlton, Magoulas, & Laurillard, 2012), (Laurillard et al., 2013). Learning Designer represents LDs as a sequence of learning activities, each of which has properties such as aims, outcomes, duration, resources etc. An innovative feature of Learning Designer is the provision of useful feedback on LDs to teachers, with meaningful text-based and pictorial representations. Another interesting feature is the recommender tool, which is integrated into Learning Designer. As the teacher creates his/her own LD the recommender tool can construct knowledge relevant to the context of this specific LD so as to be able to recommend personalized learning activities or LDs considering the properties that are best matched e.g. aims and outcomes.

Studying further the projects in the field of RS it was realized that RSs have already had a variety of applications in the broader field of TEL. Nevertheless, the majority of the work focuses on the design and implementation of RSs to support learners (e.g. (Salehi, Nakhai Kamalabadi, & Ghaznavi Ghoushchi, 2014), (Benhamdi, Babouri, & Chiky, 2017)). Only 6 projects focus on RSs that support teachers according to Drachsler, Verbert, Santos, & Manouselis (2015). For instance:

- Limongelli, Lombardi, Marani, & Sciarrone (2013) help teachers retrieve more suitable LOs from a repository based on groups of teachers with similar teaching styles. To this aim, Limongelli et al. (2013) used a revised version of the k-means clustering algorithm to create teacher's groups.
- Sergis & Sampson (2016) support teachers in selecting LOs from existing LORs based on the assumption that the appropriateness of each recommended LO is different for each teacher depending on his/her ICT competence profile. To achieve this, Sergis & Sampson (2016) used a filtering approach similar to the existing user-based collaborative filtering approaches. The major difference is that the Jaccard co-efficient, which measures the similarity between two ICT Competences, was used for creating the competence-based teacher neighborhoods. Neighbors with more similar ICT-CPs to the active user and higher Jaccard co-efficient, had a greater impact on the recommendation process.
- Fazeli, Drachsler, Brouns, & Sloep (2014) propose a trust-based RS to support teachers to find content that perfectly meets their needs and interests based on trust networks of teachers. To achieve this, Fazeli, Drachsler, Brouns, & Sloep (2014) used a user-based collaborative filtering approach, enhanced by data that comes from the social activities of teachers (e.g. bookmarking, tagging, ratings) within the Open Discovery Space (ODS) platform.

Afterall, despite the variety of technologies supporting the LD process, Agostinho et al. (2013) mention the lack of practical, relevant and flexible support tools to help teachers as they design. Recognizing the need for more research in how to help teachers in the LD process, we propose a hybrid RS that incorporates the case-based recommender technology. The case-based reasoning is an approach to problem-solving that solves a new problem by finding old cases that solve similar problems and reusing them in the new problem context. The main idea behind our proposal is to support teachers in the LD process by providing them with effective LD solutions, previously created in similar settings. The case-based recommender technology has already got numerous applications in multifarious fields. In particular:

- Considering the case-based reasoning applications to the financial domain, Musto, Semeraro, Lops, de Gemmis, & Lekkas (2015) propose a framework for financial product recommendations relying on case-based reasoning. Experiments performed have indicated that the proposed approach can significantly outperform the recommendations provided by a human advisor as well as those provided by a baseline algorithm. Moreover, Gatzioura & Sànchez-Marrè (2015) propose a case-based RS for the market basket domain. More specifically, the proposed RS considers products' co-occuring patterns and recommends products based on those that have already been selected by the user. The performance of the developed RS was compared to three of the recommendation techniques being widely used, namely association rules based, probabilistic topic model, and Collaborative Filtering user-based recommendations. The results have shown that the proposed approach performed better than the other recommendation techniques.
- Considering the case-based reasoning applications to the medical domain, Husain & Pheng (2010) use a hybrid case-based RS to propose a wellness therapy based on a user's wellness concerns. Experiments carried out with wellness consultants and therapists have indicated that the majority of participants were agreed on the recommendations made by the system.
- Considering the case-based reasoning applications to the education domain, Gomez-Albarran & Jimenez-Diaz (2009) propose a hybrid case-based RS for recommending LOs to learners from existing educational repositories. In addition, Bousbahi & Chorfi (2015) propose a case-based RS for learners in order to support them in finding the most appropriate Massive Open Online Courses (MOOCs).

From the above, it is evident that the idea of supporting users by recommending successful old experiences in analogous situations has been successfully applied to diverse domains. This fact inspired us to explore the potential of applying the case-based reasoning in the LD field so as to support teachers in the LD process.

4. Design and Implementation of Mentor

4.1. Introduction

This section presents the proposed solution to the identified research question, i.e. the Mentor RS, which is a hybrid RS, integrated into LAMS, that aims to provide teachers with guidance in the LD process based on the idea of reusing LDs. Mentor exploits pre-existing LDs and recommends the best suited of them, for a particular application context, in the form of templates as a head start in order to release teachers of authoring LDs from scratch. Each template after teacher intervention it can lead to a new LD, which satisfies his/her own unique needs and preferences.

The following sections present Mentor by answering the following key questions:

- What is the database of items that Mentor uses to generate the process of recommendation?
- What are the criteria to evaluate the appropriateness of an LD for a particular application context?
- What is Mentor's recommendation model?
- What is the user interface of Mentor like?

It is worth mentioning that our previous work has presented an initial abstract design model of Mentor (Karga & Satratzemi, 2014). However, in the context of this paper we present the final implemented model in detail.

4.2. Database of items

Mentor can be integrated into any LAMS installation and utilizes the LDs that are stored into this installation. Given that a LAMS installation is used by a community of teachers, who create and use LDs for their courses, these LDs are not in the form of generic 'guide' but are contextualized examples, which describe the design as implemented in its original context. This is compliant with the findings reported in the study of Agostinho et al. (2013) which suggest that the contextual detail included in an LD adds to its reusability. Furthermore, it is interesting to mention that according to Agostinho et al. (2013), teachers are able to understand and adapt contextualized designs originating even from disciplines other than their own.

For the purposes of our research work Mentor has been incorporated into a LAMS installation that has been populated with LDs derived from the LAMS repository of LDs in Greek available under the 'attribution, non-commercial use only, share alike' license https://creativecommons.org/licenses/by-nc-sa/2.0/ at http://lamscommunity.org/lamscentral/?language=el

4.3. Context

Mentor evaluates the appropriateness of an LD for a particular application context by considering the following critical criteria. These criteria come from the MISA project (Paquette, Teja, & K. Lundgren-Cayrol, 2006) along with the Dialog Plus project (Conole & Fill, 2005).

