Collaborative Recommender System: A Review

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Abstract— **Recommender system is widely used in various domains to assist users in finding items that relate to their needs. The collaborate filtering method is one of the popular methods in recommender systems. By using collaborative filtering method, users can make an assessment of the item based on other user experience. This method is very beneficial in education domain to assist student in getting a learning object that can help them in learning process. However, there is no review focusing on the use of the collaborative recommender system in education. Hence, the objective of this study is to review the state of the art of collaborative recommender system in education. This study reviewed twenty six articles based on recommender system components such as input, method and the output of the system. The overview and the applications of collaborative recommender system in education then discussed.**

Keywords—**recommender system, collaborative filtering, education.**

I.   Introduction

Recommender system has been a very active research topic for two decades [1]. It is widely used in various domains such as business and education. Recommender system (RS) provides personalized advice to users about items that they might like based on their preference [2]. Among popular methods –collaborative filtering method. By using collaborative filtering method, users can make an assessment of the item based on other user feedback; implicitly or explicitly.

This method is very beneficial in education domain to assist student in getting a learning object such as learning material or activities that can help them in learning process. However, there is no review focusing on the use of the collaborative recommender system in education. The [3] it has reviewed a collaborative RS, however, they cover mostly for business perspective. Education domain is different due to the needs to assist students in getting the suitable learning objects and to assist them in improving their understanding. Hence, the objective of this study is to review the state of the art of collaborative recommender system in education.

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This study investigates RS components such as input, method and feedback used in the education domain. The rest of this paper is organized as follows; a description of the research method used; followed by a discussion of literature review; discussion of the state of the art of RS input, method and output; a discussion of the RS application in education domain and finally, a conclusion is drawn and possible directions for future works are identified.

II.   Research Method

In this study, research method consists of three phases. In the first phase, the search string is identified based on the research objective. The search string defined for retrieving studies is as follows: ("recommender system" OR "recommendation system") AND "collaborative" AND ("education" OR "student" OR "learner"). In the second phase, the search string identified above was used in the trustworthy resource and exceedingly cited researcher such as IEEE Explore, Web of Science, Science Direct and Scopus. The period reviewed was the last 8 years, i.e., studies published from 2007 to 2014. Fifty six papers were identified. After manual inspection, only twenty six papers are used in this study. These papers were reviewed in term of RS components such as input, method and output stated in phase three.

III.   Recommender System

Recommender System (RS) can be defined as systems that guide users toward interesting or useful items in a large space of possible options [4]. It provides a platform to deliver the right knowledge in the right context to the right person in the right volume [5]. The advantages of RS are RS have been used in several domains to support user in decision making and decrease the effect of information overload [6]. By using RS, information can be filtered based on user needs [7]. Apart from Other than that RS can successfully help users to find the items they are interested and can provide recommendations based on user preferences [8].

RS consists of three components; Input, Method and Feedback. Input component is needed to provide input for the system. The source of an input can be derived implicitly or explicitly from the user. Method component is the technique to recommend item to user while Feedback component is the evaluation of the item from the user. Methods can be classified into the following categories:

- Collaborative Filtering Method: Collaborative method is user-to-user correlation that uses group opinions to recommend items to individuals.   This method computes similarities between user preferences and

recommends item based on rating provided by users whose preferences are similar to those of the given user and recommend items they liked. Collaborative method can be classified into three categories according to their algorithmic techniques which are memory based, model based and hybrid [9].

- Content-based Filtering Method: Content-based method or item-to-item correlation recommends items based on a comparison between items and a user profile [10]. It recommends items that are similar to the ones the user preferred in the past based on textual information of an item. The item can be vary depending on the number and on the type of attribute used to describe them.

- Demographic based method: Demographic based method categorize which users or items based on their personal attribute and recommendation is made based on demographic classes [11]. The advantage of this approach, it may not require a record history of user rating like content base and collaborative method. However, it was not widely used because the information is difficult to collect due to privacy issues [6].

- Knowledge based method: This method recommends item based on their functional knowledge. This functional knowledge contains knowledge about how a particular item meets a particular user's need [4]. This approach solved the early user rates problem and scarcity problem because it does not depend on user ratings.

- Hybrid Method: Hybrid method uses a combination of the above methods. It tries to emphasize their strengths and at the same time reduces their drawbacks. There are a few types of hybrid method such as weighted switching, mixed, feature combination, cascade, feature augmentation, and meta-level.

