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Reuse of e-learning personalization components

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Abstract
Personalized learning systems use several components in order to create courses adapted to the learners'characteristics. Current emphasis on the reduction of costs of development of new resources has motivated the reuse of the e-learning personalization components in the creation of new components. Several systems have been proposed in the literature. Each system implements a specific approach and includes a set of software components. However, many of these components are not easily reusable. This paper proposes an architecture, which aims to improve the representation of learning components in a reusable and interoperable way. As a result, these components could be integrated easily for the creation of personalized learning courses. This architecture consists of five main packages: learner model, adaptation model, reuse facilities, learner interface and pedagogical knowledge. An experiment is conducted to validate the proposed architecture. The obtained results illustrate the optimal composition of e-learning personalization components through an example.

Keywords: Federation, E-learning components, Personalization, Optimal composition, A* algorithm

Introduction

The combination of learning components for providing personalization of learning courses has been an important subject of research in recent years. Several research teams working in the field of e-learning personalization in different parts of the world have focused on this issue. Each team has achieved some results. However, many of these results are not easily reusable. The e-learning environments are characterized by the use of a set of standards. These standards facilitate the reuse of pedagogical resources as well as e-learning software components. For example, ASSA by Aljohany et al. (2018) used the SCORM (Sharable Content Object Reference Model) standard to represent the learning objects in a reusable manner. In Dominic and Francis (2015), the IMS-QTI (IMS Question and Test Interoperability) standard permitted creating and generating adaptive questionnaires. Another example was Heath and Schwerdtfeger (2009) who put forward a new approach that allowed for introducing the e-learning standards for reusing the learning components. Even though there are some components that are represented in an interoperable and reusable way through the e-learning standards, various other components are not supported by e-learning standards. As examples of these components, we cite the personalization parameters and

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strategies. Essalmi et al. (2010) used the web service technology to represent the mentioned components in reusable and interoperable manner.

To sum up, a personalized learning system uses several components in order to create a course adapted to the learners' needs. However, the used components in a given system are not exploited in others systems. Consequently, research is needed to identify how to obtain the personalization of learning courses by the federation of software components in a reusable, interoperable and flexible way. In this context, several systems allows representing the mentioned components in a flexible and accessible way. In addition, it enables teachers to select and choose the components according to students' profiles and the specifics of the courses they want to use. For example, Siddique et al. (2018) presented an approach to reuse the reusable software components adapted to learners' preferences. Another example is Harandi (2015), who proposed a new approach, which allowed authors to compose learning objects. However, very little research is available that focuses on optimizing the composition process.

The research in this paper presents an approach that allows for combining e-learning personalization efforts. The proposed approach includes packages representing information about learners, pedagogical knowledge, adaptation mechanisms and reuse facilities. Furthermore, this paper focuses on the package for reuse facilities. This package describes various technologies, methodologies and learning standards, which allows for representing student model and pedagogical knowledge in an interoperable and reusable way. The objective is to optimize the effort investment of the community in developing personalized e-learning systems. This approach uses the A* algorithm, proposed by Mehlhorn et al. (2017), which allows for finding the best solution with the least cost. It utilizes this algorithm to give optimal and shortest path to the given goal node between multiple points using the heuristic function. In Mehlhorn et al. (2017), the A* algorithm was compared with the different types of search algorithms, such as the Breadth first search, Greedy best search, Depth first search and Dijkstra. The obtained results show that the A* algorithm has the best performance by using admissible heuristics to guide its search. It permits finding the optimal and complete solution. At the same time, the mentioned approach provides many advantages for the teachers. For instance, it gives them the possibility to reuse the pedagogical and software components and to provide optimal and performance composition to satisfy their' needs. In addition, it allows teachers to incorporate these components in a relevant and easy way in their courses.

The rest of the paper is organized as follows. The following section (Section II) presents related works that focus on e-learning personalization systems. Section III presents the proposed architecture, which allows for combining and assembling the learning components in a reusable way. Section IV describes the research questions and research methodology. In section V, the suggested approach is explained with a pilot study of the simulation. Section VI discusses the proposed architecture. Finally, conclusion and future work are presented in section VII.

