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SHORT SYSTEMATIC REVIEW ON E-LEARNING RECOMMENDER SYSTEMS

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ABSTRACT

In www (W3), many researchers use recommender systems in e-learning environmental domain. The recommender system in e-learning is actually used to suggest resources and relevant learning contents to learners regarding their required goals. Goal, in the e-Learning recommender system, is an identification of requirements and achievements of relevant items (learning content) required by the learner. This paper reviews the landscapes of current state-of-art recommender systems in e-learning environment. This paper is limited to discuss four types of filtering approaches, their benefits, limitations and cold-start problem with respect to recommender systems. The review of domain and previous research improvement provide timely and useful insight about recommender systems and cold-start issue in e-learning recommendation system domain.

Keywords: *Recommender System (RS), E-learning, Content-based Filtering (CBF), Collaborative Filtering (CF), Knowledge-based Filtering (KBS), Hybrid Filtering (HF)*

1. INTRODUCTION

Traditional education systems in contrast to modern learning or e-learning offer a lot of benefits. However, the learners spend a lot of time on the web searching for the required topics that interest them. This concerns the probability of achieving the goal and suggesting relevant items (learning content) to the learners [12]. Using the information retrieval techniques, predicts the absolute value of ratings that individual users would give to the yet unseen items [15] and classify the suggestions on learning objects to learners [19].

Goal, in e-Learning Recommender System, is an identification of requirements and achievements of relevant items (learning content) required by the user. The definition of goal is [21]: "a goal specifies the objectives that a client may have when he consults a web services". e-Learning Recommender Systems use the goal as a common vocabulary to requesters and services, as requesters will select defined goals to express their relevant items (learning content) and services will link their capabilities to existing goals.

In general, e-learning recommender systems have three types of filtering approaches these are content-based filtering, collaborative filtering and knowledge-based filtering. To improve the accuracy of performance and result of filtering, researchers devised hybrid-filtering approach by combining the other approaches [15, 16].

1.1. Content-Based Filtering (CBF)

In CBF, the users/learners are recommended relevant items/learning contents that are similar to the ones they preferred in the past [15]. This type of filtering relies on the of user / item profiles that assigns consequence to these characteristics. Pendora.com is an example of it. Sometimes, there is not enough information in the items' profile [20] or the user did not access the item before and rate it before, so the system is unable to conclude any recommendation for the users / learners. This problem is called cold-start in the term of recommender systems.

Cold start problem occurs in both the user and the item [15]. These problems result when the domain system does not have enough information on both items (learning content) and users / learners' profiles. Consequently the system is unable to acclaim the users/learners interest and unable to recommend the relevant item accurately. In both (user and item) cases the cold start problem occur because of ratings. Item cold start problem

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occurs when the item(learning content) has not been rated by any user / learner or it haven't enough keywords and tags information are not available in its profile. If the user / learner has not rated any item (learning content) before and does not have sufficient information (item-ratings) regarding required interest / goals, the domain system is unable to recommend any item (learning content) to user/learner. This is called user cold-start problem.

1.2. Collaborative Filtering (CF)

In CF, the users/learners are recommended relevant items/learning contents that other users/learners with the similar interest and preferences liked in the past [15]. It works with numeric data based on multi-users network like their likes / dislikes; users-to-items profile ratings and the number of click of users on per item collaboration, etc. NewsWeeder.com is an example of collaborative filtering. However, sparsity in cold-start is the main problems in collaborative filtering [14]. Sparsity issue occurs when the learners "could not give high rating to the learning contents" and the domain system does not have relevant item (learning content) from past voting's/ratings or likes/dislikes history by significant number of learners.

1.3. Knowledge-Based Filtering (KBF)

Knowledge-based filtering (RBF) approach does not seek to build long-term generalization of their users/learners but they prefer to generate a relevant recommendation based on matching users / learner's needs, interests and preferences [16]. With this approach, the relationship between users' needs and relevant recommended items can be explicitly modulated in a knowledge base on underlying [19]. Generally, these types of systems attempt to solve three types of knowledge questions that are based on user profiling, point profiling and comparison between the user and the point corresponding to the user and binding targets / interest / needs [15]. Gradually, the knowledge profile of the user plays an essential role in this filtering approach.