- Pedagogical strategy: An STS (Balby Marinho et al., 2012b) integrated into LAMS has been implemented in order to ask from the teaching community to identify the pedagogical strategy of LDs stored in the database of items. The tagging process has been combined with suggestions originating from a controlled vocabulary in order to leverage the advantages of this approach (Golub et al., 2009). More particularly, part of the taxonomy of Conole & Fill (2005) for teaching and learning approaches has been used to provide a means of standardizing terms in the field of pedagogical strategies and a means of controlling the polysemy of words, synonyms and spelling (Noruzi, 2007). A baseline algorithm has been implemented in order to recommend the most frequently used tags for a certain LD (Balby Marinho et al., 2012a). Regarding the tagging permission, all LAMS's users assigned the role of teacher were allowed to tag the LDs stored in the database of items. Finally, the two most popular tags in the LD's tag cloud are used to characterize the LD as far as its pedagogical strategy is concerned. At this point, it is worth mentioning the study of Fazeli et al. (2014) who focused on recommending learning resources to the teachers in the context of a social network style platform, named Open Discovery Space (ODS) platform. Teachers were asked to use tagging and these tags were utilized effectively by the recommendation model. In the system evaluation 80% of the teachers who participated, found the tagging process important and useful. Teachers' positive perception of the tagging process allows one to be optimistic about teachers' participation in the tagging process.
- Subject domain: In order to ascertain whether the subject domain of an LD is relevant to the subject domain of a particular application context, a keyword analysis method that uses co-keywords appearance frequency in LDs has been implemented. More specifically, Mentor allows teachers to enter a sequence of keywords for the desired subject domain and then identifies the most relevant LDs according to the given keywords. The general rule for an LD to be deemed relevant is that the given keywords should appear throughout the title of the LD or/and in the titles of the included learning activities. The higher the number of keyword occurrences is, the most relevant the LD is deemed.
- Level: An STS integrated into LAMS has been implemented in order to identify the level of LDs stored in the database of items. The approach for the level property is analogous to the approach implemented for the pedagogical strategy, apart from the controlled vocabulary. In case of Level the vocabulary is: "Introductory, Intermediate, Advanced, Not assessed".
- Evaluation model: The sequence of LD activities determines automatically the evaluation model according to the following rules:

   - Diagnostic: when the presence of an assessment activity is identified at the beginning of an LD activities' sequence.
   - Formative: when the presence of an assessment activity is identified everywhere in the LD activities' sequence except from the beginning and the end.
   - Summative: when the presence of an assessment activity is identified at the end of an LD activities' sequence.

  At this point it is important to clarify that the following assessment activities are considered, according to ("Activities - LAMS Documents (English) - LAMS Foundation," n.d.): Submit File, Assessment Tool and Multiple Choice.
- Delivery model: There are two possible values for the Delivery model: synchronous or asynchronous. Delivery model is deduced automatically for each LD stored in database of items, based on whether synchronous conference services (chat or videoconference) are included or not in the sequence of LD activities.
- Time: An STS approach has been implemented to deduce the Time property of LDs. The author of an LD and also other LAMS's users assigned the role of teacher were given the permission to tag it.

4.4. Recommendation Model

The operation of Mentor (depicted in Fig. 1) consists of the following steps:

1. First, teacher completes a preference form, which includes the following fields: Pedagogical strategy, Subject domain, Level, Evaluation model, Delivery model and Time.
2. Mentor identifies LDs that implement the specified pedagogical strategy.
3. Mentor forms groups of similar LDs by identifying similarities in the sequence of LD activities. In particular, the Damerau-Levenshtein algorithm in conjunction with the Affinity Propagation algorithm was used for creating groups. The most multitudinous groups formed this way reveal, as to the sequence of activities, the trends that teachers choose in order to implement the specified pedagogical strategy.
4. For each of the two most multitudinous groups, Mentor identifies the LDs that satisfy most of the user's preferences and those that have the highest ratings by the teachers' community.
5. LDs are recommended to the teacher as Templates, in the sense that he/she can intervene so as to create his/her own LD.

The teacher is able to rate the templates using a simple 5 star system. Teacher ratings influence future recommendations. More specifically, LDs that have been rated with less than three stars by the teacher, as well as the similar ones, are excluded from the recommended list. For each recommended LD, Mentor provides explanations to teachers for its recommendations. Reasoning the recommendations can be beneficial for user experience with the RS (Tintarev & Masthoff, 2011).

4.4.1. The Damerau-Levenshtein Algorithm

Mentor uses the Damerau-Levenshtein Algorithm (Bard, 2007) to measure the similarity between LDs. More specifically, for each LD Mentor initially generates the imsmanifest.xml file, which represents the LD according to the IMS LD specification. In this file Mentor manages to identify the piece of code that represents the sequence of educational activities contained in the corresponding LD (Fig. 2). Then, Mentor utilizes this piece of code to create a string, which it then uses to represent the LD (Fig. 3). In this string every substring between commas, like "A-lanb11", is an indicator that identifies an educational activity and is considered as a character. For example, the "A-lanb11" indicator is used to represent the Noticeboard Activity. The possible indicators that may be contained in a string are listed in ("Activities - LAMS Documents (English) - LAMS Foundation," n.d.). The edit distance between two strings s1 and s2 is numerically expressed as the minimum number of edit operations required to convert s1 to s2. The allowed edit operations are: character insertion, character deletion, substitution of a single character, and transposition of two adjacent characters. Each operation can be weighed, so that it is considered to have more or less cost in calculating the final distance. In the case of Mentor, a cost equal to 1 has been set for each edit operation, which means that they all equally affect the

