Systematic Literature Review on Open Educational Resources Recommender Systems

https://doi.org/10.3991/ijim.v16i18.32197

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Abstract—In recent years, open educational resources (OER) gained in popularity among education and learning stakeholders. These resources are widely available on the internet, and recommender systems (RS) are commonly utilized to overcome the abundance of OER. This study aims to evaluate the advances in OER recommenders to identify the frequently used recommendation approaches, explore the technical background, highlight gaps in the existing research, and position our future research alongside the current studies. This paper comprises 413 papers published between 2005 and 2022. It is a systematic literature review with a deductive approach using the grounded theory technique, combining quantitative and qualitative analysis by adopting open coding (inductive and deductive) for content analysis. We employed Google Scholar as a search engine to crawl data, and findings are presented according to the (Bernard, H. Russell .2000) process. The review constitutes a reference for researchers in this field and the future developers of OER recommender systems. It reveals an emerging interest in the area; nevertheless, studies have not yet covered hybrid interactive recommendation systems, Chabot-based, teacher and course creators oriented. Further and future research is needed.

Keywords—recommender systems, open educational resources, systematic literature review

1 Introduction

Education refers to the process of imparting and receiving knowledge, it is an outcome of the human race's evolution that emerged for more than seven million years. In the age of new technologies, the Internet, as well as the chaotic data explosion, resulting from the intense expansion of information resources, education has experienced a revolutionary shift through its structures, enabling the invention of new teaching and learning methods incl, smart education, which is described in Ref [1], as" the completely new learning process in the modern information age". It entails the use of the newest smart technologies in conjunction with advanced pedagogical practices,

tools, and techniques [2] and makes online learning more accessible and commonly usable.

The increased use of online learning and its tools, eventually, resulted in what is known as open educational resources (OER). According to UNESCO (2019) [3], OERs are "learning, teaching, and research materials in any format and medium that reside in the public domain or are protected by copyright that has been released under an open license to permit no-cost access, re-use, re-purpose, adaptation, and redistribution by others." One might as well say, OER can be an optimal alternative to lower educational costs and make knowledge more accessible to all. They constitute an advantageous choice for educators when designing and developing courses or learning content.

The power and paradox of OERs is that they are accessible to all worldwide while also being adaptable to anyone in particular [4]. However, as a result of the massive growth of data sources, OERs exploration and filtering are becoming more challenging. Teachers, mainly, lack confidence in the curriculum's content; which necessitates their search for appropriate learning content [5]. The ability to appropriately and consistently ensure relevant, useful content is a deciding factor when making OER selection and adoption. In other words, providing proactive and interactive personalized curation and exploration platforms and systems is becoming a significant concern, since the distribution and allocation of OER should not be haphazard, and should no longer constitutes a daunting task for the education stakeholders.

We highlight and select Recommendation Systems (RS) as a crucial software tool that were created with the ultimate aim of assisting users in locating content that is actually pertinent and relevant to their needs across a variety of domains, including education. Rss can assist teachers in the decision-making process by applying information filtering, data mining, and prediction algorithms. They could provide each educator with a variety of options and choices of OER based on his or her interests, circumstances, or preferences [5].

Overall, OER-based recommender systems have been the subject of numerous studies, each of which focus on a distinct problem and raise a different concern. Despite the fact that we are only interested in teacher-oriented recommender systems, which will be the focus of our future work, we examined student-oriented systems as well; we preferred to go through all types of systems to clearly distinguish the technical approaches. We assumed that the study had to be broad and general in order to be a good academic reference in the topic. On the technical and ergonomic side, we anticipated that a student-oriented recommender system may inspire the development of a teacher-oriented system. Thus, the purpose of this paper is to review recent developments in OER recommender systems, as well as the various popular recommendation methodologies and technical specifications, in order to lay the groundwork for future research. The study identifies, also, gaps in the existing literature and research.

The paper is organized as follows:

- Theoretical framework: includes quantitative and qualitative analysis according to the research questions
- Conceptual frameworks: includes discussion and literature gaps.
- Our conclusion follows.

2 Systematic review of the literature research

A systematic literature review (SLR) identifies, organizes, and evaluates studies in order to discuss a clearly articulated query [6]. Our SLR is inspired by the research of the Ref [5], which aims to examine and review the existing studies on recommendation systems that support educational practices. Believing that OER accelerate the access to information and provide lifelong leaning; our paper focus and investigates further on OER based Recommenders. The research embraces the field's current evolution. It's an examination of existing theories to gauge the cogency of present studies in order to identify and discover, henceforth, technical tendencies gaps and potential and future research opportunities. We followed the research of the ref [5] to draw up our methodology:

2.1 Methodology

Our process consists of the following steps: 1) Mean need for the study, 2) Research questions, 3) search query and strategy, 4) data source choice, 5) data analysis, including quantitative and qualitative analysis, 6) Results and findings according to the search question and 7) discussions and conclusions.

To optimize the accuracy of this study, our review is composed of quantitative and qualitative modules, and our methodology consists on gathering data to analyze, going from generalities in the quantitative analysis, and examining in depth using a grounded theory in the qualitative analysis. The study is conducted following the presented phases;

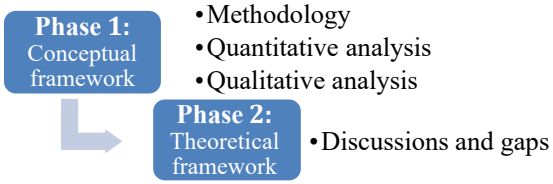

Fig. 1. Conceptual/Theoretical framework

The need of the study. The study is an in-depth analysis of recommendation systems specializing in OER. This paper covers various aspects from the current literature. It constitutes a reference and a foundation for future research of OER based recommenders. It serves, also, as a prelude to our future researches. The research is guided by the research questions

Research questions

Analog classification of the research. Authors of the reviewed papers approached the topic of OER recommender systems from several angles and perspectives. What are the different categories of the OER recommenders in the reviewed papers?

Approaches. What are the different approaches and the several technical features covered by the review studies? And what are the datasets of OER that were explored by the existing studies?

Findings and future works. What are the gaps that are not covered by the existing literature? What are the possible future works?

Inclusion exclusion criteria

Inclusion criteria. This review only includes research related to Open Educational Resources Recommender Systems. For the search and metadata retrieval, we used the software Harazing's publish or perish (pop) Harzing, A.W. (2007). It is software that analyzes academic citations. It gathers raw citations from various data sources, analyzes them, and offers citation metrics. The inclusion criteria were as follows:

1. Written in English, 2 papers were written in Spanish
2. Published between 2005 and June 2022
3. Peer reviewed
4. Including different decisions/models/theories/ technologies/approaches regarding
5. Education, learning, course creation.