IV. State of the art of Collaborative Filtering Recommender System in Education

One of the popular methods to generate the recommendation in RS is collaborative filtering method. Collaborative filtering (CF) method is used by recommender systems to predict the utility of items for users based on the similarity among their preferences and the preferences of other users [12]. Below is the state of the art collaborative RS in education based on RS components.

A. Input

Input is needed to provide information for the system in the recommendation process. It is important to build user model to provide personalized recommendation. User model is the most important element in RS and it should be modelled accurately (James et al., 2009). Inputs for user model can be elicited from demographical data, user profile and user preferences about features of the items

[13],[14]. One of the major input sources for user model is from user profile. In order to give a good recommendation, it is necessary to acquire a user profile such as the user's abilities, needs, knowledge and preference. User profiling is the process of gathering specific information for each user. It is typically either knowledge-based or behavior-based and can be accomplished either explicitly or implicitly through interactions with a system. Table 1 provides the summary of the input used in the collaborative RS.

TABLE I. CATEGORIZATION OF INPUT IN RECOMMENDER SYSTEM

Input Type	Reference
Demographic data	[15],[16], [17], [18], [16]
User profile	[12], [15],[16], [17], [18], [16] [19], [20]
User preferences	[21], [22]

Demographic data can be domain of study, gender and age [4,5,6,7,5]. In education, User Profile is the most used Input types. This is due to the need in identifying user level of education. Example of User Profile attributes is academic result, academic level, course, learning material and activities [3,4,5,6,7,8,9] Examples of User Preference attributes are by user searching history, such as recommended argument, basic search and keyword search [10, 11].

B. Collaborative Filtering Method

Collaborative Filtering (CF) method can be categorized by three categories [23]:

- Memory-based methods: This method used feedback such as rating to recommend an item to the user. The implementation of this method is easy but it depended on user feedback. Example of memory-based method are Item-based and user based top-N recommendations [24],[25].

- Model-based methods: This method used model to generate the recommendation. This method addressed the sparsity and scalability problem. However, the implementation is more complex. Examples of model-based methods are Clustering CF [26], MDP-based CF [27] and Latent semantic CF [28].

- Hybrid Methods: Combined both above methods.

TABLE II TYPE OF COLLABORATIVE METHOD USED IN RS IN EDUCATION

CF Method	Reference
Memory-based methods	[29],[30],[16],[31] ,[32],[33],[34],[20]
Model-based methods	[35],[36],[37],[12],[22],[18],[17],[38],[39],[15] ,[20],[21]
Hybrid Methods	[40], [36],[19],[41],[42],[43],[44]

In collaborative RS in education, model-based method is the most prefered as shiwn in Table II. Among the methods used are Tag-based [40], clustering [18], [22], data mining [17], [12], [39], [28] iterative method [45], Learner's Role based Multi-Dimensional [21], and 2-Tuple fuzzy linguistic approach [15], [20] [38].

Memory-based methods also been used such as Multi-label k-nearest neighbour (ML-k-NN) [16], context-based

[30], content-based [20] [31], slope one [32], usage context profiles [33], Neighbourhood-based algorithms [34], user based [46] [43].

Hybrid Methods: user-based and mixed hybridazation method [44], model-based and memory-based [19], [36], [40], [41], cognitive and collaborative filtering [42]

C. *Feedback*

Feedback is an important component because it generates additional inputs for future recommendations. Feedback for recommendations can be varied depending on items and information provided to users. Feedback can classify as below:

- Review: Review is an evaluation of the item. It can be in the form of text comment or rating. Examples of review in Collaborative RS are: consideration learner's characteristics [14], ontological interpretative and approach [19].
- Suggestions: Example of suggestions output are in the form of "try this" in the result page. It can be a single item such as simply placing "this" or a set of suggestions in the form of list.   Examples are recommendation of activity class for multi-label classification [16]. formalize the weighting of the recommendations [36], used of set of context model [30], recommendation of feasible learning goals that covering the learning needs [45], recommendations to courseware authors using association rule mining and collaborative filtering [45], recommendation system according to readers' interest and books properties [35], recommendation of e-learning recommender systems [41], and recommendation to read lessons based on the recommender scores[5]
- Ranking - It is presented in the form of ordering list. Several RS provides a prediction of the rating for an item to help users understand the strength of a recommendation. The example is rank the algorithms from the offline and user evaluation [40].
- Log - Based on user history in the system. The example of log are continuous improvement of e-learning course framework [4] [20] solutions for extra tasks [22].

Table III show the feedback used in Collaborative RS in education.