1.4. Hybrid Filtering (HF)

The HF generally combines the content-based and collaborative filtering methods [15]. These combined methods borrow both content-based and collaborative (some time knowledge-based and collaborative or combination of all) features to get the user's interest and recommend him / her required relevant items (learning content) more closely related to learner goal / interest and preferences. eBay.com learners and Amazon.com are examples of these kinds of systems. Hybrid filtering technique improves the user element of the cold start problem more than both content-based filtering and collaborative.

In hybrid systems, however; the main problem is the complexity of time data. Time complexity occurs when the size of the same dataset increases and the recommender system performs slowly when the system uses more than one but different dataset. These multiple datasets slow down the recommendation performance and decrease the learner interests. To summarize the above approaches of recommendation systems, Table 1 shows the detailed comparison between these four approaches.

Table1: Comparison Of E-Learning Recommender System Approaches

Approach(es)	Benefit(s)	Limitation(s)
Content-based filtering	No domain information required	Cold-start, Overspecialization
Collaborative filtering	No domain information required	Cold-start, Sparsity
Knowledge-based filtering	Sensitive to preference change	Knowledge acquisition
Hybrid filtering	Improve item-user cold start problem	Slow Performance, Time complexity

For providing a deep review, this Systematic Review is divided into different research sections. The organization of the sections is as follows:

I. Take an introduction about recommender system approaches and their comparisons in this section.
II. This section describes related work that has been done by previous researchers.
III. In this section, we display systematic review methods that have been used in this paper.
IV. Study review is shown in this section.
V. Provides clustering results of this systematic review on e-learning recommender system.
VI. Discussion portion of this literature review is given in this section.
VII. Conclusion of this literature review is given in this section.
VIII. Finally; this section gives a tiny description about future work.

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2. RELATED WORK

R. I. Ashwin [4] describes the recommender systems as software solutions that are employed in e-commerce Web sites to improve the services offered to their online customers by helping to find the products that may more closely relate to their interest, and meet their required goals and consequently help them to overcome the information overload.

R. Nachimas [5], states that by increasing the number of e-learning platform, learners are often surpassed by the significant amount of learning resources available online. However, instead of spending much of their time in the consideration and engagement of items (learning contents) the learners lose their time sailing up the Internet and try to locate the information that fits their required goals. Perhaps, they are eventually getting extraneous (not related) contents.

The Recommendation process H. Wrethner [1], enables a system to utilize various factors to formulate a recommendation effectively. It comes to a personalization that presents the system to a particular user in response to their requirements whilst taking into account their preferences and the desired goals. It is the view of A. A. Kardan [7] that recommender systems can be used to suggest topics of interest to learners in an e-learning environment. To do this, they have presented an innovative architecture for a recommender system based on collaborative tagging and conceptual maps.

Feng jang Liu [13], narrated technical activity-based course recommendation system. The author defined an architectural model of this method using collaborative filtering technique. This filtering model works based on collecting and analyzing information about user activity. Reginaldo [19] presented an approach for recommending content for customized e-learning systems. This recommendation is based on tree-matrices, the interest of learners, to determine the preferences of learners using collaborative filtering approach.

Croft, W. B. [3] has defined recommender system as a system able to send contents available to a group of users, using contents from their long-standing profiles search. It should be done based on understanding of what has been learned about text retrieval over the history activities. He used domain knowledge to support inference as a part of information retrieval. Mostly inference and domain knowledge used in information retrieval process and learning techniques to improve the system performance and time complexity.

N. J. Belkin [2], views a recommendation system as a method to provide the user with contents that are able to satisfy their information requirements. K. I. Bin Ghauth [11], proposed a hybrid system of recommendation for the e-learning environments. Researchers combined the collaborative and content-based filtering approaches and used a keyword maps technique for extracting the content automatically. The selection of keywords from context-based documents therefore, helps to minimize the necessary time for providing those key words. To summarize the above-related work of recommendation systems, table 2 shows the related literature work map by focusing the filtering approaches.