Exclusion criteria

1. Papers that were not written in English or Spanish;
2. Papers to which there was no full access or are available;
3. Papers that focus on recommender systems but does not focus on OER;
4. Papers that were not performing adaptation on at least one factor;
5. Papers that are not detailed or lack explanation;

Inclusion exclusion chart flow, research strategy and data screening

Search query. The main two keywords used for this review are "Recommendation systems" and "Open educational resources" For each result; we concluded an initial relevance based on the research titles and abstracts. We specifically used the terms "Recommender Systems" and "Recommendation Systems" as intuitive generic key words combined with "Open Educational Resources". We also used the common abbreviations "RS" for Recommender Systems and "OER" for Open Educational Resources. The accurate Boolean query is (("Open educational Resources") AND (" Recommender OR "Recommendation" OR "Recommendations") OR (("educational resources) AND (" Recommendations OR "Recommenders"). We ran the above query in the Google Scholar database to become acquainted with the terms and to acquire a qualitative understanding of the existing research.

Research strategy. We extended the search terms in the pop search engine. We used "Open Educational resource" as a main search term in the title and “Recommendation system” and” recommender system” as key words.

Research period. We reviewed all the papers scrapped, starting from 2005 to June 2022.

Data source. We used Google Scholar for providing the most comprehensive coverage of data, as stated in ref [8]. To avoid recurrences and duplications, we chose not to extract data from other academic databases since google scholar includes and co-

vers, largely, other digital libraries. The choice of this database enabled the acquisition of "grey literature," such as conference proceedings.

This section emphasizes the Prisma chart's four steps of inclusion and exclusion: "identification," "screening," "eligibility," and "inclusion." The results of the search on the google scholar engine led to a total of 795 articles.

382 publications were eliminated since they did not fit the topic's relevancy based on their titles, keywords, or abstracts. The subsequent papers were removed as they failed the eligibility criteria, either for the reason that their text did not directly connect to our search field or their content lacked details and precision. Duplicated research papers were revealed and eliminated during the "screening" procedure. We obtained 413 documents using pop.

Using the pop program to collect, screen, and save data, we discovered 413 papers containing the main keyword OER and the related keywords to Recommender System. As indicated in ref [119], we utilized the python program AsReview, a machine learning software tool for systematically review papers, and analyze metadata. Asreview has the ability to significantly improve the efficiency and relevancy of the SLR [120] process. Asreview allows the user to screen the records while the active learning algorithm (Naïve bayes in our case) ranks the unlabeled records in the back from the most to the less relevant.

Only 110 studies were judged relevant to our research objectives. Aside from OER Recommender Systems-related papers, research on OER that do not contain Recommender Systems; and studies that include the keyword "recommendation" but do not pertain to the technical connotation of our interest, are deemed wholly irrelevant.

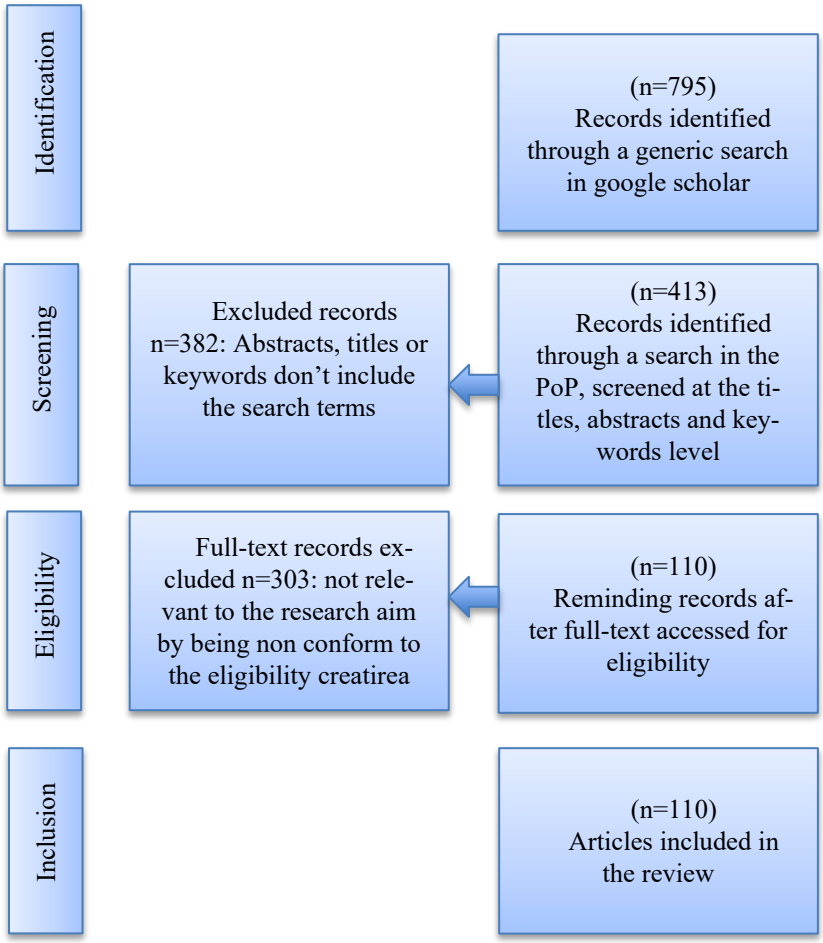

Fig. 2. Prisma chart

3 Phase 1: Conceptual framework

3.1 Quantitative analysis

This section considered all the 413 screened papers in the pop software, analyzing only titles, abstracts and key words. Figure 3 demonstrates that from 2005 to 2018, the number of publications increased exponentially.

From 2012 to 2018, however, the number of publications per year oscillated between the same values, never falling below 23 publications and never rising above 33 publications, research in the field knew a maturation period. In 2019, noticeable increase was recorded. UNESCO called for more research on OER sustainability models the same year (UNESCO General Conference in 2019).

In 2020, researchers produced, for the first time, 50 studies. This sudden increase is attributed to Covid-19's expansion, which encouraged the use of online learning in general and OER in particular.