TABLE III SHOW THE CLASSIFICATION OF FEEDBACK

Feedback	Reference
Review	[29],[41], [19], [30], [31], [18],[21] [32], [42], [34], [45], [39], [22], [38]
Suggestion	[16], [39], [15], [45], [34],[33], [42], [32], [41], [21], [15], [17], [31], [47], [41], [36], [30], [35],[37]
Ranking	[16], [34], [40]
Log	[45] [15], [36]

V. **Application**

This study aimed to review collaborative RS in education. This section discussed the component in the applications of the collaborative RS.

A. *Respondent*

In education domain, respondents are mostly students. Tablle IV show the summarization of respondents in the collaborative RS application. Below is the categorization of the respondents:
- Undergraduate: Student who studying in their first degree.
- Postgraduate: Student who is denoting of studying undertaken after completing first degree
- School student: School student contain primary and secondary student.

TABLE IV RESPONDENT.

Respondent	Reference
Undergraduate	[29], [41], [36], [17],[21] , [16], [34], [39], [22], [37], [48], [49]
Postgraduate	[19], [32], [42], [33],[38] , [40]
School student	[30], [45], [31], [18], [15]

B. *Learning Object*

Learning object plays as a main component in the collaborative RS application. Learning objects can be defined as learning material and learning activities. The summarization can be discussed as below:

- Learning material: Student can use learning material include text and multimedia on all areas in the curriculum. Example of learning material are book [41], [45], slide [30], [22], scheme [16], and audio [32]
- Learning activities: are activities that designed by instructor.

TABLE V CATEGORIZATION OF LEARNING OBJECT

Learning Object	Reference
Learning material	[41], [30], [22], [45], [16], [32]
Learning activities	[29], [41], [36], [22], [40], [21], [39], [34], [16], [33], [12], [24], [32],[15]

I. **Conclusion**

Collaborative Recommender System is widely used in education domain. It plays an important role in helping student to retrieve suitable learning object and assist educators in preparing and distribute the learning object. This study aims to review state of the art in collaborative recommender system in education.

The findings show that most of collaborative RS using model-based method in recommending learning material. Undergraduate student is the most popular respondent in this field. This paper can help researcher in shaping their research and assist educator in developing a better

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recommender system to assist student in their learning process.

References

[1] S. Cleger-Tamayo, J. M. Fernández-Luna, and J. F. Huete, "Top-N news recommendations in digital newspapers," *Knowledge-Based Syst.*, vol. 27, pp. 180–189, 2012.

[2] J. F. Huete, J. M. Fernández-Luna, L. M. De Campos, and M. a. Rueda-Morales, "Using past-prediction accuracy in recommender systems," *Inf. Sci. (Ny).*, vol. 199, pp. 78–92, 2012.

[3] P. N. Shendage, "Review on Collaborative Filtering and Web Services Recommendation," vol. 2, no. 6, pp. 912–916, 2014.

[4] R. Burke, "Integrating knowledge-based and collaborative-filtering recommender systems," *Proc. Work. AI Electron. Commer.*, pp. 69–72, 1999.

[5] L. Zhen, Z. Jiang, H. Song, C. Liu, and J. Liang, "Information supply: an approach based on demand modeling and information filtering," *Proc.IMechE Part B J. Eng. Manuf.*, vol. 222 , no. 4, pp. 541–557, 2008.

[6] M. De Gemmis, L. Iaquinta, P. Lops, C. Musto, F. Narducci, and G. Semeraro, "Preference Learning in Recommender Systems," *Prefer. Learn.*, vol. 41, 2009.

[7] A. Ibm and T. A. Road, "Mining Association in Large Databases," *IBM Almaden Res. Cent.*, pp. 207–216, 1993.

[8] I.-E. Liao, W.-C. Hsu, M.-S. Cheng, and L.-P. Chen, "A library recommender system based on a personal ontology model and collaborative filtering technique for English collections," *Electron. Libr.*, vol. 28, no. 3, pp. 386–400, 2010.

[9] J. Bobadilla, F. Serradilla, and J. Bernal, "A new collaborative filtering metric that improves the behavior of recommender systems," *Knowledge-Based Syst.*, vol. 23, no. 6, pp. 520–528, 2010.

[10] X. Wan, T. Ninomiya, and T. Okamoto, "LRMDCR: A learner's role-based multi dimensional collaborative recommendation for group learning support," *Proc. - 8th IEEE Int. Conf. Adv. Learn. Technol. ICALT 2008*, pp. 603–605, 2008.