Table2: Summary Of Related Literature Work By Their Filtering Approaches

Content-based Filtering	Collaborative Filtering	Knowledge-based Filtering	Hybrid Filtering
R. I. Ashwin [4], R. Nachimas [5]	H. Wrethner [1], A. A. Kardan [7], Feng jang Liu [13], Reginaldo [19]	Croft, W. B. [3]	N. J. Belkin [2], K. I. Bin Ghauth [11]

3. SYSTEMATIC REVIEW METHOD

A systematic review method is a way to indentify and classify research study related to research topic. The method of this systematic literature review is concluded with the aim to find and identify the gap in order to direct future work. Figure 1 shows the process flow of our systematic literature review method.

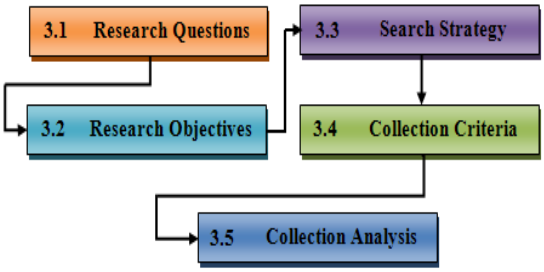

Figure1: Flow Of Systematic Literature Review Method

The goal of this study is to program the Systematic Reviews, using a stepwise method. These steps of the Systematic Review method are outlined below:

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3.1. Research Questions

The research questions (RQ) of this paper are listed as follows:

RQ1. What are the appropriate sources to search for qualitative material on recommender systems?
RQ2. Which recommendation approaches are mostly used and how do they function?
RQ3. How do recommender systems improve the quality of e-learning?
RQ4. What are the current issues in recommendation systems and how did previous researchers improve them?
RQ5. Which are the most important studies that have been researched and how can they be categorized?

3.2. Research Objectives

The research objectives (RO) of this Systematic Review were:

RO1. Comparative discussion on e-Learning Recommender system and their filtering techniques (addressing RQ1).
RO2. Number of journals, conferences and white papers published per year, their sources and acronym (addressing RQ2).
RO3. To identify the improvements in previous studies in e-Learning recommender system domain using their Algorithm/techniques and their improved problems and clustering them in Filtering Accuracy (FA) and Time Complexity (TC) (addressing RQ3).

3.3. Search Strategy

With the timely growth of e-Learning contents and resources, this literature review follows three search strategies (SS) as follows:

SS1. In the 1st strategy, we used some basic keywords like "Recommender systems", "e-learning", "content-based filtering", "collaborative filtering", "knowledge-based filtering" and "hybrid filtering". The purpose of this step is to refine the preliminary search of literature review content in different indexed journals database.
SS2. In the 2nd strategy, we refined the preliminary keywords like "content-based e-Learning recommender system", "knowledge-based e-Learning recommender system", "recommender system in e-Learning environment." etc. The major indexed journal databases are mentioned in Figure 1.
SS3. In the 3rd and last strategy, we classified the literature review articles according to their type, year of publication, publication source and their acronym. Table 2: presents the third strategy in detail.

3.4. Collection Criteria

The materials collection process is a manual search process of specific journals and conference proceeding papers. Table 3: shows the selected journal and conference papers that are included in this Systematic Literature Review. This table defines the collection process of data from different indexed databases. For this purpose we indicate paper type, year of publication; publisher and acronym of the following sources.

Table3: Selected Material Collection Sources

Paper Type	Year	Source(s)	Acronym
Conference paper	2011	Semantic Technology and Information Retrieval	IEEE
Conference paper	201c1	Multimedia Computing and Systems	IEEE
Journal & Magazine	2010	Electronic Search of vast information exchanger	ELSEVIER
White Papers	2010	Science Resources Search	SCIRUS
Journal & Magazine	2010	International Digital Organization for Scientific Information	IDOSI
Journal & Magazine	2010	Australian Journal of Educational Technology	AJET
Conference paper	2010	Information Technology (ITSim)	IEEE
Conference paper	2010	Electronics and Information Engineering	IEEE

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Conference paper	2009	*Irvine Computer Vision Laboratory*	ICVL
Conference paper	2006-2009	Institute of Electrical and Electronics Engineers	IEEE
Journals & Magazines	2008	Expert Systems and Applications	ELSEVIER
Conference	2007	9th Multimedia Workshop	IEEE
Journals & Magazines	2005	Knowledge and Database Engineering	IEEE
Conference paper	2005	7th E-Commerce Technology	IEEE
Journals & Magazines	2002	User Modelling and User-Adapted Interaction	SPRINGER
Journal & Magazine	1993	Institute of Electrical and Electronics Engineers	IEEE
Journal & Magazine	1992	Association for Computing Machinery	ACM