Related works

Personalized learning systems generate courses adapted to the learner's characteristics. In order to ensure personalization in the educational field, these systems use several components such as the student's model and the pedagogical knowledge, but the problem is the implementation of these components in a reusable manner. Several authors have treated this problem by using e-learning standards and technologies. For example, Aljohany et al. (2018) proposed an approach, which considered the adequacy of existing e-learning standards. These standards might support and facilitate the introduction of adaptive techniques in learning systems. The suggested approach aimed to provide personalized learning questions. In Aljohany et al. (2018) learning objects were organized through shareable content objects (SCORM). This latter was a content unit that had a pedagogical sense which could be reused in other learning resources. Their approach highlighted the learning questions that had to be suitable to each learner according to the learner's level of knowledge and the Felder-Silverman learning style. Moreover, Heath and Schwerdtfeger (2009) suggested an approach that described a learning scenario suitable for both the personal preferences and the delivery context. They presented the integration of different standards, working groups and specified organizations that allowed for the accessibility to contents and to the customized interface by certain users in a given context. In Dominic and Francis (2015), the IMS-QTI standard permitted creating and generating adaptive questionnaires. Through this standard, the authors were given the possibility of representing the test and questions in reusable and interoperable way.

Even though there were some components that were represented in an interoperable and reusable way through the e-learning standards, other components were not supported by e-learning standards. Therefore, as a solution, Essalmi et al. (2010) put forward an approach that described the reuse of personalization strategies. In particular, the authors used the technology of Web services for the implementation of their approach. In another example, Virvou and Troussas (2011) propounded a personalized learning system that enabled each student to learn two languages (English and French) individually depending on the student model. To do that, the student model and the educational components were represented as Web services. As a result, these components could be reused by other educational applications. Elbeh and Biundo (2012) put forward an approach, using an ontology and a Hierarchical Task Network (HTN) planning technique, that allowed for creation of a course structure and course contents adapted to each student according to the type of personality, learning style, emotional and motivational state and cognitive ability. Yarandi et al. (2013) utilized semantic Web technologies (a semantic Web is an extension of a Web that aims to provide software programs with machine interpretable metadata of the published resources) to enable the reuse of learning contents and to add a semantic layer in charge of customization. The authors used these technologies to represent the domain, student and content models. The aforementioned models were based on the ontological representations, which provided an appropriate solution for each individual learner. Wu et al. (2017) represented an approach that allowed for adapting learning objects by specific users via the adaptation model. The learner model, adaptation model, domain model and learning objects were not represented in a reusable way. Another example of Gutiérrez et al. (2016) introduced an approach that permitted to design and implement the shareable auto-adaptive learning object in online learning environment. The main objective of the work was to define a solution for real-time adaptation in e-learning systems based on the use of dynamic languages.

E-learning personalization components can be classified into three categories. First category is the ***pedagogical knowledge*** that defines the different learning elements, which are used to create a learning course, as described below.

- **Domain model:** It represents learning objects and contents. For example, in Ahmed et al. (2017), the domain model included various contents of lessons. In Wu et al. (2017), the domain model described the concepts of learning objects.
- **Learning materials:** It represents theories, examples, practicums and tests, represented by appropriate learning objects.
- **Pedagogical model**: It contains the system knowledge and implements the different pedagogical strategies. For instance, in Virvou and Troussas (2011), this model included demonstrations, presentations, modeling, and so on, as a type of pedagogical strategy.
- **Learning resources**: They include various information, documents, programs, data banks, and so on. For instance, Yarandi et al. (2013) used documents as a type of learning object.
- **Learning objects**: They are digital and non-digital entities related to the concepts of learning material. For example, Essalmi et al. (2010) represented the learning object in reusable way.
- **Contents**: It represents the topics, themes, behaviours, concepts and facts, often grouped within each subject or learning area. For instance, in Yarandi et al. (2013), this model described the contents of learning concepts.
- **Learning activities**: They include a set of tasks and associated tools, which can be used to perform the task. For example, in Gutiérrez et al. (2016), this component included the description and the type of the learning activity.
- **Test**: This component includes various types of test questions: simple choices, multiple choices, fill in the blanks, etc. For instance, Virvou and Troussas (2011) used an exercise as a test of assessment.
- **Lesson structure**: It represents the course structure. For instance, Elbeh and Biundo (2012) used a lesson structure in order to prepare the course (Fig. 1).

  Second category is the ***learner model*** that represents learner's information and characteristics. It represents information about a learner. For instance, Aljohany et al. (2018) used the level of knowledge and the Felder-Silverman learning style as information about the learner. In Elbeh, and Biundo (2012), the proposed system defined the personality type, the learning style, the emotional and motivational state, the student's goal, the performance history and the cognitive ability as information about the learner.
- **Personalization parameters:** It is a set of learners' characteristics such as learning styles or learners' level of knowledge.
- **Context**: It includes two types of constraints: learner models and environment constraints. For instance, in Heath and Schwerdtfeger (2009), this component contained learners' preferences and environment constraints.

  Last category is the ***adaptation mechanisms*** that defines the different techniques and methods of adaptation. These components are presented as follows:

- **Adaptation model**: It includes adaptation methods, techniques and technologies, as well as the adaption algorithm. For example, Gutiérrez et al. (2016) used the adaptive presentation and the adaptive navigation support as adaptation technologies.