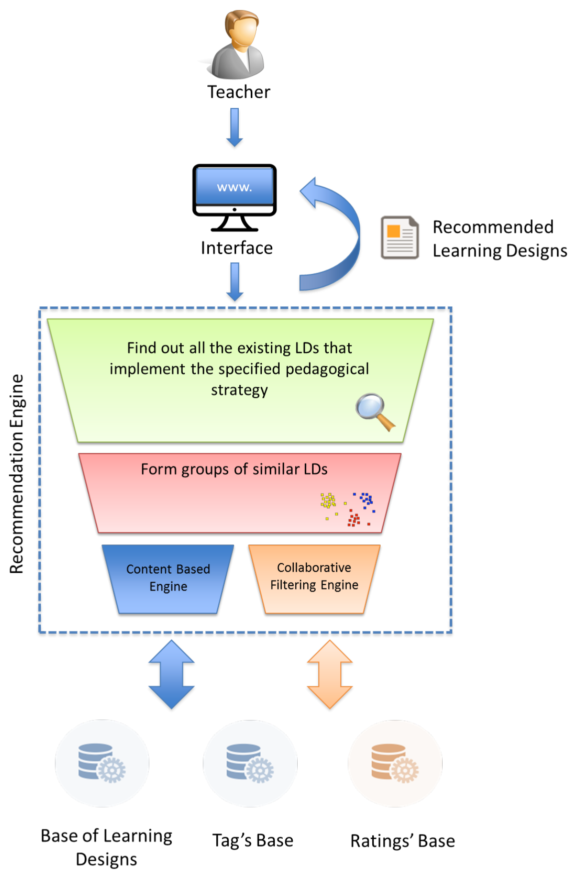


Fig. 1 Mentor's overview

final distance. By applying the Damerau-Levenshtein algorithm Mentor manages to calculate the similarity between strings corresponding to different LDs and thus to measure the similarity between LDs. Fig. 4 presents the results of the Damerau-Levenshtein algorithm on the small dataset of Table I. Because Damerau-Levenshtein calculates the distance between the strings the minus sign is used to express the similarity between strings. Thus, the greater the resulting number in Fig. 4, the more similar the strings are.

4.4.2. The Affinity Propagation Algorithm

The Affinity Propagation Algorithm was used to detect clusters of LDs (Frey & Dueck, 2007), (Frey Lab, n.d.), (Apprentissage & Optimisation Team, n.d.). The Affinity Propagation algorithm was chosen among many other clustering algorithms, the most popular of which is the k-means algorithm. K-means was rejected because it requires a predefined number of clusters, but in the case of Mentor's database of items the number of clusters cannot be decided a priori. Furthermore, k-means, like most clustering algorithms, is based on a randomly selected initial set of estimated cluster centers and then makes improvements on them, but this procedure works well only if the initial set of centers is good enough. Affinity Propagation is a relatively new algorithm, which initially considers all LDs from the database of items as possible centers of clusters (exemplars). Then, real-valued messages are exchanged among data points. The algorithm terminates when a constant and high-quality set of exemplars and corresponding clusters emerge or after a fixed number of iterations.

```
<activity-structure identifier="A-sequence" structure-type="sequence">
<title>LAMS Learning design sequence</title>
<learning-activity-ref ref="A-lanb11-98" />
<learning-activity-ref ref="A-laqa11-92" />
<learning-activity-ref ref="A-larsrc11-94" />
<learning-activity-ref ref="A-lachat11-102" />
<learning-activity-ref ref="A-laasse10-100" />
<learning-activity-ref ref="A-lanb11-93" />
</activity-structure>
```

Fig. 2 The piece of code in the imsmanifest.xml file that represents the sequence of educational activities

[A-lanb11,A-laqa11,A-larsrc11,A-lachat11,A-laasse10,lanb11]

Fig. 3 The corresponding string to piece of code in Fig. 2

	A	B
A	0	-5
B	-5	0

Fig. 4 The results of the Damerau-Levenshtein algorithm on the dataset of Table I.

TABLE I

INPUT DATASET FOR DAMERAU- LEVENSHTEIN

ID of Learning Design	Corresponding String
A	[A-lanb11, A-laqa11, A-lamind10, A-larsrc11, A-larsrc11, A-larsrc11, A-lavote11, A-lanb11]
B	[A-lanb11, A-larsrc11, A-lanb11, A-laqa11, A-lamc11, A-lanb11]

Affinity Propagation takes as input a list of numerical similarities {s (i, k)} between pairs of data points. In the case of Mentor, the similarity matrix of LDs (Fig. 4) which is obtained as an output of the Damerau-Levenshtein algorithm is used as input to Affinity Propagation, but with a slight modification which is that the diagonal of the similarity matrix was supplemented with the value of preference variable. The preference of point i, called s(i,i), is the a priori suitability of point i to serve as an exemplar. According to Frey & Dueck (2007) if all data points are equally suitable as exemplars, the preferences should be set to a common value for all data points. The recommended initial value for the preference is the minimum or median similarity (Frey Lab, n.d.). In the case of Mentor the median similarity was chosen taking into consideration that the median similarity will usually lead to a medium to large number of clusters, whereas setting the preference to the lowest similarity will lead to a moderate number of clusters (Frey Lab, n.d.). Indeed, in tests performed, it was found that due to the small size of the dataset processed by Mentor, minimal similarity often led to only one group. The small sample size is a common problem for TEL data.

4.5. User interface

Mentor has been implemented as a separate tab along the top of the screen for the logged in users of LAMS installation (fig. 5a). The Mentor's tab is only available to users assigned the Teacher or/and the Monitor role. On the Mentor's tab there are two options: "Contribute Tags" and "Start authoring with Mentor".

Contribute Tags option displays the interface that has been implemented for the STS that allows users to tag an LD based on the following attributes: Pedagogical strategy, Level and Time. In order to tag an LD, the user initially selects the LD that he/she wishes to tag by specifying its Category, Title and Teacher. Subsequently, the user selects the value for the Pedagogical strategy, the Level and the Time attributes. During the tagging process users are offering the following options:

- Recommended Tags: those already used more frequently by teachers.
- Sequence Preview: a graphic representation of learning activities of the specified LD.
- View as learner: LD execution experienced from the learner's viewpoint.

The last two options enable the user to bring in mind the specified LD before tagging it.

Start authoring with Mentor option at first asks the teacher to complete a preference form, which includes the following: Pedagogical strategy, Subject domain, Level, Evaluation model, Delivery model and Time. In fig. 5b an example of a completed form can be seen. If the teacher doesn't select one of the fields then this field is not taken into account for the recommendation mechanism.