Scientific production continues its spectacular evolution to reach its peak with 64 publications in 2021. We also note that during the first half of the year 2022, the number of publications is 26

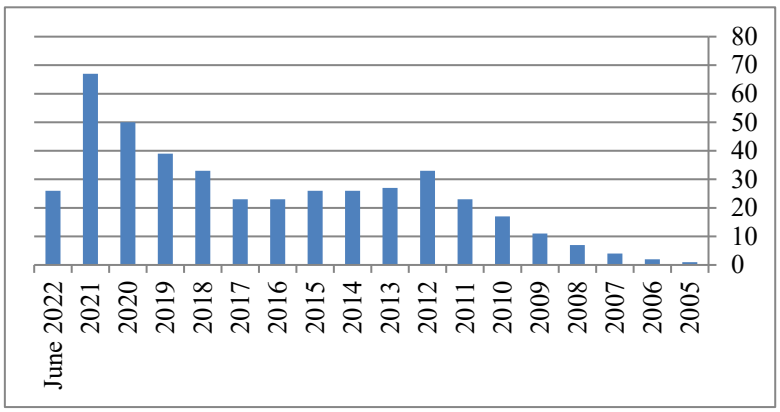

Fig. 3. The yearly evolution of the OER and recommenders

The studies were mostly published in the *Taylor & Francis*, *ieeexplore.ieee.org*, *Springer* databases. The following plot depicts the databases where our articles were founded. Our analysis does not consider rows of missing data also databases where less than 2 papers were published:

Table 1. Distribution of papers found in Academic Databases

Taylor & Francis	62
Ieeexplore	31
Springer	29
Proquest.	17
Researchgate.	26
Academia	12
MDPI	5
Elsevier	3
Wiley Online Library	3
ERIC	3
Science direct	3

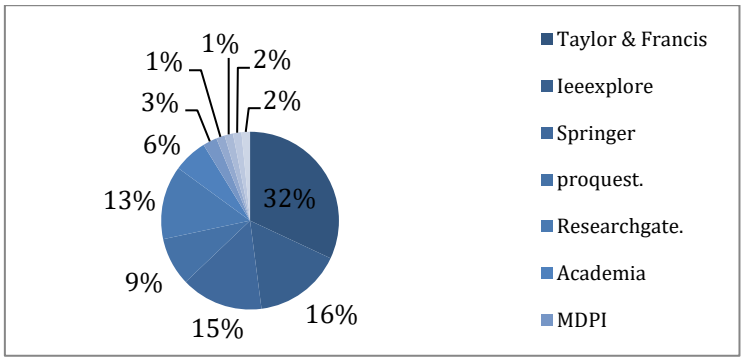

Fig. 4. Distribution of papers found in academic databases

After exploring the databases, we traced our data to extract the papers typology. 69.59% of PDF, 12.16% Books, 8.11% citations, 7.43% HTML and 2.7% DOC. We detected 256 Empty values among our data.

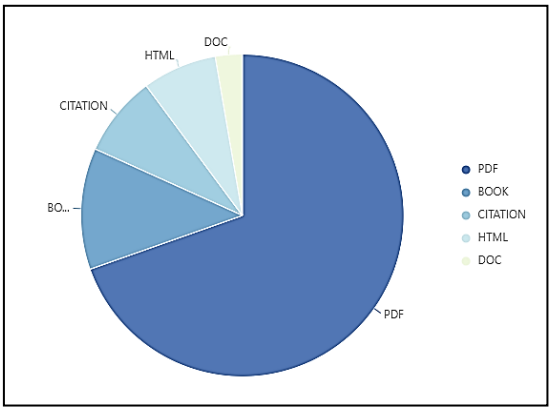

Fig. 5. Typology of papers

At this point, we looked at the geographical distribution of the publications and discovered that some of them are collaborative efforts between authors from different countries, the study of ref [117], which is a contribution from Colombia, Spain, and Argentina.

86 papers are from the United States, 50 from the United Kingdom, 37 from Spain, 21 from Canada and Germany each, 14 from China, 12 from Ecuador, and 11 from India, with the rest being equal to or less than 10 in number.

Fig. 6. Distribution of work relative to countries

3.2 Qualitative analysis

A systematic review's goal is to provide a detailed synthesis of all accessible primary research in answer to a research topic, as stated in Ref [9]. To undertake a thorough examination of a topic, an in-depth analysis through synthesis is required.

The key challenges addressed and important contributions on recommender systems related to OER are highlighted in this section. After applying all the inclusion and exclusion criteria and the screening rules, this section considers only the 110 relevant studies. We followed the described process in ref [10], to answer the research questions methodologically:

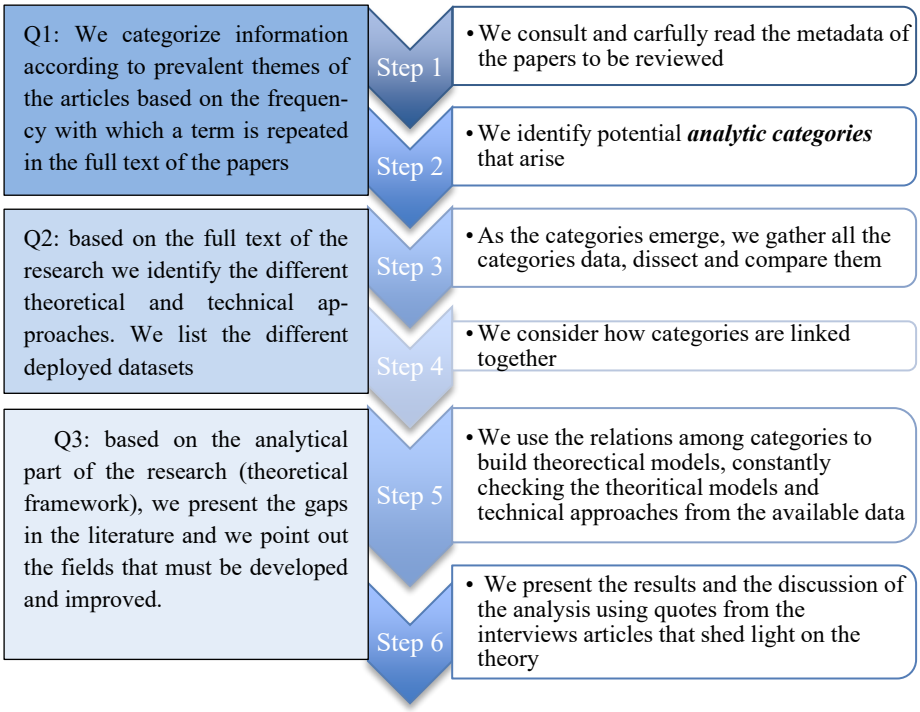

Fig. 7. The process of the qualitative analysis methodology

To initiate the process of determining analytic categories, the Tags Cloud chart was utilized to choose the root words. Figure 8 identifies the crucial terms in the abstracts and present their relative prominence and significance. The words cloud graph was created with Python, Pandas, Numpy, and Matplot.