Table 1 summarizes the aforementioned approaches and shows the various components utilized to provide personalized learning scenarios. In particular, it presents the components that are widely used in the personalization of e-learning systems.

To sum up, personalized learning systems use several components in order to create a course adapted to learners' needs and characteristics. The need for reduction in the costs of new personalized courses has motivated researchers to think about the reuse of personalization components. In the literature, there are several mechanisms available to help tutors reutilize appropriate software components and results. In particular, one can observe that some components are represented in an interoperable and reusable way through the e-learning standards and/or technologies, while other components are not supported by e-learning standards and technologies. In addition, the used components in a given system are not exploited in other systems.

This paper proposes a new solution that makes the e-learning personalization components reusable. The goal of this solution is the federation of them in the creation of a new component.

Proposed architecture

This section presents the proposed architecture that describes various components to create a personalized learning scenario. Figure 2 presents the proposed architecture. This figure shows the interaction between the different components in order to provide a personalized learning course. When course developers create a personalized learning course, they require an input from modeled components, such as the learner model, the pedagogical strategy, the domain model, the content, the learning activities and the adaptive mechanisms.

On the one hand, the learner's profile component can be represented in a reusable way utilizing one of the reuse mechanisms. On the other hand, the pedagogical knowledge component can be represented through one of the ways to reuse in order to provide reusable knowledge. According to the learner's profile, the learning system provides personalized and adapted pedagogical knowledge to the learner. Through the learner's interface, the learning system collects information about the learner and saves it in a package of learner models. The authors can select the necessary learning contents in order to create a learning course.

Such architecture includes the potential packages that make these components reusable. These packages are inspired from Table 1 in the related works (see section II). In software engineering, package is a collection of items grouped together. It is based on logical grouping. It contains diagrams, classes and other packages. This research uses these benefits to construct the mentioned packages. The proposed architecture consists of five main packages: learner model, adaptation model, reuse facilities, learner interface and pedagogical knowledge that, as described in the next sub-sections.

Table 1 Learning components

Article	Components	Used technologies	Used standards
ASSA Aljohany et al. (2018)**;** Chookaew et al. (2014)	Learner model Test Domain model Learning objects	Ontology Ontology Ontology	SCORM
Ahmed et al. (2017)	Learner model Learning content Domain model Learning objects		IMSLIP LOM
Wu et al. (2017)	Learner model Adaptation model Domain model Learning objects		
Gutiérrez et al. (2016)	Adaptation model Domain model Learning objects Learning activities Learner model		SCORM
Yarandi et al. (2013)	Domain model Leaner model Adaptation model Learning content	Semantic Web Semantic Web Semantic Web Semantic Web	
PANDA Elbeh and Biundo (2012)	Learner model Learning objects Lesson structure Pedagogical model Adaptation model	Ontology Ontology	
Virvou and Troussas (2011)	Domain model Learning objects Learner model Test Lesson structure Adaptation model Pedagogical model	Web services Ontology Ontology	
Essalmi et al. (2010)	Personalization parameters Learner model Learning activities Learning materials Learning objects	Web services Web services	
Heath and schwerdtfeger (2009)	Context Learning Resources Learner model	Ontology Ontology	
E LENA Kravcik (2005)	Learner model Domain model Learning resources Learning activities Learning objects Context Adaptation model Pedagogical model Contents Test Issues	Ontology Ontology Ontology Ontology Ontology	
Paramythis and Loidl-Reisinger (2004)	Learning objects Learner model Group model Adaptation model		LOM IMS LIP PAPI IMSLD

Package of learner models

The package of learner models (Fig. 3) contains important information and requirements about the learners, such as their interests, preference, goal, tasks, background, learning

