



## Editorial

# Application of implicit and explicit attribute based collaborative filtering and BIDE for learning resource recommendation



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## ABSTRACT

Explosive growth of e-learning in the recent years has caused difficulty of locating appropriate learning resources to learners in these environments. Recommender system is a promising technology in e-learning environments to present personalized offers and deliver suitable learning resources for supporting activity of users. Compared with resource recommendation in e-commerce systems, users in e-learning systems have topic preferences in e-learning systems. However, e-learning systems have their own characteristics and current e-commerce algorithms cannot effectively use these characteristics to address needs of recommendations in these environments. To address requirement of e-learning resource recommendation, this research uses attribute of resources and learners and the sequential patterns of the learner's accessed resource in recommendation process. Learner Tree (LT) is introduced to take into account explicit multi-attribute of resources, time-variant multi-preference of learner and learners' rating matrix simultaneously. Implicit attributes are introduced and discovered using matrix factorization. BIDE algorithm also is used to discover sequential patterns of resource accessing for improving the recommendation quality. Finally, the results recommendation of implicit and explicit attribute based collaborative filtering and BIDE are combined. The experiments show that our proposed method outperforms the previous algorithms on precision and recall measures and the learner's real learning preference can be satisfied accurately according to the real-time up dated contextual information.

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## 1. Introduction

In the recent years, with advances in wireless networking and mobile broadband Internet access technologies, and also the maturing of portable mobile devices, online e-learning has become a relatively widespread learning method. The popularity of e-learning has created huge amounts of educational resources (learning materials). Hence, locating the suitable learning resources has become a big challenge. One way to address this challenge is the use of recommender systems [1]. In addition, one of the new forms of personalization in e-learning environment that has been expressed as a need by several researches is to give recommendations to learners in order to support and help them through the e-learning process [2]. The task of delivering personalized learning resource is often framed in terms of a recommendation task in which a system recommends items to an active user [3].

Recommender systems use three main strategies to generate recommendations including content-based, collaborative, and hybrid recommendation [4]. Content-based recommendation uses the features of items and user and then builds a matching model for them. Recommendations are made based on comparison of user's preference and item's features. On the other hand, collaborative filtering assumes that users who had similar choices before will make the same selection in the future. CF approaches used in

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e-learning environments focus on the correlations among users having similar interests. Combining several recommendation strategies can be expected to provide better results than either strategy alone [5]. Hybrid recommendation mechanisms attempt to deal with some of limitation and overcome drawbacks of pure content-based approach and pure collaborative approach by combining the two approaches.

An appropriate recommendation technique must be chosen according to pedagogical reasons. These pedagogical reasons are derived from specific demands of lifelong learning [6]. Therefore, some recommendation techniques are more suitable for specific demands of lifelong learning than others. One way to implement pedagogical decisions into a recommender system is to use a variety of recommendation techniques in a recommendation strategy. The decision to change from one recommendation technique to another can be done according to pedagogical reasons, derived from specific demands of lifelong learning [7]. This paper uses two recommendation techniques based on attributes of learners and resources and sequential patterns of resource accessing.

The first technique introduced two types of attributes including implicit attributes and explicit attributes. Implicit attributes were discovered by matrix factorization. Learner Tree has been developed for integrating multi-dimensional explicit attributes of resources; learner's rating information and time-variant multi-preferences of learner. Our proposed framework can use this information simultaneously to model adaptive multi-preference of learners. The second technique integrates sequential patterns of resource accessing to improve the accuracy of recommendations based on learning process.

Using this hybrid approach, first, we take in account contextual information of learner and learning resources by implicit and explicit attribute CF. Second, implement a time-variant approach for producing recommendations. Third, improve accuracy of recommendation using implicit attribute when we do not have adequate information about explicit attributes of resources or coding and describing these attributes are impossible. Fourth, obtain more accurate recommendation based on the order of accessed resources in learning process.

The rest of this paper is organized as follows. In the [Literature analysis](#) section, the previous related works on e-learning resource recommender systems is discussed. The [Methodology](#) section introduces the overall system framework and describes the proposed algorithms step by step. The [Implication](#) section applies the proposed framework for a dataset to evaluate and analyze the performance and limitations of it. Finally, the [Conclusion](#) section provides the concluding remarks along with suggestions for future work.

## 2. Literature analysis

Recommender systems have been researched extensively by the Technology Enhanced Learning (TEL) community during the last decade [8]. TEL aims to design, develop and test sociotechnical innovations that will support and enhance learning practices of both formal and informal learning [9]. Recommender system is one of the technologies that have been used for e-learning environments to recommend useful resources to users. These systems address information overload and make a personal learning environment (PLE) for users. PLEs refer to a set of learning tools, services, and artifacts gathered from various contexts to be used by the learners. We briefly survey some of the important works and explain the drawbacks that can be addressed by our proposed approach.

### 2.1. Content based filtering

This strategy uses the features of items for recommendation [2]. These features may be used by case based reasoning (CBR) or data mining techniques for recommendation. CBR approach recommends new but similar items. However data mining techniques recommend items based on the matching of their attributes to the user profile. CBR mechanisms have to evaluate all the cases in the case base to retrieve those most similar case(s) which makes their efficiency strongly and negatively related to the size of the applicable case base. The performances of CBR mechanisms are closely related to the case representation and indexing approach, so their superior performances are unstable and cannot be guaranteed. As examples for e-learning application, Khribi et al. [2] used learners' recent navigation histories and similarities and dissimilarities among the contents of the learning resources for online automatic recommendations. Sharif et al. [10] provided a framework for discovering most relevant resources from CiteULike for learners. In their approach, the keywords of learning resource are matched with tags of CiteULike using Direct Match, Partial Match, and Synonym Match. Then, the resources are further ranked based on number of weights.

In the existing content based recommendation algorithms, due to considering learner's preference information alone and not considering similarity between learners, only certain resources which are similar to learner's historical preference could be recommended. This causes overspecialized recommendations that only include items very similar to those the user already knows. To avoid the overspecialization of content-based methods, researchers proposed new personalization strategies, such as collaborative filtering and hybrid approaches mixing both techniques.

### 2.2. Collaborative filtering

Majority of researchers used collaborative filtering based recommendation system [11–14]. CF approaches can be divided in to three categories. Neighbor-based CF finds similar items or users based on rating data and predicts rating using weighted average of similar users or items. Model-based techniques predict rating of a user by learning of complex patterns based on the training data (rating matrix). In the demographics approach users with similar attributes are matched, then this method recommends

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