Fig. 5 (a) Mentor's t ab into LAMS's interface (b) "Start authoring with Mentor" interface

By clicking the "Get Recommendations" button, the recommended LDs are displayed. For each recommended LD one can see:

- its title and description, provided by the author of this LD.
- the graphical representation of the sequence of activities it includes. According to Agostinho et al. (2013) the graphical representation is very useful for teachers to become familiar with the design.
- the Live Edit button, which enables the teacher to open the LD into author's environment and thus take a close look at the details. If the teacher decides to select a particular LD for adaptation then he/she has the option to edit it so as to create his/her own LD, which is better suited to his/her needs. This feature is compliant to the prompt for flexible design support tools that allow teachers to personalize a design within a support system (Sue Bennett et al., 2015).
- a few words of explanation about the rationale behind the recommendation. For example: "Mentor recommends this particular LD for the following reasons: 1. This is the predominant LD that represents a group of similar LDs, which implements the pedagogical method of your choice 2. The LD's subject matter is relevant to the input keywords

3. The LD's estimated duration is similar to the desired one.“

- the 5 star system that enables teacher to rate the recommendation.

5. User-Centric Evaluation

5.1. Introduction & Objectives

Traditionally the evaluation experiments on RSs aimed at testing the performance of the underlying recommendation algorithms from a technical point of view by using system-centric metrics such as the prediction accuracy, the prediction speed and the recall of the algorithm (Gunawardana & Shani, 2009), (Shani & Gunawardana, 2011). However, it was gradually realized that focus on these kinds of metrics can be sufficiently narrowed down as to miss the broader point of the evaluation, which is to assess the user's satisfaction since the ultimate goal of each RS is to satisfy its users (Knijnenburg, Willemsen, Gantner, Soncu, & Newell, 2012), (McNee, Riedl, & Konstan, 2006). Recently, many surveys have proved that the system-centric evaluation of RSs does not always correlate with user's satisfaction (Cremonesi, Garzotto, Negro, Papadopoulos, & Turrin, 2011)(Cremonesi, Garzotto, & Turrin, 2012)(McNee et al., 2002) (Ziegler, McNee, Konstan, & Lausen, 2005). The best solution and the most direct way to measure the user's satisfaction as well as other user-centric metrics as the user's perceived usefulness of the RS is by explicitly asking the users through a user study (Herlocker, Konstan, Terveen, & Riedl, 2004), (McNee et al., 2006), (Pu & Chen, 2011). In the context of TEL, the necessity for implementing user-centric evaluation experiments has also been recognized (Erdt, Fernandez, & Rensing, 2015). With regard to the above, we have decided to implement a user-centric evaluation with the specialized objective of assessing the perceived usefulness of Mentor. This research objective was primarily guided by the following questions:

1. Could an RS be leveraged so as to make the LD process easier for teachers?
2. Could an RS be leveraged so as to reduce the amount of time needed for the LD process?

In addition to the aforementioned questions, our evaluation experiment mentions whether the proposed RS is able to facilitate the sharing of good teaching practices as well as handles the issue of the quality in user experience with the proposed RS by measuring the user's general perception.

5.2. Participants

Employees of the Learning activities management service of the Greek School Network (GSN) who have teaching experience were invited to participate in the evaluation of Mentor. The GSN (www.sch.gr) is the national network of the Ministry of Culture, Education and Religious Affairs (MCERA) which safely interconnects all schools of primary and secondary education, including educational units abroad, services and entities supervised by the MCERA at central and regional level, service providers of lifelong learning, students, teaching staff, other educators and other entities of MCERA (www.minedu.gov.gr). Through GSN the MCERA provides the educational community with e-learning services, such as the Learning activities management service. The Learning activities management service is based on LAMS and enables teachers to create LDs, which are executable by students. Moreover, secondary school counselors, who are responsible for the training of secondary school teachers of Central Macedonia on issues related to LDs and LAMS, were invited to participate in the evaluation of Mentor. In addition, employees in the e-learning center of the Aristotle University of Thessaloniki who have teaching experience were invited to participate in the evaluation of Mentor. The team of specialists at the e-learning center provides professional methodological and technical advice on building e-courses, creating e-learning materials and using ICT tools in learning process. The prerequisite for participating in the evaluation was the minimum ten years of experience in teaching and use of e-learning environments. These criteria were used to ensure the credibility of the participants. Finally, twelve people participated in the evaluation of Mentor. A more detailed description of the participants' profile is presented in Table II.

The most multitudinous age group of participants was that of 50-60 (27,3%) years old while the majority of participants (72,8%) were between 40-60 years old. Among the participants 66.7% were female and 33.3% were male. Regarding the academic disciplines, the 58.3% of the participants have studied science while the rest have studied other sciences (e.g. pedagogical sciences, physics).

Participants were recruited in November-December 2016 and in February 2017 via email. After having accepted the participation invitation, they were informed about the steps of the evaluation procedure also via email.

TABLE II
PARTICIPANTS' PROFILE

Statistics			
ID	Role	Main Duties	Discipline & Educational Level
1-4	Secondary school counselor and a researcher in learning technologies	Consults teachers on how to implement appropriate pedagogical theories to enhance the student learning experience; Develops and leads on a range of seminars on learning design tools and e-learning technologies for public secondary school teachers	1. Bachelor's degree in physics; Bachelor's degree in informatics; PhD in learning technologies
			2. Bachelor's degree in mathematics; Master's degree in informatics; Postgraduate studies in Distance Education and Adults Education; PhD in applied informatics.
			3. Bachelor's degree in informatics; Master's degree in education science; PhD in mathematics; Certificate in adult education by the national organization for the certification of qualifications & vocational guidance
			4. Bachelor's and master's degree in informatics;
5.	Manager of learning technologists	Responsible for the administration of e-learning technology projects; Provides support, guidance and extensive training to staff in learning design tools and learning management systems	Bachelor's degree in economics; Bachelor's degree in informatics; Master's degree in informatics; Certificate in adult education by the national organization for the certification of qualifications & vocational guidance
6.	Learning technologist and an administrator	Leads the development of the university's LMS and other centrally-supported learning technologies	Bachelor's degree in informatics; Master's degree in Information and Communication Technology
7.	E-learning consultant and course designer	Consults and collaborates with faculty to create high quality e-learning courses	Bachelor's & Master's degree in informatics; Moodle course creator certificate
8.	Learning technologist and a Lecturer	Develops and leads on a range of e-learning training events for faculty and students throughout the academic year	Bachelor's degree in pedagogical science; Master's degree in Education sciences and learning technologies