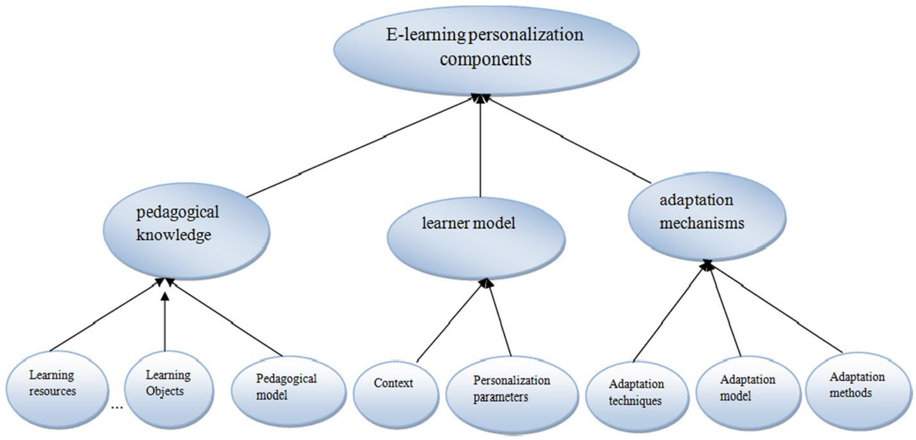

Fig. 1 E-learning personalization components

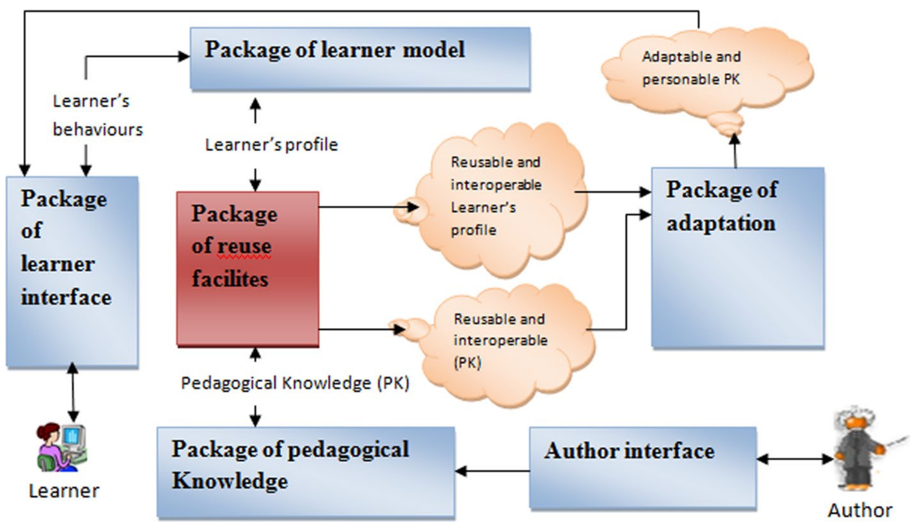

Fig. 2 Architecture of the proposed system

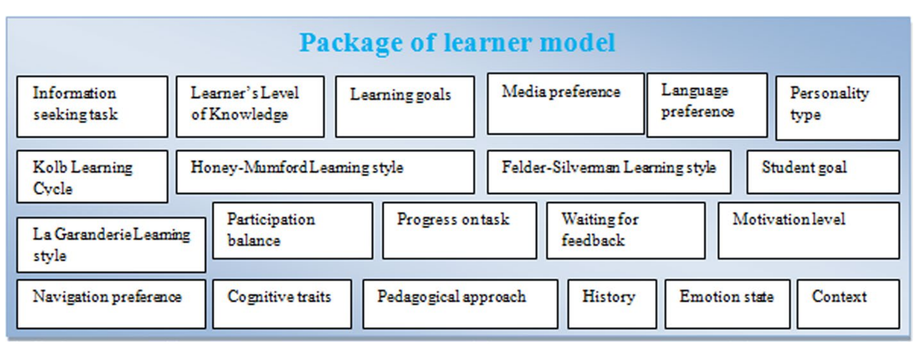

Fig. 3 Package of learner models

performance, learning style, aptitude and environment, as well as other useful features. This model is used to provide learning contents adapted to learners' needs. Khamis (2015) divided information in the learner model in two groups: domain independent

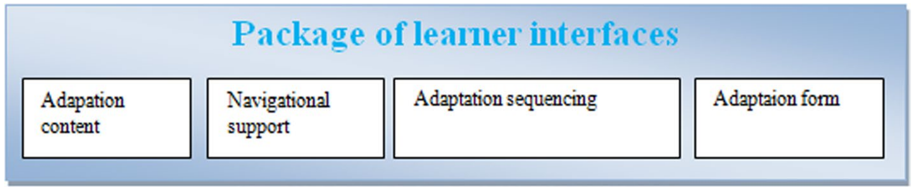

Fig. 4 Package of learner interfaces

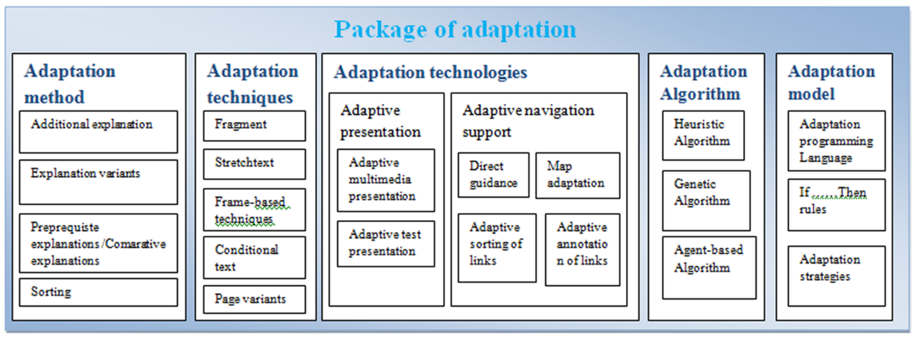

Fig. 5 Package of adaptation

information and domain specific information. The first group describes the learner's characteristics, such as aptitudes, goals, and personal traits. The second group represents various domain related elements (such as the topic, the concept and the subject).