Fig. 8. Words cloud from the abstracts of the retrieved articles

The most relevant and remarkable terms are:

- Open educational, OER, Educational Resources: the main terms.
- Recommender System, recommendation system, recommendation: generic keywords.
- Teaching, learning, teacher, student, learner: Terms that represent the study stakeholder, main users and their actions.
- Higher education, University: the targeted academic levels
- Public domain, use, available, freely, free, cost, sharing, international, institutional: as previously defined in the introduction section; OER are free to use, reuse and share in public domain by users. This consolidates the learning approaches that match sustainability models for sharing learning international and institutional resources.
- Tool, platform, system: technical supplies to implement
- Quality: used feature to evaluate the OER
- Repositories, textbook: other features
- Literature, Review

To identify potential analytic categories, we generated the word tree charts. They presented codes based on the keywords appeared in the words cloud. We selected words with strong impact to establish the connections with our topic areas in order to expound on and appropriately evaluate the findings of the preceding graph.

Recommender Systems are categorized as a significant element of an open online learning environment, as a web application that interacts with the user and may be integrated into an Open Learning Environment (OLE), and they can evaluate and foresee group learning experiences. These interpretations can be understood by reading the word tree in Figure 9 recommender Systems of OERs might be pedagogy-focused or multi-objective (MORS), even recommend resources in MOOCs.

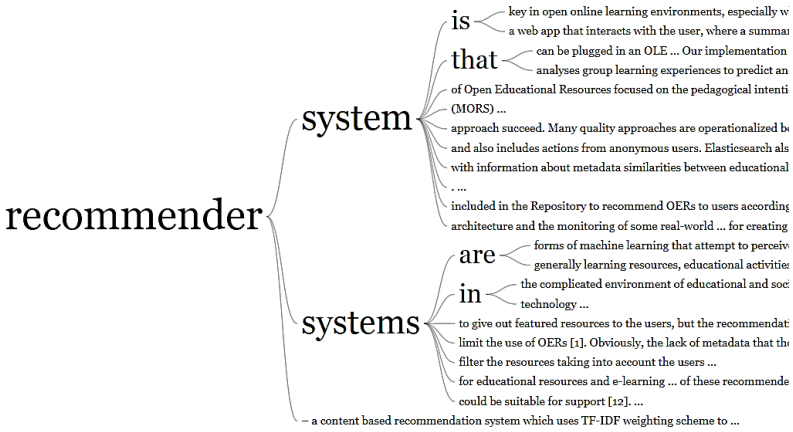

Fig. 9. Word tree for the abstracts and titles corpus related to Recommender

Recommendation systems are highly substantial to explore OER, as seen in the graph in Figure 10. They utilize OER repositories to provide the most relevant content. RS might be utilized and deployed in the OpenCourseWare (OCW) and could employ SOLO taxonomy.

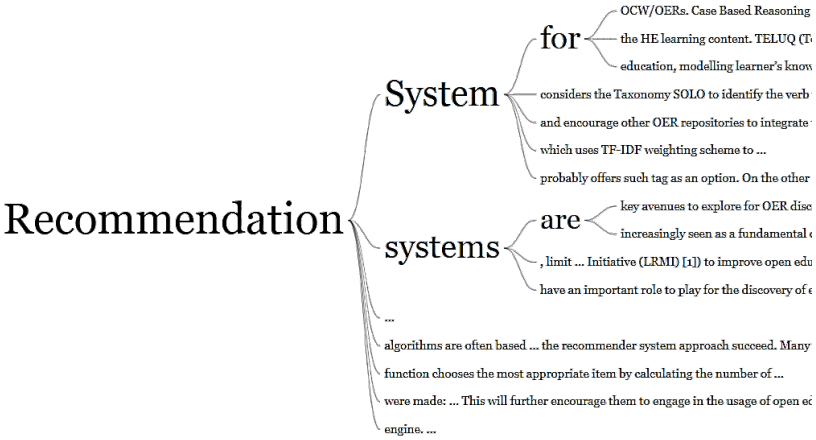

Fig. 10. Word tree for the abstracts and titles corpus related to Recommendation

We observe, in Figure 11, that teaching is contextualized relatively to innovation, pedagogy and open educational resources for teaching guides and practices.

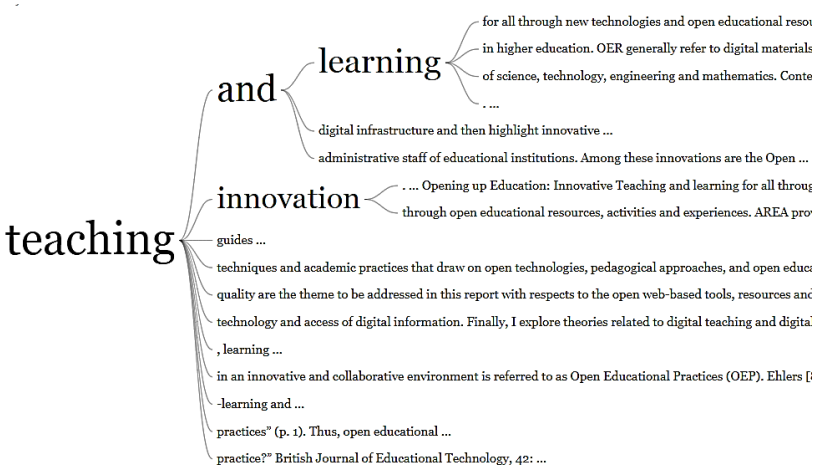

Fig. 11. Word tree for the abstracts and titles corpus related to teaching

OER could also constitute learning objects according to the word tree in Figure 12. And OER could be relative to learning pathways in MOOCs.

Fig. 12. Word tree for the abstracts and titles corpus related to learning

Based on the word trees, we assume that our data is categorized according to the following themes:

- General OER Recommender Systems: This theme includes propositions of OER based Recommender process that involved Recommender for teaching, learning and other purposes
- OER recommender for teaching purposes and course creation
- OER recommender based on MOOCs
- Generalities: includes all the literature reviews and the preliminary studies

Table 2. Data classification

Analog classification	Search concern	Related studies
Solutions for learning purposes (Student oriented)	General OER Recommender systems	[11], [12], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [30], [30], [30], [30], [42] , [44], [45] , [46], [49], [50], [51], [52], [53], [54], [56], [57], [58], [59] [100], [104], [111], [113], [114], [126], [127], [129], [131]
	OER in MOOCs	[28], [60], [55], [61], [62], [13], [16]
Solutions for teaching purposes or general solutions that could be applied to teaching purposes (Teacher oriented)	OER Recommenders for teachers or could be adopted for teaching purposes	[34], [35], [36], [17], [37], [31], [20], [36], [22], [39], [24],[25], [26] [27], [40], [29], [41], [42], [43],[44], [45], [46], [47], [31], [48], [49], [50], [51], [52], [53], [54], [124], [125], [128], [130]
Generalities	Literature reviews, SLR, surveys,,	[63], [64], [65], [66] , [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78] ; [79], [80], [81], [82], [83], [84, [85], [86], [87], [88], [89], [90], [91], [92], [93] ; [94] ; [95] ; [96] ; [97], [98], [99], [101], [102], [103], [105], [106], [107], [108], [109], [110], [112]; [115], [6]