9.	Learning technologist and a research assistant	Undertakes research on learning technologies; Advises staff in the development of new approaches to blended learning by leveraging the appropriate e-learning tools and technologies	Bachelor's degree in informatics; Master's degree in Information and Communication Technology; Certificate of Pedagogical and Teaching Competence by the national school of pedagogical and technological education; Certificate in adult education by the national organization for the certification of qualifications & vocational guidance
10.	E-learning consultant and course designer	Consults and collaborates with faculty to create high quality e-learning courses	Bachelor's degree in library science
11.	Learning technologist and an Administrator	Leads the day-to-day administration of the LAMS platform	Bachelor's degree and PhD in informatics
12.	Senior learning technologist	Contributes to the development of the university's e-learning strategy and policy by investigating, evaluating and proposing appropriate e-learning technologies according to the faculty's needs	Bachelor's degree in physics

5.3. Procedure

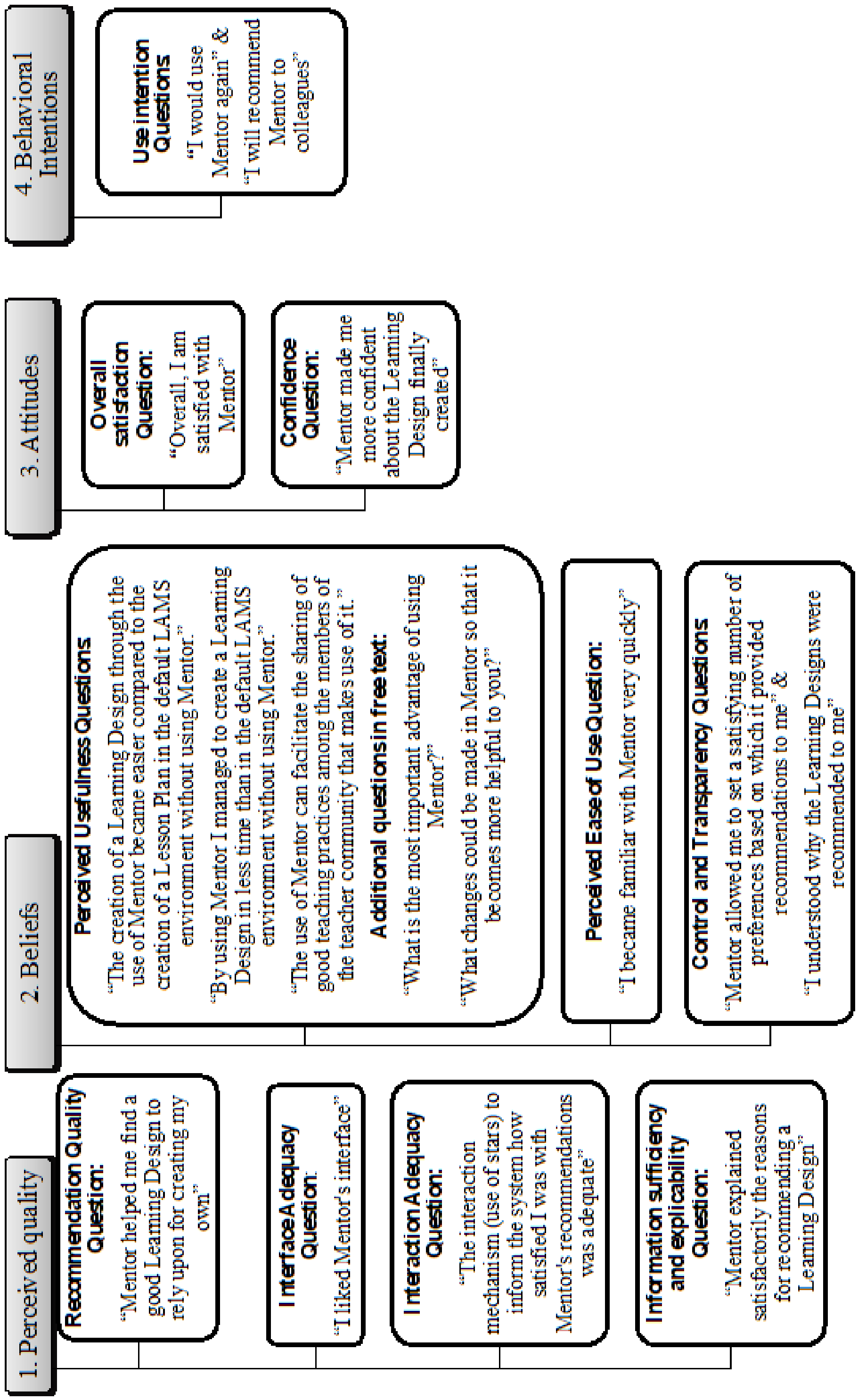
At first, participants were shown how to use Mentor through a video on demand. Then, they were asked to log in to a LAMS live demo installation, into which Mentor was integrated, in order to implement two task scenarios. The first task scenario was to create an LD focused especially on the subject area of Internet Safety by using Mentor and the second one was to create an LD for the same subject area by using the default environment of LAMS. Certainly, Mentor's database of items was sufficient to support the task scenarios, which were selected. For the purposes of the evaluation experiment, the LAMS live demo installation has been populated with LDs derived from the LAMS repository of LDs in Greek available under the 'attribution, non-commercial use only, share alike' license https://creativecommons.org/licenses/by-nc-sa/2.0/ at http://lamscommunity.org/lamscentral/?language=el. After participants completed both task scenarios, they were asked to fill in the online questionnaire that is presented in the following section.

5.4. Questionnaire

The questionnaire was based on the short version of ResQue, which is a user-centric evaluation framework for RSs that has been proposed by Pu & Chen (2011). It is noteworthy to mention that the ResQue model is based on principles from well-known usability evaluation models, such as TAM (Weller, 2004) and SUMI (Wills & McDougall, 2009). The questionnaire was constructed in four parts: 1. user perceived quality, 2. user beliefs, 3. user attitudes and 4. behavioral intentions. All the questions were mandatory and apart from two free text questions the rest were based on the following five-point Likert scale: 1 (strongly disagree), 2 (mostly not agree), 3 (rather agree), 4 (mostly agree), 5 (strongly agree).

The first part of the questionnaire was designed to assess the users' perception of the objective characteristics of the RS. The dimensions of the perceived quality part were developed rooted in the original Perceived System Qualities layer of Pu & Chen (2011) and included 4 items shown in Fig. 6. The recommendation quality dimension focuses on the degree to which users feel the recommendations match their interests and preferences. The interface adequacy dimension refers to the users' satisfaction of the interface. The interaction adequacy dimension focuses on whether the system allows user feedback in a sufficient way. The information sufficiency and explicability dimension are related to the system's ability to provide explanations for suggested items.