Package of learner interfaces

The package of learner interfaces (Fig. 4) helps learners to find their paths through the hyperspace by adaptive presentations, a selection of adaptive contents and an adaptive form to students' characteristics. Ahmed et al. (2017) provided a comprehensive summary of the various elements, which enable adapting learning contents according to students' characteristics.

Package of adaptation

The package of adaptation (Fig. 5) is responsible for creating and generating a personalized and adapted learning course according to learners' characteristics. This package is achieved by providing different contents for each learner. It contains several sub-packages: the package of adaptation methods, the package of adaptation techniques and the package of adaptation model. Gutiérrez et al. (2016) made a distinction between adaptation methods and techniques to obtain a selection of adaptive pedagogical knowledge.

- Adaptation methods: They are based on a clear adaptation idea, which can be presented at the conceptual level.
- Adaptation techniques: They are the means used to implement a method.
- Adaptation model: It is achieved by providing different media representations for each learner. This model describes the adaptation rules to select the content according to learners' features.

Brusilovsky (2001) distinguished two main technologies of adaptivity:

- Adaptive presentation: It is used to adapt the selection of different media depending on user preferences and the adaptation of learning contents based on a learner model.
- Adaptive navigation support: It is a technique to change the link-structure between pages that together make up a hyper-document. The most popular techniques are direct guidance, sorting, hiding and adaptive annotation.

Package of pedagogical knowledge

The package of pedagogical knowledge (Fig. 6) represents the system knowledge that allows for managing the learning process. This package consists of three sub-packages: the package of assessment contents, the package of pedagogical contents and the package of pedagogical models.

- Package of assessment contents: It describes different evaluation methods (tests, issues, etc.) to assess learners' knowledge.
- Package of pedagogical contents: It contains all the resources necessary to create a learning course.
- Package of pedagogical model: It defines different pedagogical strategies, lesson structures, and domain models used to represent a learning scenario.

Package of reuse facilities

The package of reuse facilities (Fig. 7) contains various emerging technologies, methodologies and learning standards, which allows representing the student model and pedagogical knowledge in an interoperable and reusable way. This package contains three main sub-packages:

- Package of technologies: In this package, we present the used technologies (such as Web services, semantics Web service and semantics Web) which aim to facilitate the