3.5. Collection Analysis

This section counts the number of search contents that were obtained from different sources; names are mentioned in Table 2. The reviewed contents are mainly in English. Literature review from other language sources will be defined in future work. For analyzing the indexed databases of used sources, we are using Analysis (AS) as follows:

AS1. Analyze the total number of contents/papers used in this paper regarding their publisher databases (in table 3).
AS2. Demonstrate material analysis of publisher databases using bar-based graph (in figure 2).

In this section, we analyze the total number of papers from each publisher databases and depict them in Figure 2. This graph explores an overview of indexing databases and the total number of conference proceedings, journal papers and white papers were collected from them. Bar colour representation is also defined at the bottom of it. All the collection of the contents is based on e-Learning Recommender System.

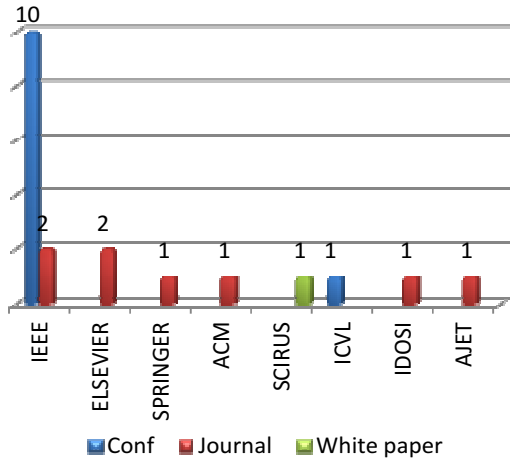

Figure2: Systematic Literature Review Indexed Databases For E-Learning Recommender System

4. SYSTEMATIC REVIEW STUDY

This section summarizes the findings of this study. Appendix 1 shows the detail of Systematic Review (journal, conference or white papers) with issue, volume and page numbers. In this Appendix 1: α represents journal paper, β represents conference papers and δ represents white papers. Dark portions of the tables means there is no such information available. Appendix 1also mentioned the total number of primary studies and years range of primary studies that the authors used in referenced papers. Appendix 1 is presented at the end of this paper.

5. SYSTEMATIC REVIEW RESULTS

This section includes the algorithm / techniques and their improvements that have been done by the primary study authors of this Systematic Review. The results are based on clustering the improvements of previous works. Table 4 shows the algorithm/technique, the author's improved work in primary study of this Systematic Review and its improvements. Clustering results are also displayed in the table.

According to the review of the literatures, clustering of improvements or drawbacks of recommender system has been defined in two ways namely: Filtering Accuracy represented by (FA) and Time Complexity represented by (TC). Table 4 shows the clustering results.

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Table4: Review Results On E-Learning Recommender System

ID	Algorithm/ Technique	Improvements	Results	
			FA	TC
SLR-01	Collaborative Filtering	Predicting learners goals	✔	✘
SLR-02	Selective Dissemination of Information (SDI)	Information filtering of recommender system	✔	✘
SLR-03	Knowledge-based Text mining filtering	Quick document sending to group of people	✘	✔
SLR-04	Text Mining-based content filtering	Improve recommendation service. Overcome information overload.	✔	✔
SLR-05	Web-based multimedia content filtering.	Improve the learning time with suitable resources.	✘	✔
SLR-06	Hybrid filtering	Improve item rating.	✔	✔
SLR-07	Collaborative tagging-based filtering with concept mapping.	Improve learning data suggestions	✔	✘
SLR-08	Hybrid filtering	Improve recommendation effectiveness in e-learning.	✔	✔
SLR-09	Hybrid filtering	Automatically filtering text-based documents. Minimize computational time	✔	✔
SLR-10	Content-based filtering	Improve correlation between user and item.	✔	✘
SLR-11	Content-based filtering	Improve user-item matching query. Improve user performance.	✔	✔
SLR - 12	Semantic-based filtering and Rule-based Filtering	Improve learner profile and recommendation storage accuracy.	✔	✘
SLR - 13	LDAP and JAXB - Techniques using to reduce the load of search engines.	Reduce the complexity of content parsing.	✔	✘
SLR - 14	Hybrid Recommendation using content-based and knowledge-based filtering	Improve new item (cold-start) problem, rating-sparsity problem and limited content analysis (transparency) problem.	✔	✘
SLR-17	Hybrid approach using content-based analysis, collaborative filtering and data mining techniques	Improve item (learning content) filtering accuracy and learner interest.	✔	✘
SLR-18	Knowledge-based recommendation technique.	Improve product selling opportunity and identifying results accurately.	✔	✘
SLR-20	Content-based filtering using extraction method	Improve recommendation quality	✔	✘