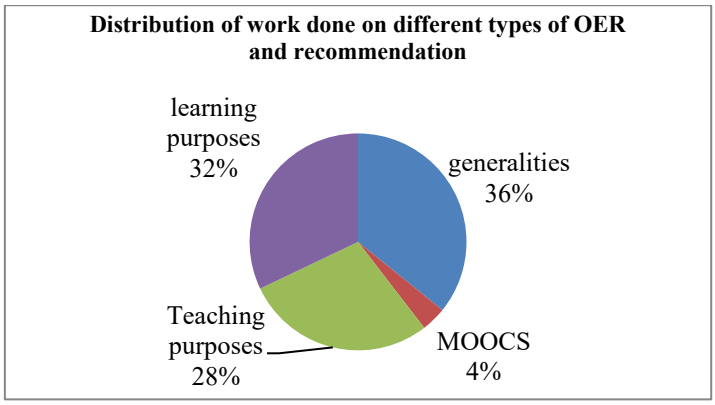

Fig. 13. Distribution of papers by themes

To adequately reply to the second research question, we read through each study one at a time to present the technical methods and the different algorithms and approaches used to create OER Recommender Systems. We are listing diverse sittings, approaches, features, used repositories and datasets.

Table 3. Approachs and features

Research concern	Used approach	Used technologies	Database
[11] Recommend OER in accordance with the teacher's pedagogical intention in his/her learning session. This model requires the use of resource metadata to describe the cognitive processes covered by this resource.	**Profil based:** Analyzing semantically the main verb relative to the objective of the course. This "verb" should be mentioned in the parameters that the teacher indicates in addition to the keywords for the thematic search, Language of the resources, Resource Type (exercise, magisterial course..), Level of knowledge of students, Level of interactivity of students	Taxonomy solo based on the LOM standard for metadata analysis	MERLOT repositories/ the Adriane repository FLOWER/OER commons repositories
[12] Hybrid Recommender System	**Profile based:** -Content-Based filtering -Collaborative Filtering to organize the priorities of the recommendations - Rule-Based Filtering -Demographic-Based Filtering	A crawler agent that retrieves resources from the web to CMS/LCMS K-nearest neighbor for for the collaborative filtering	Different Web repositories
[13] Recommender System for edex MOOC that could be implemented in any other MOOC that provides the users' profiles and the MOOCs' profile	**Profile based :** Xblock modular recommender system/ A model to automatically generate learning pathways from available open learning resources	Learning Object ontology of mapping (LOOM) and SPARQL endpoints Deep Learning Support Vector Machine (SVM) Long Short-Term Memory (LSTM) Natural language processing	Stored metadata from OER repositories

[14] Knowledge-based approach Based on the application of the Semantic Web technology	**Profile based:** Filtering based on linked data using ontologies	The LSI algorithm (Latent Semantic Indexing), which is implemented by Gensim3, library of the Python; Java (programming language) and the knowledge field from UNESCO, Programming Language	Semantic Web
[15] Educational Adaptive Hypermedia systems (EAH) based on pluggable components	**Profile based:** Automate open corpus slicing techniques to produce large volumes of content on-demand, at very low costs and with a suitability comparable to manually produced resources	Web Converted as Slices by using Information retrieval (IR), Information Extraction (IE) and densitometric approach to fragmentation	Semantic web
[16] Recommender engine that provides cross-site user recommendations based on the content they have visited	**Profile based:** Session based approach to analyze the users' cross-side behaviors: using cookies with the users' permission value is generated by the library and, with the user's permission, is stored as a cookie in the user's browser value is generated by the library and, with the user's permission, is stored as a cookie in the user's browser - Learning Analytics, session-based approach To analyse the users' cross-site behaviour - session-based approach To analyse the users' cross-site behaviour	K-means algorithm for clustering	Repositories: eucbeniki, University of Nantes, Universitat Politecnica de Valencia (UPV), Videolectures.NET (VL), and virtous by University of Osnabrueck - ese repositories are used in this research as they integrated the Connect Service into their platforms.
[17] A web based system to automatically generate and use an OERID so that all resources can be discovered, curated, and reused.	Describing an OER, by attribuating a unique ID (OERID) according to the Dublin Core Metadata Element Set standard	Node.js with several open source javascript components and Angular.js	Semantic web
[22] Skill-and-Competence based search and retrieval web services	**Profile based;** Categorization based on skill-and- competence features.	A competence taxonomy Simple Query Interface (SQI) SOLR which is a search server based on Lucene in Apache federated search technologies	A personalized dataset using a skill-based search and retrieval web services of European OER repositories
[23] A lifelong learning recommendation system for education	**Profile based** Recommendation based on the users' engagement	Bayesian Algorithms Wikifier, an entity linking technique that annotates resources with relevant	Videolectures.Nt

		Wikipedia concepts	
[25] Integrated Search Platform for Open Educational Resources based on a Recommendation System	**Profile/ Collaborative intelligence based:** A hybrid recommendation system, which consists of a collaborative filter and a content-based filter for collective intelligence and social recommendation (Based on the comments, likes and ranking	Alternating Least Squares (ALS) algorithm term frequency–inverse document frequency (tf-idf) statistic	Dspace
[29] Social and Semantic Tools into Open Educational Resources Production	**Quality based:** The features that are used Validity, Content, Language, Didactic, Applicability, Video , File format, License	Semantic linking using ontologies Folksonomies	Youtube, slideshare and OCW sites
[27] Recommending (driven by a quality model tenet) with (collaborative) feedback from users to recommend OCW and OER s within a unified framework	**Quality based with users' features filtering:** Hybrid approach of recommending framework for open OCW and OER that combines case based recommending based on a quality model with (collaborative) feedback from users	Similarity functions such as k-Nearest Neighbors (knn) algorithm search engine, taxonomy based	Online learning object repositories
[30] Ascertaining the Relevance of Open Educational Resources by Integrating Various Quality Indicators	**Quality based:** Studying the relationships among various, quality indicators (Evaluative, Empirical, Characteristics to establish correlations	A function to calculate the quality indicators' relevance	MERLOT repository
[27] Recommending (driven by a quality model tenet) with (collaborative) feedback from users to recommend OCW and OER within a unified framework	**Quality based with users' features filtering:** Hybrid approach of recommending framework for open OCW and OER that combines case based recommending based on a quality model with (collaborative) feedback from users	Similarity functions such as k-Nearest Neighbors (knn) algorithm search engine, taxonomy based	Online learning object repositories
[19] Metadata-based scoring and prediction models to anticipate the quality of OER	**Quality based** Machine learning model to predict the quality of OER based on their metadata and our scoring model using the following features: title, description, and subject	A Random Forest model was trained to make a binary decision highquality or low-quality	Personalized dataset based on a search result retrieval using skillscommons API
[27] Recommending (driven by a quality model tenet) with (collaborative) feedback from users to recommend OCW and OER within a unified framework	**Quality based with users' features filtering:** Hybrid approach of recommending framework for open OCW and OER that combines case based recommending based on a quality model with	Similarity functions such as k-Nearest Neighbors (knn) algorithm search engine, taxonomy based	Online learning object repositories