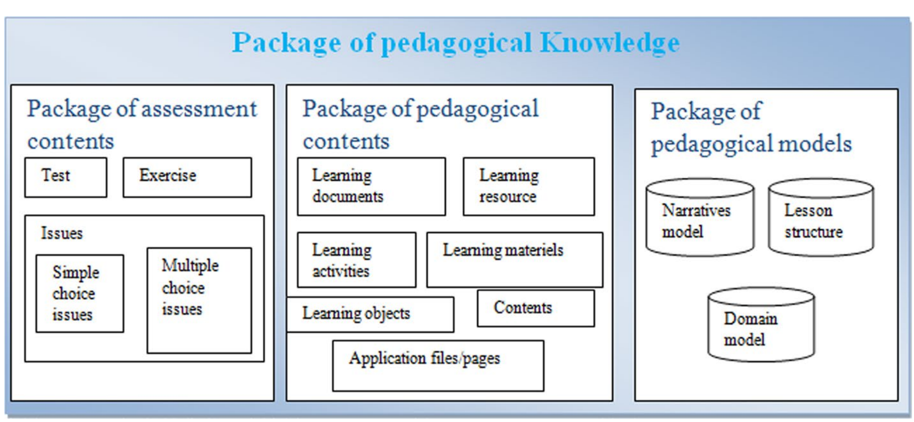

Fig. 6 Package of pedagogical knowledge

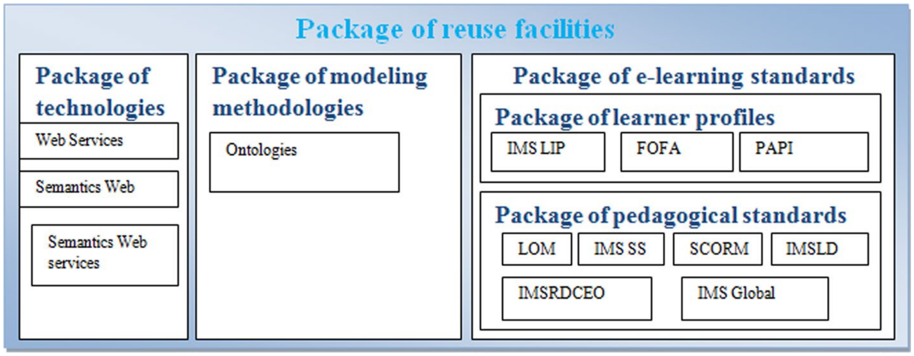

Fig. 7 Package of reuse facilities

access between applications, thereby simplifying data exchange. We present here an example of a learning environment based on Web services. In Virvou and Troussas (2011), the e-learning platform can be seen as a set of autonomous and independent services. These services can be simple or composite. They are the basis of this research, since the objective of the research presented in this paper is that e-learning capabilities are accessible and available via the Internet as reusable and interoperable services.

- Package of modeling methodology: It represents methodologies (such as ontology, pattern design and model driven architecture) which can build the pedagogical knowledge and the learner profile in a standardized way. Design patterns provide the reuse of various components in a standard way. Some work has used design patterns in game engines; we cite the work of Karavolos et al. (2017). This latter propounded a solution that permitted presenting the various components of a game engine using design patterns to model and standardize the main components of a game engine. Other works has used ontology for representing the learner model in reusable way. For example, Aljohany et al. (2018) suggested the learner model as generic user ontology.
- Package of learning standards: The e-learning standards enable realizing the interoperability between the different platforms and the reuse of pedagogical resources. For example, The LOM (Learning Object Meta data) standard defines the various elements of description of a learning object (Ahmed et al., 2017; Essalmi et al., 2010). Moreover, the SCORM allows e-learning platforms to find, import, share, reuse and export learning resources in a standardized way (Gutiérrez et al., 2016). Several standards have been used to represent learner profiles. For instance, the IMS LIP (Instructional Management System Language Preference) provides a means to store information about a learner in a database (Ahmed et al., 2017)

Research questions and research methodology

Research questions

To facilitate the reuse of e-learning personalization systems, two alternatives (A1 and A2) are presented in (Ghallabi et al., 2013), as described below. Furthermore, A1 is divided into three alternatives: A1.1, A1.2 and A1.3.

A1: The components needed for reuse are available. In this case, these components may be reusable and interoperable, reusable and non-interoperable, neither reusable nor interoperable.

A1.1: If the components are reusable and interoperable, it can be easily integrated into a learning course. So, as solution, the components could be easily integrated in the system. In the literature, there are some components which are represented in reusable and interoperable way through the e-learning standards or Web services.

A1.2: If the component is reusable and non-interoperable. In the literature, there are some components which are represented in a reusable way through ontology. However, there is no guarantee that these components could be integrated in others systems.

A1.3: The component is neither reusable nor interoperable. There are several components which are not represented in a reusable way. Thus, to make these components reusable and interoperable, the teacher will create adapters or translators to obtain a standard format for each component.

A2: If the components needed for reuse are not available, then to create the needed components in reusable and interoperable way, the teacher can use one of the reuse solutions (Web services, e-learning standards, etc.) to represent the new learning components in a standard way. Then, these components will be available to be reused in other learning systems.

Research methodology

The research in this paper is specifically focused on the following alternative A1.1: If the components are reusable and interoperable, thus *how to reuse these reusable and interoperable components*? To respond to this alternative, several learning systems in the literature have allowed teachers to compose and assemble the learning components by reusing existing ones. For example, Rahadian and Budiningsih (2017) put forward an approach that allowed for the combinations of student learning styles to get the most suitable one. In Taniguchi et al. (2015), the suggested approach permitted combining pedagogical resources through a composition model. The goal of this model was to combine and assemble the existing pedagogical resources in order to create a new component. However, these cited works has focused on optimizing the composition of e-learning components according to authors' needs. Furthermore, such composition has not been based on smart algorithms to generate optimal components. This leads to the following question: *How can we obtain the optimal composition of e-learning personalization components adapted to teachers' needs?*

To answer this question, this paper uses the A* algorithm which allows for finding the best solution with the least cost. It enhances the federation of e-learning components. This algorithm is an optimization process. It allows for inserting the nodes (in this paper, each node is represented the learning component) in the open list according to the following function:

$$\mathbf{f}(\mathbf{n}) = \mathbf{g}(\mathbf{n}) + \mathbf{h}(\mathbf{n})$$

where **g (n)** is the cost of the optimal path from the initial node to node n, **h (n)** is the estimation of the additional cost of an optimal path to reach the goal from n, and **C(n, ni)** is the cost to pass from ni to nj. We will use two arrays, namely **Open list** and **Closed**

list, for the execution of the A^* algorithm. **Open list** is an array that includes the nodes which have been generated, but not examined yet. **Closed list** is an array that includes the nodes which have been examined.