Note: Some reference materials (refer to Appendix 1) like: SLR-15, SLR-16 and SLR-19 are survey/review papers on study domain. These are excluded from this portion of the paper.

6. DISCUSSION

e-Learning is a materialistic electronic term of teaching. Traditional e-Learning services provide the page-to-page learning path to users/learners which increases the (time complexity) for finding the required learning content and decreases the learner interest. Recommender systems are covering these sorts of issues in e-Learning. e-Learning Recommender systems are far from page-to-page learning environment. It helps to decrease the content overload, increase the learner interest, and improve the time complexity issue by recommending the relevant learning content/item to the learner using collaborative filtering, content-based filtering, knowledge-based filtering, and hybrid filtering approaches.

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Focusing on the studies of previous researchers, we observed the relationship between user requirements and relevant recommended items (learning content) in a knowledge base underlying. The following reasons arising from the discussions on the recommendation of screening approaches were outlined for the sake of discussion (DR):

DR1. This approach can be a solution for the weakness of previous recommendation.
DR2. This recommendation can be domain independent while the majority of related works have dependency to the domain.
DR3. Recommended contents for e-learning must be objective, understandable and correct that collaborative filtering and content filtering is not based on an appropriate choice for the recommendation in e-learning.
DR4. Given the sensitivity and importance of learning and education, e-learning recommendation must have access to deep domain knowledge. Collaborative filtering and content filtering based systems aren't meets this requirement.

7. CONCLUSION

Systematic Literature Review (SLR) is a new technique for writing deep analysis literature reviews. In this paper, we have outlined the technical presentation of the study domain of the e-learning recommender systems. These systems are very helpful to improve the credibility of electronic learning. Such systems also help the learners' to spend less time to find the relevant learning objects and help to gain the learner interest. Recommender systems analyze the learner requirements, conclude the relevant learning content/items and recommend the most suitable information content to the learner. This paper takes an overview on recommender system filtering approaches namely, content-based filtering, collaborative filtering, knowledge-based filtering and hybrid filtering. Table 1 described the benefits and limitations of these four filtering approaches. We see that hybrid filtering is better in performing a vital role in recommender system domain. It improves both collaborative filtering and content-based filtering problems individually. The spread of topics covered by current Systematic Review are method, study and results.

8. FUTURE WORK

With the explosive increase of e-Learning publications and research resources, recommender systems contribute to the quality and effectiveness of e-Learning. Our planned future work is to embark on systematic literature review focussed on hybrid filtering recommender system for e-Learning environment. All the research retrieval is in English. In future research, we will also check research contents in other languages if they can be translated into English using translate.google. com.my.

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Appendix1: Summary of existing research on e-Learning Recommender System (α = Journals, β = Conference, δ = White paper).