[11] M. A. Ghazanfar and A. Prugel-Bennett, "A scalable, accurate hybrid recommender system," *3rd Int. Conf. Knowl. Discov. Data Mining, WKDD 2010*, no. 2, pp. 94–98, 2010.

[12] C. Cechinel, M. Á. Sicilia, S. Sánchez-Alonso, and E. García-Barriocanal, "Evaluating collaborative filtering recommendations inside large learning object repositories," *Inf. Process. Manag.*, vol. 49, no. 1, pp. 34–50, 2013.

[13] P. Massa, I. Fbk, P. Avesani, and I. Fbk, "Trust-aware Recommender Systems."

[14] X. Wan and T. Okamoto, "Utilizing learning process to improve recommender system for group learning support," *Neural Comput. Appl.*, vol. 20, no. 5, pp. 611–621, 2011.

[15] J. Serrano-Guerrero, F. P. Romero, and J. a. Olivas, "Hiperion: A fuzzy approach for recommending educational activities based on the acquisition of competences," *Inf. Sci. (Ny).*, vol. 248, pp. 114–129, 2013.

[16] M. G. De Oliveira, P. Marques Ciarelli, and E. Oliveira, "Recommendation of programming activities by multi-label classification for a formative assessment of students," *Expert Syst. Appl.*, vol. 40, no. 16, pp. 6641–6651, 2013.

[17] M. H. Hsu, "A personalized English learning recommender system for ESL students," *Expert Syst. Appl.*, vol. 34, no. 1, pp. 683–688, 2008.

[18] M. H. Hsu and S. Cheng, "Toward an optimum combination of English teachers for objective teaching," *Expert Syst. Appl.*, vol. 36, no. 3 PART 2, pp. 5942–5947, 2009.

[19] N. Capuano, G. Mangione, A. Pierri, and S. Salerno, "Learning Goals Recommendation for Self Regulated Learning," *Int. J. Eng. Educ.*, vol. 28, no. 6, pp. 1373–1379, 2012.

[20] a. Zafra, C. Romero, S. Ventura, and E. Herrera-Viedma, "Multi-instance genetic programming for web index recommendation," *Expert Syst. Appl.*, vol. 36, no. 9, pp. 11470–11479, 2009.

[21] X. Wan, Q. Jamaliding, and T. Okamoto, "Analyzing learners' relationship to improve the quality of recommender system for group learning support," *J. Comput.*, vol. 6, no. 2, pp. 254–262, 2011.

[22] K. I. Ghauth and N. A. Abdullah, "Measuring learner's performance in e-learning recommender systems," *Australas. J. Educ. Technol.*, vol. 26, no. 6, pp. 764–774, 2010.

[23] J. Bobadilla, F. Ortega, A. Hernando, and A. Gutiérrez, "Recommender systems survey," *Knowledge-Based Syst.*, vol. 46, pp. 109–132, 2013.

[24] D. H. & C. K. John S.Breese, "Emprical Analysis of Predictive algorithm for Collaborative filtering," 1998.

[25] B. Sarwar, G. Karypis, J. Konstan, and J. Riedl, "Item-based collaborative filtering recommendation algorithms," *Proc. 10th …*, vol. 1, pp. 285–295, 2001.

[26] S. H. S. Chee, J. Han, and K. Wang, "RecTree: An Efficient Collaborative Filtering Method," *Third Int. Conf. Data Wareh. Knowl. Discov.*, pp. 141–151, 2001.

[27] G. Shani, D. Heckerman, and R. I. Brafman, "An MDP-Based Recommender System," *J. Mach. Learn. Res.*, vol. 6, pp. 1265–1295, 2005.

[28] E. W. Hoffman, B. E. Pinkleton, E. W. Austin, and W. Reyes-Velázquez, "Exploring College Students' Use of General and Alcohol-Related Social Media and Their Associations to Alcohol-Related Behaviors.," *J Am. Coll. Health*, no. April 2014, pp. 37–41, 2014.

[29] B. Awerbuch and R. Kleinberg, "Competitive collaborative learning," *J. Comput. Syst. Sci.*, vol. 74, no. 8, pp. 1271–1288, 2008.

[30] I. Bosnić, M. Orlić, and M. Žagar, "A survey on LMS context dimensions for teacher-oriented recommender systems," *Int. J. Emerg. Technol. Learn.*, vol. 8, no. 3, pp. 23–29, 2013.