Some work in the literature (e.g., Mehlhorn et al., 2017; and Potdar & Thool, 2014) has compared between the different types of search algorithms. Four comparison criteria are presented as follows:

- **Optimal:** It is to find the best and shortest path from a starting node to a goal if one exists.
- **Complete:** It must solve the problem and obtain a solution if the goal exists. **Heuristic function:** It is an estimate of the optimum cost from the current node to a goal.
- **Time complexity:** It presents the amount of time it takes to run an algorithm. Here, **n** presents the number of nodes in a graph, and p defines the graph arcs (Table 2).

In summary, this algorithm has some advantages. It is complete and optimal. It achieves better performances by using admissible heuristics to guide its search. For that, this paper utilizes this algorithm in order to enhance the reuse of e-learning personalization components and to find the optimal composition. It is based on heuristics to select the best appropriate component. Besides, this algorithm is used to solve very complex problems. Therefore, it allows for finding the shortest path from a starting node to a goal if one exists.

Simulation

This section validates the suggested approach through a pilot study.

Case study

In this section, a case study is presented to show how the proposed architecture could be used to create a personalized learning course. When a teacher creates a personalized learning course, he/she requires an input from modeled components (such as the learner model, the pedagogical strategy, the domain model, the content, the learning activities and the adaptive mechanisms) which influence the generation and the creation of an adaptive course. In the literature, there are some components that are represented in reusable and interoperable way through Web services technology. The A* algorithm combines and federates the mentioned components that will satisfy a teacher's request. In particular, Fig. 8 presents the taxonomy of personalization parameters, as presented in Essalmi et al. (2015). In

Table 2 Comparison between A* algorithm and other search algorithms (Mehlhorn et al., 2017; Potdar & Thool, 2014)

Criteria	Search algorithms				
	A* algorithm	**Breadth first search**	**Greedy best search**	**Depth first search**	**Dijkstra**
Complete	Complete	Complete	Incomplete	Incomplete	Complete
Optimal	Optimal and fast	Not optimal	Not optimal	Not optimal	Optimal and slow
Heuristic function	Admissible	Not admissible	Not admissible	Not admissible	Not admissible
Time complexity	$O(b^n)$	$O(b^n)$	$O(b^n)$	$O(b^n)$	$O(n^2)$

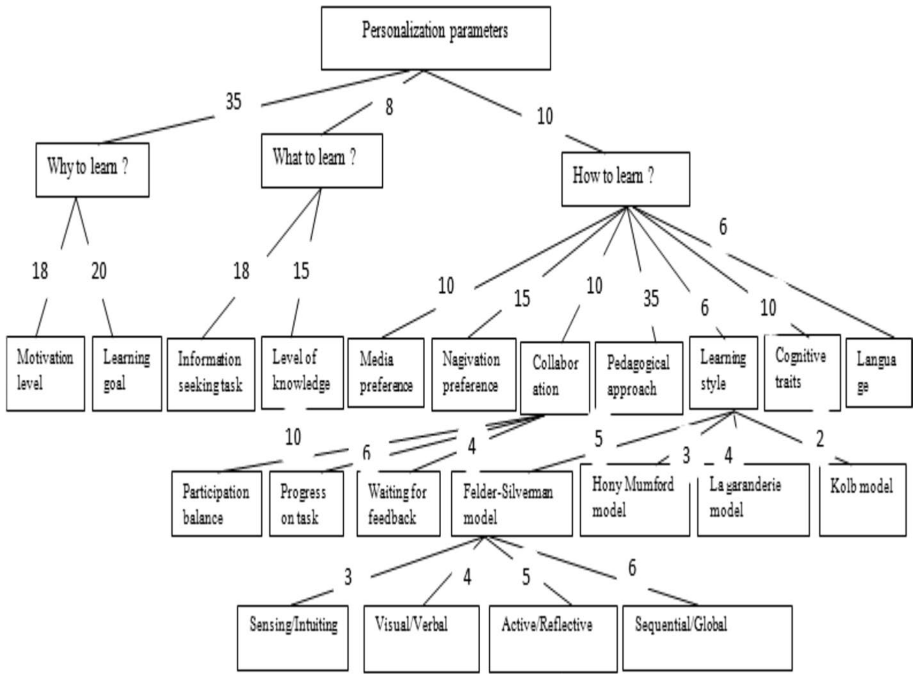

Fig. 8 Example of composition of personalization parameters based on taxonomy of Essalmi et al. (2015)

Fig. 9 Optimal path of personalization parameters

addition, the figure includes a heuristic value for each parameter. These parameters define characteristics and needs of learners such as the learner's level of knowledge and the motivation level. Each parameter is represented as a Web service. The goal of this case study is to reuse these parameters in order to create personalized learning courses and to find an optimal composition (Fig. 9).