	(collaborative) feedback from users		
[24] A technology framework to facilitate the accurate centralized search of OER from the heterogeneous repositories	**Quality based** An ontology based search framework for OER parametrically measure the usefulness of an OER, taking into consideration the openness, accessibility and relevance attributes	Text mining algorithm to autonomously mined domain specific keywords	Directory of Open Educational Resources (DOER) the Rice University's Connexions repository
[27] Recommending (driven by a quality model tenet) with (collaborative) feedback from users to recommend OCW and OER within a unified framework	**Quality based with users' features filtering:** Hybrid approach of recommending framework for open OCW and OER that combines case based recommending based on a quality model with (collaborative) feedback from users	Similarity functions such as k-Nearest Neighbors (knn) algorithm search engine, taxonomy based	Online learning object repositories
[26] Prototype proposal for the selection of Quality Open Educational Resources	**Quality based:** Metadata analysis approach	Extract, Transform, and Load (ETL) process	MERLOT
[27] Recommending (driven by a quality model tenet) with (collaborative) feedback from users to recommend OCW and OER within a unified framework	**Quality based with users' features filtering:** Hybrid approach of recommending framework for open OCW and OERs that combines case based recommending based on a quality model with (collaborative) feedback from users	Similarity functions such as k-Nearest Neighbors (knn) algorithm search engine, taxonomy based	Online learning object repositories
[45] A methodology to Analyze hidden semantics in social bookmarking of OERs by using the crowd-sourcing phenomenon of social bookmarking for extracting semantics from the tags added by users, which describe links related to OERs	**Profile/ Collaborative intelligence based:** Using the most used tags as most relevant	Principal Component Analysis wordnet	Personalized combining data from Delicious and the users tags
[46] Evolve a computerized model that would drive the implementation of a OER information system particularly as it affects the assessment of all NUSOER repositories.	**Profile/ Collaborative intelligence based:** The model is based on users' ranking	Erwin data modeleriv. PC running Microsoft Windows 7/8/10 with at least 8GB RAM and 2.4GHZ quad-core processor.	-
[39] An approach that facilitates curators and instructors to annotate	**Quality based** A ranking based on indexation provide thematically OERs	Ontologies : LO Ontology/ Web Ontology Language	Pubmed repository

thematically educational content	suggestion	(OWL)/ Learning Object Ontology Repository knowledge graph representations vector-based learning the doc2vec algorithm	
[114] An approach for curation of open educational resources	**Quality based:** Metadata analysis	Application-linked repository MIKE2 http	Opencast Matterhorn and up2 to extract the metadata from the videos
[56] A tool for open education resource creation in a mobile context, and sharing in a social constructivism pedagogy	**Quality/Collaborative intelligence:** The tool is based on metadata analysis	Mobile sensors , IMS Content Package, and IMS Learning Design; coppercore HTTP and TCP/IP protocol.	Web-based repository: the learning content, added by users, is stored on the server, which acts as arepository
[49] Proposal of supporting framework for OER validation and testing process, considering both versioning and remixing features	**Quality based :** To support OER quality assurance and validation processes via a set of Software Engineering-based tests that take into account OER-specific features such as versioning and remixing, as well as the nature of some OER, The framework is being created in three aspects, namely the pedagogical, content, and technical dimensions.	Fuzzy logic	-
[50] Open Educational Resources Ontology	**Quality based:** Ontology used as consensual knowledge for the semantic description of educational content	An ontology based on the specifications of docbook and LOM metadata, language OWL	-
OER Recommender based on parsing metadata	**Quality based:** This framework validates OERs through metadata by parsing metadata, calculating local term weights, and calculating similarity scores	Local Term Weights Function Global Term Weights Function Similarity score calculation	Ozmozr harvester to gather atom metadata fromocwfinder
[54] Semantic framework in order to be used in the process of authoring educational material, it is an approach to assist educational practitioners in the generation and use of mashups of ers	**Quality based:** Provides to creators of ers a mashup of core components for the structuration of LOD OERs. The proposed method is for guiding to creators in the structuration of LOD OERs	Text mining and linked open data using dbpedia Spotlight and Keygraph; Lucene5 tool for indexation	Open University, MIT opencourseware, Stanford online Retrieved by Using SPARQL queries
[58] An open learning infrastructure that manages and makes avail-able Open Educational Resources	**Quality based:** Metadata analysis	OAI-PMH protocol/ LOM/XML dataset/ Simple Query Interface (SQI)/ REST API with a JSON binding of LOM/ SPARQL target on top of an RDF	Adriane repository (Added repositories to Adriane network)

		binding of LOM Dublin Core	
[35] Resource discovery hybrid approach where the textual components of open educational resources are automatically annotated with relevant entities; resources can be searched "by similarity" with another existing resource	**Quality based;** Approach based on semantic indexing	Dbpedia Spotlight for annotations Lucene open source search engine library for semantic description using thev "morelikethis" mechanism	Retrieved resources (obtained using the SPARQL endpoint of data.open.ac.uk)
[36] A system to automatically Create a course content package by remixing OER based on the Input syllabus	**Profile based:** An ABM approach to automatically create a course content package by remixing OER based on the input syllabus	Agent-Based Modeling (ABM)/fuzzy	Adriane and Slideshare (The approach is generic; it can be used with any OER repository and any content management system with free reuse and remix licenses)
[54] A proposal to identify OER Through an extraction process And with a recommendation Strategy that analyzes each one of the resources	**Quality based** The approach verifies Completeness, Consistency, Coherence, Modularity, Extensibility, Plurilingualism by analyzing Descriptions • Keywords • User Rating • Material Type • License Type	Python extraction functions, Scrapyb Latent Dirichlet Allocation (LDA) the three-tiered Bayesian model	Merlot/ OER Commons/ MIT
[55] A method for classification of educational resources based on user comments	**Collaborative/ Quality based** Rating OERs by analyzing positive and negative comments of users using quality centric collaborative filtering recommender	Sentiment analysis using term frequencies analysis and k-means algorithm for clustring	MERLOT repositories
[34] Edu-AREA : a Web 2.0 application whose main goal is to contribute to teaching innovation through open educational resources	**Social / collaborative based** Users can make contributions, arrange and annotate information records. The solution uses OERs metadata	Non-flat folksonomy ADEGA web service for text processing Ruby on Rails has been used as programming framework in the Web server CSS, javascript, Jquery and AJAX	Retrieved from different resources
[41] alternativa; technological infrastructure designed for supporting teachers in the creation, publishing and recovering of accessible OERs	**Profile based :** A technological framexork based on Collaborative filtring; LMS; Knowledge management; recommender user based filtering technologies such as demographic filtering, content-based filtering and collaborative filtering The user profile is founded on the following features: General, alternativa (	Business Analysis and Decision	The Fedora Commons digital content repository and the Islandora framework