Fig. 6 Representative questions addressed to the participants



The second part of the questionnaire was designed to assess the users' beliefs about how well the system can serve their needs. The dimensions of the beliefs part were developed rooted in the original Beliefs layer of Pu & Chen (2011) and included 3 items shown in Fig. 6. The perceived usefulness dimension focuses on users' beliefs about how the system is useful to them. In this dimension, three specialized questions were added to make the questionnaire tailored to the case of Mentor. Moreover, two questions were added in order to give participants the opportunity to express, in free text, their opinions about the most important advantage of using Mentor and the changes that could be made in Mentor so that it becomes more helpful. The perceived ease of use dimension measures how easy it is for users to learn the system and complete tasks. The control and transparency dimension refers to the system's ability to allow users to revise their preferences and understand the reasons why an item is recommended to them.

The third part of the questionnaire was designed to assess users' overall feeling towards the system. The dimensions of the attitudes part were developed rooted in the original Attitudes layer of Pu & Chen (2011) and included 2 items shown in Fig. 6. The overall satisfaction dimension refers to the overall subjective perception of users on the quality and adequacy of the system. The confidence dimension measures the degree to which users feel assured about the recommended items.

The fourth part of the questionnaire was designed to assess users' subjective probability to be engaged in the use of the system. The dimensions of the behavioral intentions part were developed rooted in the original Behavioral Intentions layer of Pu & Chen (2011) and included 1 item shown in Fig. 6.

Furthermore, a background questionnaire was created to gather data regarding: (a) demographics (age and gender) and (b) professional profile (discipline, educational level and experience).

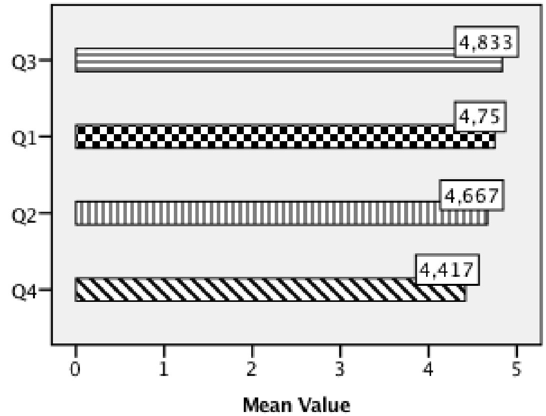
5.5. Results

The results indicate that the perceived usefulness of Mentor is high, which means that respondents believe that using Mentor would enhance their performance in the LD process. This is an optimistic indicator for Mentor's acceptance among the members of educational community and future usage. Fig. 7 shows the responses for each of the four questions that were used to measure the perceived usefulness. The questions Q1 and Q2 correspond respectively to the research sub-questions 1 and 2, posed at the introduction of this paper. The answers to these questions revealed that respondents believe that Mentor can make the LD process easier (mean value for Q1=4.75, SD=0.622) and less time-consuming (mean value for Q2=4.67, SD=0.651). This means that the answer to both research sub-questions is positive. Additionally, respondents believe that Mentor can facilitate the sharing of good teaching practices (mean value for Q3=4.83, SD=0.389) and also helps them find a good LD to rely upon for creating their own (mean value for Q4=4.42, SD=0.669).

According to ResQue framework perceived usefulness is statistically most significantly influenced by perceived recommendation accuracy ($\beta=0.57$, $p<0.001$) and by information sufficiency ($\beta=0.20$, $p<0.01$), which means, as one would expect, that participants were satisfied with Mentor's recommendations accuracy and information sufficiency. Indeed, according to respondents Mentor's recommendations correspond to their needs satisfactorily (mean value=4.25, SD=0.622) and also there was sufficient information accompanying an LD to help them choose it (mean value=4.33, SD=0.651).

Respondents expressed strong intention to use Mentor in the future and also to recommend it to colleagues/friends. In particular, the 67% of respondents strongly agree that they would use Mentor again and also they would recommend it to colleagues/friends. This is a positive indicator for the adoption of Mentor. According to the ResQue framework use intention is statistically the most significantly influenced by perceived ease of use ($\beta=0.36$, $p<0.01$) and overall satisfaction ($\beta=0.22$, $p<0.05$). Indeed, Fig. 8 illustrates that the 67% of respondents who strongly agree that they would use Mentor again also strongly agree that they became familiar with Mentor quickly. Moreover, the 42% of respondents who strongly agree that they would use Mentor again also strongly agree that they are overall satisfied with Mentor.

Fig. 7 Perceived usefulness results. (**Q1:** The creation of a Learning Design through the use of



Mentor became easier compared to the creation of a Lesson Plan in the default LAMS environment without using Mentor. **Q2:** By using Mentor I managed to create a Learning Design in less time than in the default LAMS environment without using Mentor. **Q3:** The use of Mentor can facilitate the sharing of good teaching practices among the members of the teacher community that makes use of it. **Q4:** Mentor helped me find a good Learning Design to rely upon for creating my own.)

The responses to other interesting constructs, included in the questionnaire, are summarized

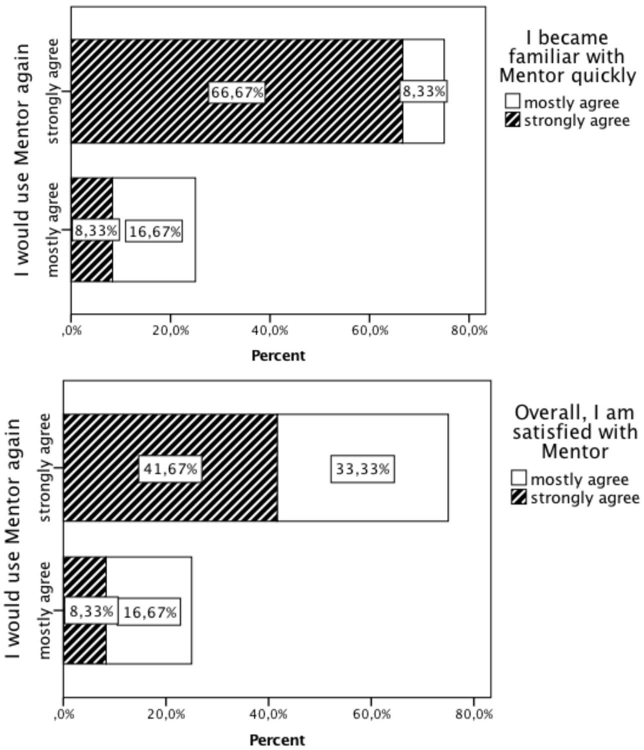


Fig. 8 Use intention analysis

in Table III. The results showed that most respondents liked the interface of Mentor. As far as the reasons for recommending an LD are concerned, they were explained satisfactorily to respondents. Moreover, it seems like they were involved into the internal logic of Mentor as they claimed that they understood why the LDs were recommended to them.