Findings

This section presents different results of composition of e-learning personalization parameters. The A* algorithm is applied in order to choose the best composition of services (representing personalization parameters). It is based on heuristics to select the best appropriate service. It uses the following heuristic values to estimate a cost to the destination node less than the real cost. In this case, Table 3 shows the estimated cost of each service to achieve the goal: (**personalization parameter: Information seeking task**). The heuristic value for each node is assigned randomly.

After running this algorithm, the nodes are inserted in the open list by applying the following function:

$$\mathbf{f(n) = g(n) + h(n)}$$

Table 3 The estimated cost of each component

Personalization parameters	Heuristics (h(n))
Personalization parameters (start)	9
Why to learn?	7
What to learn?	6
How to learn?	8
Motivation level	1
Learning goal	1
Information seeking task	1
Level of knowledge	0
Media preference	1
Navigation preference	1
Collaboration	6
Pedagogical approach	1
Learning style	1
Cognitive traits	3
Language	1
Participation balance	1
Progress on task	1
Waiting for feedback	1
Felder-Silverman model	2
Honey Mumford model	1
La Garanderie model	2
Kolb model	2
Sensing/Intuiting	1
Visual/Verbal	1
Active/Reflective	1
Sequential/Global	1

For instance: f (how to learn) = g (start) + C (start, how to learn) + h (how to learn). = 0 + 10 + 8 = 18.

Open list Closed list

Open list	Closed list
[Start (9)]	
[How to learn (18), what to learn (14), Why to learn (42)]	[Start (9)]
[Information seeking task (27),[Start(9),What to learn(14)]	
Goal	
Level of knowledge (23), How to learn (18), Why to learn (42)	

The optimal composition can be obtained with a minimal cost through the information recorded in the open list:

The proposed approach aims to find the optimal composition of personalization by considering the minimal cost of e-learning personalization. It provides the appropriate and optimal components according to authors' requests.

Discussion

A number of approaches are available in the literature that allow for federating the e-learning personalization components. However, none of them focuses on optimizing composition by considering minimal costs. In addition, these compositions are not based on intelligent and optimization algorithms to create a new course.

For that, we put forward a new approach for assembling these components by selecting the optimal ones. The proposed approach is based on the A* algorithm which permits finding the optimal path within short time and with a low cost. The findings of the study suggest that this algorithm is more efficient than any other algorithm (see section IV) since it decreases the set of nodes to explore. It enhances the reuse of learning components. A* algorithm is based on heuristics to select the optimal appropriate component. But, the heuristic value is assigned randomly. As result, with a growing these values, the execution time of the SVM algorithm is slow. In addition, it is not used the criterion of Quality of Services (QoS) to choose an optimal composition.

The suggested approach aims to represent the e-learning personalization components in reusable and interoperable way using Web services technology. These components are uploaded to the databases. As a consequence, they are centralized and are not mobile. In addition, and users cannot incorporate learning courses from heterogeneous personalized learning systems.

Conclusion

In order to achieve the personalization of e-learning courses, learning systems use different components. This paper has proposed a new solution to federate and combine the reusable, interoperable, available and accessible components to build a new course. The goal of this solution is to enhance the composition of e-learning personalization components by selecting the optimal ones.

The suggested approach uses the A* algorithm which allows for finding the best and the optimal composition within short time and with a low cost. This algorithm combines and federates the mentioned components that will satisfy a teacher's request. It is based on heuristics to select the best appropriate component.

To show the feasibility and effectiveness of this approach, an experimentation has been conducted. The obtained results have enabled the optimal composition of software components by considering the minimal cost of e-learning personalization.

The proposed approach provides many advantages for the teachers. For instance, it gives them the possibility to reuse the pedagogical and software components and to provide optimal and performance composition to satisfy their' needs. In addition, it allows teachers to incorporate these components in a relevant and easy way in their courses and to choose the required parameter they want to use.

At the same time, the mentioned approach can also help researchers in the e-learning personalization domain to understand federation of personalization efforts, and exploitation and composition of different personalization components according to the specifics of courses while considering the minimal cost and time. However, this paper is needed to present how to integrate and adapt the selected component into a particular course. Therefore, to overcome this limitation, we envision using the adapter interface (e.g. XML format, or ontology) which will represent these components in an understandable and readable way. This adapter interface will allow to realize the correspondence between the author's needs and the different components' formats.

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Availability of data and materials
The authors do not have ethics approval to make the raw student data or the tool available to anyone outside the organization, in which the experiment was conducted.

Declarations

Competing interests
The authors declare that they have no competing interests.

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