	Performance, expertise in education and preferences of access to information), interaction and communixcation and pnp (Personal Needs and Preferences) section standard (ISO/IEC, 2006)		
[48] Modern, mixed search / recommendation system under user control for OERs	**Profile based** It provides discovery functionalities for educational resources according to the domain-oriented task adapted to pedagogical aspects It is based on discovery-oriented exploratory search, and supporting users in their domain-oriented tasks	Taxonomy of discovery-related tasks	Parsing educational resources directly in Google serps
[116] ATCE- A learning analytics tool to trace the creation and evaluation of OERs	**Quality based** A learning approach tool to support teachers in decision-making for the OERs quality and accessibility at the creation time as well as to provide information related with their competences	The automatic storing of HTML, The API of achecker DL (Decision tree)	
[53] Recommendation System with graph-oriented databases for repository of open educational resources	**Profile based** A system that gives recommendations of topics to each user separately according to the interest of each one of them based on search history	Neo4j architecture for graphics database	NEO4J graph-oriented database based on OERs from Antonio José de Sucre University in Colombia
[30] IIPSER.IIPSER a Proposed Recommender System for Open Educational Resources	**Profile/collaborative based** Context aware and collaborative recommender by predicting resources for users based on rating of other users	Machine learning: K Nearest Neighbors Classifier (KNN)and naïve Bayes	Created by the author using mysql with 13 attributes and 10,000 different resources
[31] Metadata-based scoring and prediction models to anticipate the quality of OERs	**Quality based** Analyzing the following metadata: url, title, description, date of availability, date of issuing, subject list, target audience-level, time required to finish, accessibilities, language list, and quality control	Pafy python library Z-score Random Forest classifier Normalized Importance Rate	Skillscommons / youtube data-set
[32] Blended Learning and Linked-Open-Educational-Resources-Data Approach	**Collaborative based** Enhance the discoverability, reuse and integration of OER into classroom instruction based on metadata	RDF graph-matching algorithm based on SPARQL queries Ad-hoc mechanisms, individual Web apis/Services	Most OER data are retrieved from, OER Commons4 , OCW initiatives , Merlot , and other OER repositories, where data are annotated
[33] An u-learning on the cloudbased open learning environment architecture	**Profile based/ context-aware** Context-Aware Ubiquitous Learning on the Cloud-Based Open Learning Environment	CBR approach Nearest Neighbor Algorithm (NNA) Fuzzy logic	-
[124] An Open	**Profile based**	Collaborative filtering	-

Educational Resources Recommendations Based on Elicited Teachers' preferences and competences	Recommendations are based on teachers' competencies and preferences	algorithms	
[125] A Personalized Recommendation System for English Teaching	**Quality based**	The multi-K nearest neighbor regression algorithm	Retrieved
[126] A model to rank OERs	**Collaborative filetering based** The aim of the reseach is to rank OERs	Forward Neural Network (FNN) The Timeline Aware Neural Network (TANN)	The YALEOPENCOURSEWAR
[127] An Educational and Career-Oriented Recommendation Ontology	**Profile based** Career-oriented ontology that provides a foundation for representing online learning resources	IEEE LOM Standard4 and LRMI Standard5. Curriculum Course Syllabus Ontology (CCSO) and schema.org6.	-
[129] An AI-based open recommender system for personalized labor market driven education	**Qality based and profile based** The system provides high quality OER based on the future career of the learner	Latent Dirichlet Allocation (LDA	-
[131] A deep matrix decomposition model extended from standard Matrix decomposition to recommend learning resources	**Profil based** The proposed system aims to recommend learning resources based on learners' abilities and requirements	Standard matrix factorization and the deep Matrix factorization models	- Ratings dataset -BX-Book-ratings dataset - Ratings-Books dataset -Related-Article Recommendation dataset - librarythings dataset

3.3 Findings

To recapitulate explicitly the answers to the research questions, we present the statements below:

- The reviewed papers approached the OER recommenders either from learning or teaching perspective. We observe that researches pertaining to learning objectives comprise 64% of the total corpus, whereas studies pertaining to teaching purposes compensate just 36%.
- Even if they are underutilized, MOOCs are potential and promising venture for implementing OER recommendation systems.
- The authors of the reviewed articles relied on the user's profile approach, the quality of the OERs or on both together to create their system:

Quality based approach. Most of the reviewed research focused on the quality approach. However, quality is a nebulous concept, not a fixed element [82]. It is only defined when it is linked to another notion or criteria. For example, authors are considering quality approach by refering to the quality of metadata describing the

OER, the ease by which they were found an selected or even the quality of the OER content and its accuracy.

To evaluate quality authors considered:

- Validity, which represents the resource's applicability based on its creation date.
- Language as the feature that assesses the appropriate use of composition, spelling and grammar.
- Didactic which concerns proper structure, in order to maintain attention, knowledge and learning process.
- Applicability to examine the connection between theory and practice. Video quality (if the OER contains a video).
- File format and license which indicate the type of usage that the resource can be made available for, as described in ref [121].

The quality-based approach is founded on semantic indexing as the technic in which resources can be found "by similarity" through resemblance to other existing resources, as stated in Ref [35]. This approach tends to scan OER metadata to identify quality objects and features and then make recommendations.

Also, we notice that researchers are moving toward automation practices and increasingly turning to intelligent patterns to facilitate and optimize the recommendation process for OER based on quality characteristics and parameters. And ontologies are the commonly used technical asset for retrieving and categorizing OERs based on quality. Text mining algorithms [24], deep learning algorithms such as decision tree [116] or even fuzzy logic [49] and Bayesian models are substantially deployed.

Profile based approach. In recent years, research has shifted attention to a context-aware, profile-based approach to provide more tailored recommendations. This emphasizes the importance of putting users' concerns first. Consequently, personalization in Technology-Enhanced Learning (TEL) has been a key focus of active research for many years, and contextual information is utilized to simulate and predict users' interests. The user's profile is derived indirectly or directly from his/her activities and other components recorded in the system, including his/her boards. This gives a decent picture of the user's skills, abilities, experiences and interests. The profile-based recommendation must consider the environment or configuration, which includes, as stated in ref [47], both the technology accessible and the elements such as audience, dates, subject, location, and so on.