ID	Author(s)	Title	Type	Publisher	Journal / Conference	Vol. No	Issue No	Date	Pages	Total Primary Studies	Years Primary Studies
SLR-01	Werthner, H., H.R. Hansen, and F. Ricci [1]	Recommender Systems	β	IEEE	40th Annual Hawaii International Conference on System Sciences			2007	167	2	2001
SLR-02	Belkin, N.J. and W.B. Croft [2]	Information Filtering and information retrieval	α	ACM	Communications of the ACM	35	12	1992	29-38	33	1971-1990
SLR-03	Belkin, N.J. and W.B. Croft [3]	Knowledge-based and Statistical approach to Text Retrieval	α	IEEE	IEEE Expert	08	02	1993	8-12	5	1995-2011
SLR-04	Ittoo, A.R., Y. Zhang, and J. Jiao [4]	A Text Mining-based Recommendation System for Customer Decision Making in Online Product Customization	β	IEEE	Management of Innovation and Technology	01		2006	473- 477	22	1992-2005
SLR-05	R. Nachimas and L. Segev [5]	Students' User of Content in Web-Supported Academic Courses	α	ELSEVIER	The Internet and Higher Education	06	02	2003	145-157	30	1997-2002
SLR-06	Mohsin, S.F. and R.U. Rashid [6]	Web based Multimedia Recommendation System for e-Learning Website	δ	SCIRUS	Int. J. of Advanced Networking and Applications	01	04	2010	217-223	19	1996-2005
SLR-07	Kardan, A.A., S. Abbaspour, and F. Hendijanifard [7]	A hybrid recommender system for e-learning environments based on concept maps and collaborative tagging	β	ICVL	4th International Conference on Virtual Learning			2009		14	1995-2008
SLR-08	Bin Ghauth, K.I. and N.A. Abdullah [8]	Building an E-Learning recommender system using vector space model and good learners average rating	β	IEEE	Advance Learning Technologies			2009	194- 196	8	1977-2008
SLR-09	E. Emadzadeh, A. N., K. I. Ghauth and Ng Kok Why.[9]	Learning Materials recommendation using a hybrid recommender system with automated keyword extraction	α	IDOSI	World Applied Science	09	11	2010	1260-1271	23	1980-2008
SLR-10	Khribi, M.K., M. Jemni, and O [10]	Automatic Recommendations for E-Learning Personalization Based on Web Usage Mining Techniques and Information Retrieval	β	IEEE	Advance Learning Technologies			2008	241- 245	12	1994-2007

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SLR-11	Ghauth, K.I. and N.A. Abdullah [11]	Measuring learner's performance in e-learning recommender systems	α	AJET	Educational Technology	26	06	2010	764-774	21	2000-2010
SLR-12	Shishehchi, S., S.Y. Banihashem, and N.A.M. Zin [12]	A proposed semantic recommendation system for e-learning: A rule and ontology based e-learning recommendation system	β	IEEE	Information Technology	1		2010	1-5	24	1995-2009
SLR-13	Feng-jung, L. and S. Bai-Jiun [13]	Learning Activity-Based E-Learning Material Recommendation System	β	IEEE	Multimedia Workshop			2007	343-	10	1993-2005
SLR-14	P. Pan, C. Wang, G. Horng, and S. Cheng [14]	The development of an Ontology-Based Adaptive Personalized Recommender System	β	IEEE	Electronics and Information Engineering	1		2010	76-80	7	1993-2010
SLR-15	Adomavicius, G. and A. Tuzhilin [15]	Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions	α	IEEE	Knowledge and data engineering	17	06	2005	734-749	112	1971-2004
SLR-16	Burke, R. [16]	Hybrid recommender systems: Survey and experiments	α	SPRINGER	User Modeling and User-Adapted Interaction	12	04	2002	331-370	49	1971-2001
SLR-17	Hsu, M.-H. [17]	A personalized English learning recommender system for ESL students	α	ELSEVIER	Expert Systems with Applications	34	1	2008	683-688	22	1988-2004
SLR-18	Felfernig, A. [18]	Koba4MS: Selling complex products and services using knowledge-based recommender technologies	β	IEEE	E-Commerce Technology			2005	92-100	25	1987-2005
SLR-19	Shishehchi, S., Banihashem, S. Y., Zin, N. A. M., & Noah, S. A. M. [19]	Review of personalized recommendation techniques for learners in e-learning systems	β	IEEE	Semantic Technology and Information Retrieval			2011	277-281	25	1998-2010
SLR-20	Souali, K., Afia, A. E., Faizi, R., & Chiheb, R. [20]	A new recommender system for e-learning environments	β	IEEE	Multimedia Computing and Systems			2011	1-4	13	1992-2010
SLR-21	Fensel, D. and C. Bussler [21]	The web service modeling framework WSMF	α	ELSEVIER	Electronic Commerce Research and Application	2	1	2002	113–137	48	1992-2003