From the results above, it is reasonable to conclude that the user's perceived quality of the proposed RS is high.

TABLE III

KEY CONSTRUCTS RESULTS

Statistics			
Key Construct	N Valid / Missing	Mean	Std. Deviation
I liked Mentor's interface (Interface Adequacy)	12 / 0	4.33	.778
Mentor explained satisfactorily the reasons for recommending a Learning Design (Explanation)	12 / 0	4.58	.515
The interaction mechanism (use of stars) to inform the system how satisfied I was with Mentor's recommendations was adequate (Interaction Adequacy)	12 / 0	4.50	.798
Mentor allowed me to set a satisfying number of preferences based on which it provided recommendations to me (Control)	12 / 0	4.42	.669
I understood why the Learning Designs were recommended to me (Transparency)	12 / 0	4.42	.669
Mentor made me more confident about the Learning Design finally created (Confidence)	12 / 0	4.25	.965

Regarding the responses to the free text questions about the most important advantage of Mentor and the changes that could be made in Mentor so that it becomes more helpful to teachers, they were multiple and varied. Representative answers include the following:

"Leveraging pre-existing solutions is particularly useful for beginners with little or no experience in creating learning designs. I remember that as a novice teacher I felt uncomfortable asking for help from more experienced colleagues."

"Creating learning designs requires so much time that teachers often find it hard to complete the designs they have started. I believe that the use of Mentor is a good solution for engagement with learning design."

"It's my pleasure to share my designs with colleagues. However, I would appreciate a reference mechanism integrated into Mentor."

"In recent years, I have realized that experienced teachers have gradually become reluctant to adopt new tools despite the benefits that may arise from their use. The fact that the system you are proposing is built into the familiar LAMS platform in conjunction with the ease of use is a great asset to me."

Furthermore, challenging suggestions were made by the respondents, which aimed to improve Mentor and they will be taken into account. In particular the following suggestions were mentioned:

- Regarding the information accompanying the recommendations, respondents suggested that the information could be enriched with evaluation comments by the students who have attended the corresponding course. These comments could help teachers with making a decision on which is the best-suited LD to their needs. In this sense, respondents also suggested to enhance information sufficiency with the profile of the teacher who has created the suggested LD.
- Another notable suggestion was the use of a thesaurus structure in order to improve recommendations' thematic relevance.
- Moreover, respondents would find receiving alternative recommendations about the content of the learning activities in a learning sequence useful.

6. DISCUSSION

The research and development of Mentor, as presented in this paper, has aimed to introduce a possible answer to the main research question, posed at the introduction of this paper. Moreover, the potential benefits to the LD community by leveraging RSs into the LD research field came to light. More specifically, RS technology seems to have the potential:

- to support teachers in the LD process by making it easier and less time-demanding
- to lead the educational community to a further exploitation of LDs' reusing advantages such as the dissemination of best teaching practices
- to enhance the adoption of LD tools and practices by teachers

Mentor, provides a great number of advantages when compared to other similar RSs. The contribution in the proposed RS is related to: (a) the use of a hybrid recommendation method based on case-based and item-based collaborative recommendation approaches with several recommendation criteria (b) the fact that Mentor is integrated into a pre-existing environment so as to relieve the teacher of the time-consuming learning effort (c) the fact that the recommended LDs are executable by the students (d) the provision of explanations for each recommended LD. A detailed discussion follows regarding the advantages of Mentor compared to related works.

Laurillard et al. (2013) compiled a list of design requirements for an LD support environment taken into account the user requirements that resulted from extensive interviews with ten experts. Mentor's core design conforms to the following principles, which are in common with the aforementioned list: (a) Recommend pre-existing LDs that are clearly relevant to current needs. (b) Allow users to edit the content and structure of recommended LDs in order to maintain flexibility. Despite the fact that Mentor has common design principles with Learning Designer, there are basic differences in the implementation approach. First, Laurilland et al chose to implement the aforementioned principles into a new software environment. This overwhelms the teacher as he/she needs to learn the new software before he/she manages to create his/her own LDs. Instead, Mentor has been integrated into a popular pre-existing environment so as to relieve the teacher of the time-consuming learning effort. In addition, in the case of Learning Designer the recommendations are based on LDs which should also have been created with Learning Designer, which significantly limits the set of data on which the recommendations are based. In the case of Mentor the dataset of LDs from which recommendations are produced may include any LD expressed in IMS LD specification, provided that the LD can be inserted into LAMS. Finally, in the case of Learning Designer the LDs created and shared are not executable by the students so if the teacher wants to implement an LD in a runtime environment he/she will bear the cost in terms of time and effort to create the LD into an environment which allows students to execute it, such as LAMS. In the case of Mentor, this problem has been eliminated given that Mentor is integrated into LAMS.

Moreover, the related works (Limongelli et al., 2013), (Sergis & Sampson, 2016), (Fazeli et al., 2014) focus more on user-based collaborative filtering methods that construct and leverage user profiles for providing personalized recommendations. On the other hand, Mentor focuses more on a case-based recommendation technique and uses a hybrid recommendation approach, based on:

- Case-based recommendation approach (Smyth, 2007): Mentor represents LDs as cases described by a set of well-defined features (e.g. pedagogical strategy, level, evaluation model, delivery model) and feature values (e.g. there are two possible values for the delivery model feature: synchronous and asynchronous) and recommends the most similar cases to the teacher's query. A well-known limitation of case-based recommenders is that they often produce recommendation sets that lack diversity, as the top ranking cases tend to be very similar. Several techniques have been proposed in order to diversify the recommendation lists (Ziegler et al., 2005), (Boim, Milo, & Novgorodov, 2011), (Ho, Chiang, & Hsu, 2014). An overview of research done related to the diversity problem is presented in (Kunaver & Požrl, 2017). Aytekin & Karakaya (2014) propose a novel method (named ClusDiv) to increase the diversity of recommendation lists based on clustering items into groups and provide recommendations by selecting items from different groups. The rationale underlying this approach is that if we choose items from distant clusters, then we can get more diversified recommendation lists. In the same logic, Mentor forms groups of similar LDs and then produce recommendations based on different groups. However, there are significant differences in the implementation of the basic idea. In the case of ClusDiv the item clusters are built using the standard k-means clustering algorithm and items are clustered based on their ratings given by the users of the system. In the case of Mentor clusters are built using the Damerau-Levenshtein algorithm in conjunction with the Affinity propagation algorithm and items are clustered based on similarities in the sequence of LD activities. The reasons why the k-means algorithm was not applicable to Mentor were explained in section 4.4.
- Item-based collaborative recommendation approach: Mentor takes into account the teacher's ratings of the LDs and the history information on the highest rated LDs in order to refine the recommended list.

Another advantage of Mentor when compared with the aforementioned related works, is that it provides explanations about the recommendation results so as to help users to understand both the underlying logic of how the recommendations were generated and the qualities of the item so as to decide whether it is relevant to the user or not. Providing explanations is a particularly important feature since it can enhance users' perceived credibility of the system and increase users' satisfaction (Drachsler et al., 2015), (Tintarev & Masthoff, 2011).

In addition to recognizing the strengths of this study, it is also important to recognize the major limitation, which is the small number of participants included in the evaluation process, due to the fact that participants should be specialized in the LD field. While the inclusion of few participants prohibits the extrapolation of the findings to the general population, the outcomes are unlikely to be due to chance alone because of the high credibility of the participants. The reason for first conducting a pilot study is that this will be a reliable indicator to help us decide on the cost of conducting a larger scale research in real-world conditions by teachers.

Given the fact that Mentor is integrated into LAMS, another issue under discussion concerns the strengths and weaknesses of the LAMS platform in comparison with other LD tools. LD tools can be grouped into two generations as theorized in the C2Learn research project (National Centre for Scientific Research Demokritos, 2013). First generation tools are the closest to the IMS LD specification, they do not have graphical interfaces and they are aimed at users already familiar with the technology of the IMS LD specification (e.g. Alfanet, CopperAuthor). Second generation tools only cover some parts of the specification but they provide graphical interfaces and do not require high technological expertise (e.g. MOT+, LAMS). In the context of our work, it is crucial to release teachers of the hard coded and incomprehensible LD elements of the first generation tools and furthermore provide teachers with a graphical environment that is meaningful for them. Thus, we focused on second-generation tools. Based on the up-to-date and exhaustive review on twenty-nine LD tools introduced by Celik & Magoulas (2016), we argue that

LAMS presents a set of advantages when compared to other second-generation LD tools with graphical/visual based interfaces (i.e. MOT+, Web Collage, CADMOS, Resource, OpenGLM and Compendium LD). First of all, LAMS is the only integrated environment that provides teachers with an authoring editor together with a monitoring environment to track real-time student progress and a student run-time delivery of LDs. Moreover, LAMS is the only LD tool among the revised that can be deployed into so many different VLEs (i.e. Moodle, Blackboard, Sakai, .LRN, WebCT, SharePoint, OLAT, Desire2Learn). This feature adds significant value to Mentor as it broadens the target group of teachers that will potentially benefit from Mentor. On the other hand, it is also important to recognize the limitations of LAMS. According to some research experiments LAMS seems to have some technical limitations since it is an online web-based system that requires a Flash enabled browser, a reliable internet connection and a satisfactory connection speed. For example, Burns & Walker (2009) refer tasks taking a long time or failing to load and Bower & Wittmann (2011) refer system crashes. Besides, an important challenge is also the handling of complex sequences by a large number of students simultaneously (scalability) according to Lam, Yeung, & McNaught (2007). An interesting test on LAMS scalability with 180 concurrent users using three different lessons has been performed by Yan Li and Jun-Dir Liew in the Huazhong Normal University (Ghiglione & Dalziel, 2007). Each lesson had from 15 up to 30 activities. The results indicated that LAMS performed very well and could have handled a lot more users. Other drawbacks of LAMS referred in the literature include: (a) the lack of personalization for different learning styles (Smart, 2005) (b) the lack of ways to pass information from one tool to another (Cameron, 2007) (c) the highly structured/linear nature of LAMS sequences (Bower & Wittmann, 2011) (d) the fact that students cannot revisit and revise a learning activity that has already been completed (Adesina & Molloy, 2014). Consequently, some limitations are occurred concerning the pedagogies that can be modeled. For example, in a collaborative scenario it would be necessary for students to turn to a supporting forum whenever they want to ask a question. This scenario could not be implemented into LAMS due to the lack of the back and front navigation.

7. CONCLUSION

This paper has presented Mentor, which is an integrated RS into LAMS, that has been designed, implemented and evaluated, recognizing the need for supporting teachers during the LD process. Mentor recommends LDs for a particular application context defined by the teachers themselves. After the teacher selects a recommended LD he/she can customize it by means of creative intervention.

The answer to the research sub-questions posed at the introduction of this paper was reached by conducting a first evaluation experiment taking into account participants' experience and comments on Mentor. In particular, the user-centric evaluation framework defined by Pu & Chen (2011) was applied. The experimental results demonstrated that the answer to both research sub-questions is positive since respondents believe that the Mentor RS can make the LD process easier and also less time-consuming. Further results show that respondents believe that Mentor can facilitate the sharing of good teaching practices and also helps them find a good LD to rely upon for creating their own. Therefore, it is not surprisingly that respondents' intention to use Mentor is high, as well. While the results of the first evaluation experiment are strong due to the high credibility of participants, further research in long-term authentic usage of Mentor by practicing teachers is needed to verify them. In future work, we indent to carry out such a research given that the results of the pilot study encourage a deeper analysis of the proposed RS.

An intriguing future research direction is to enhance the hybrid recommendation approach presented in this paper by incorporating a social-based recommendation approach. Based on studies that have already proved that social data can be used to improve the performance of traditional RSs (Liu & Lee, 2010), (He & Chu, 2010), (Yang, Guo, Liu, & Steck, 2014), it would be interesting to enable teachers to connect with other teachers and modify Mentor so as to utilize information in the emerging social network in order to improve recommendations.

8. References

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