[31] M. H. Hsu, "Proposing an ESL recommender teaching and learning system," *Expert Syst. Appl.*, vol. 34, no. 3, pp. 2102–2110, 2008.

[32] R. Nadolski, "Simulating light-weight personalised recommender systems in learning networks: A case for pedagogy-oriented and rating-based hybrid recommendation," *J. Artif. …*, pp. 1–30, 2009.

[33] K. Niemann, M. Scheffel, M. Friedrich, U. Kirschenmann, H. Schmitz, and M. Wolpers, "Usage-based Object Similarity," *J. Univers. Comput. Sci.*, vol. 16, no. 16, pp. 2272–2290, 2010.

[34] N. Pukkhem and W. Vatanawood, "Personalised learning object based on multi-agent model and learners' learning styles," *Maejo Int. J. Sci. Technol.*, vol. 5, no. 3, pp. 292–311, 2011.

[35] Q. Chen, K. Wang, W. Huang, Z. Tang, and X. Wu, "The Design of Auto New Book Recommendation System Using Data Mining Technology," *J. Comput. Inf. Syst.*, vol. 9, no. 7, pp. 3054–3061, 2011.

[36] J. Bobadilla, F. Serradilla, and A. Hernando, "Collaborative filtering adapted to recommender systems of e-learning," *Knowledge-Based Syst. 22*, pp. 261–265, 2009.

[37] S. B. Aher and L. M. R. J. Lobo, "Combination of machine learning algorithms for recommendation of courses in E-Learning System based on historical data," *Knowledge-Based Syst.*, vol. 51, pp. 1–14, 2013.

[38] A. Klasnja-Milicevic, B. Vesin, M. Ivanović, and Z. Budimac, "Integration of recommendations and adaptive hypermedia into java tutoring system," *Comput. Sci. Inf. Syst.*, vol. 8, no. 1, pp. 211–224, 2011.

[39] M. Salehi, I. Nakhai Kamalabadi, and M. B. Ghaznavi Ghoushchi, "Personalized recommendation of learning material using sequential pattern mining and attribute based collaborative filtering," *Educ. Inf. Technol.*, pp. 1–23, 2012.

[40] M. A. Chatti, S. Dakova, H. Thus, and U. Schroeder, "Tag-based collaborative filtering recommendation in personal learning environments," *IEEE Trans. Learn. Technol.*, vol. 6, no. 4, pp. 337–349, 2013.

[41] P. Dwivedi and K. K. Bharadwaj, "Effective trust-aware E-learning recommender system based on learning styles and knowledge levels," *Educ. Technol. Soc.*, vol. 16, no. 4, pp. 201–216, 2013.

[42] N. Capuano, M. Gaeta, P. Ritrovato, and S. Salerno, "Elicitation of latent learning needs through learning goals recommendation," *Comput. Human Behav.*, vol. 30, pp. 663–673, 2014.

[43] M. K. Khribi, M. Jemni, O. Nasraoui, and T. Hussein, "Automatic Recommendations for E-Learning Personalization Based on Web Usage Mining Techniques and Information Retrieval," *IEEE Int. Conf. Andvanced Learn. Tech.*, vol. 8, pp. 241 – 245, 2008.

[44] G. a Tsihrintzis and L. C. Jain, *Multimedia Service in Intelligent Environments: Advances in Recommender System*, 24th ed. Springer Cham Heidelberg New Yoirk London: Springer, 2013.

[45] E. García, C. Romero, S. Ventura, and C. De Castro, *An architecture for making recommendations to courseware authors using association rule mining and collaborative filtering*, vol. 19, no. 1–2 SPEC. ISS. 2008.

[46] salavador garcia-martinez and abdelwahab Hamou-lhadj, "Educational Recommender System: A pedagogical-focused perspective," in *multimedia serivice in intelligent environments: recommendation service*, 24th ed., M. V. and L. C. J. George A.Tsihrintzis, Ed. Springer Cham Heidelberg New Yoirk London: Springer, 2013, pp. 113–124.

[47] A. G. L. H. and S. A. Herrera-Viedma, Enrique,Carlor Porcel, "A Fuzzy Linguistic Recommender System to Advice Research Resource in University Digital Libraries," in *Fuzzy Sets and Their extension: Representation, Aggregation and Models*, 2007, pp. 554–567.

[48] H. Bustince, F. Herrera, and J. Montero, *Studies in Fuzzy and Soft Computing*. springer, 2008.

[49] G.A Tsihrintzis and L. C. Jain, *Multimedia Services in Intelligent Environments*. springer, 2013.

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