Another component of the profile-based method could be OER suggestion and predictions based on an input syllabus or guide to automatically build a course material bundle, such as in ref [36]. Also, the suggestion based on user profiles might depend on activities and interactions history, as stated in ref [53], additionally to users' engagement, as labeled in ref [23]. The profile-based approach includes context-aware techniques, that incorporate discovery functions for educational materials based on tasks and domains that adhere to certain pedagogy [48].

Similarity functions based on taxonomies are, commonly utilized for OER recommendations using profile-based [33].

Collaborative and social approach. It is a hybrid approach that combines profile or quality-based features, or both, with collaborative components such as rating and rankings provided by users [30]. This approach could be based, also, on users' impressions expressed in comments or social interactions using sentiment analysis algorithms, as described in ref [55]. This form of recommendation could be founded on users ranking based on a quality evaluation [27]. As stated in ref [32], Linked-Open-data could be used for this approch as well.

The authors of the reviewed research have used the following repositories and datasets:

- Personalized dataset based on stored data and metadata from different sources (31,58%)
- MERLOT repositories (16%)
- Universities repositories (13,16%)
- Semantic web (10,52%)
- Social media (Youtube, Slideshare..) (8%)
- OERcommon repositories (6%)
- Adriane repositories (6%)
- Others: Fedora, ocwfind, pubmed, Dspace (8,74%)

4 Phase 2: Theoretical framework

4.1 Discussion and gaps

Numerous studies have shown that learners and teachers can benefit significantly from OER recommender systems, as they pursue educational materials that are more in line with their preferences, requirements, and learning processes and pedagogy in general. Compared to other literature research [127], this paper is a thorough extension of preceding reviews. Our analysis is consistent with previous literature reviews, although it is broader and more extensive; it is presumably the first study to consider teacher-oriented and student-oriented systems, and it spans studies from 2005 through 2022.

Authors of the [132] have already conducted preliminary studies on the Digital Learning Objects (DLOS) and/or Digital Simulation Tools (DST) management for teachers, without dwelling on the technical aspect but focusing more on the viability, prerequisites and potential adoption of digital learning objects by teachers.

The majority of empirical surveys and theoretical studies examine the motivation and the volition of the teaching community to adopt OER. Teachers often welcome sharing and reusing OER and aim to try Life Long Learning. Different studies were concluded in several countries, including Canada [99], China [101]. Netherlands [95], Australia, and others.

In the systematic review of the ref [127], authors have reviewed 98 articles related to the use of RS in education. According to this study, Data in the education field is coming from heterogeneous sources, even though; OER should be given more consideration and attention by the education sector [69]. We only focus on OER, since; it

was found that no literature review has been done to cover studies relating to recommender systems for OER. We conducted the following statements in order to address gaps in the literature:

Adoption of pedagogy as a quality approach and feature. Pedagogical quality scores could be used to enhance traditional content-based OER Recommenders by allowing them to recommend OER that are of higher quality and similarly pertinent to users. Pedagogy is a main feature for quality of OER that should be considered and evaluated [65]. Open content, even of excellent quality and well located for the user, might be insufficient for successful lifelong learning. Before discussing valuable open materials, technologies, and licenses, it's important to think about whether these resources meet conforming pedagogical criteria [122]

Adoption of MOOCs as OER sources. Additional to the OER repositories, datasets, and databases listed in the previous section, MOOCs contitute valuable sources of OERs. MOOCs have a lot of potential to address different issues in education, such as improving the quality of instructional content and making quality educational resources available [70].

Accuracy between OERs providers and users. It was discovered that there is a disconnect between the opinions of potential OER users and the OER solutionssuppliers. There was a disagreement in various areas, with occasionally startling mismatches between reality and expectations. According to Ref 80. Similarities between OER users and providers should be calculated to provide accurate recommendations.

Adoption of mobile technologies. We observe an obvious lack in the OERs recommenders for mobile technologies. According to Ref [133], researchers worldwide are called to publish research papers on mobile technology's pedagogical uses.

Local and national context. A state-of-the-art for the evaluation of national projects in Morocco was undertaken at Cadi Ayyad University [77]. According to this study, Morocco began adopting OERs, convinced of the role that ICT integration can play in improving the quality of teaching and learning in its educational system. Starting from 2009, Morocco established the "Maroc Numeric 2013" plan under the administration of His Majesty King Mohammed VI. A strategy plan led by the Minister of Commerce, Industry, and New Technologies that intends to transform our country into a technology powerhouse.

Thus, to ensure the continuation of the momentum established by the previous national strategy "Morocco Numeric 2013" and to further accelerate the development of the digital economy, a new digital vision for 2020 has been developed using a participatory approach. The national strategy "Morocco Digital 2020" aims to accelerate Morocco's digital revolution, to reinforce Morocco's position as a regional digital center, and to remove environmental systemic barriers, with a particular focus on the governance and digital skills issues. (UNESCO 2017, Maroc 2017 report)

Morocco is the most engaged country in the OER movement of the Arab States that responded to the study relative to OERs [109]. The Ministry of National Education established the National Laboratory of Digital Resources, which creates and distributes digital resources and collects digital educational materials, including open educational resources.

There are a number of other initiatives in this field in Morocco, including collaboration between Al Akhawayn University and the Korea International

Cooperation Industry project, which aims to create digital resources that are free to access and use for scientific disciplines at the secondary level. The Moroccan-Korean Center of ICT Training also has a Unit for the Promotion of Software and Open Educational Resources, which was created to support the national policy of ubiquitous use of these technologies through the generalization of Information Technologies and Communication in Education (GENIE) program by providing very low-cost, and often free, ICT solutions. [123]. Morocco hasn't yet explored mobile learning or mobile recommenders for educational materials. The Ref [134] prototype might serve as inspiration to begin developing and examining mobile learning in Morocco.

Adoption of OER recommenders for teaching purposes only. Students-focused and general OERs recommenders are much more prevalent than teachers-oriented ones. Only the study of the ref [128] presents steps toward personalized recommendations for teachers' use of educational resources.

5 Conclusion and future work

This study is a comprehensive review of OERs recommendation systems, and it's goal is to conduct a SLR on existing OERs recommendation systems. It could serve as a milestone for researchers and academics in the field, as it deals with and evokes the sides concerned by these systems, namely teachers and students, presents in detail the approaches relating to quality and profile, as well as the various technical components that can be deployed by an OERs Recommendation System, and finally traces all the gaps in the literature, the points to be improved, and the untreated aspects. We draw that OERs' Recommender systems remain an inherent solution for the choice, the classification, the curation and the selection of the most adequate and relevant resources for the users. The unique preferences and requirements of the users, on predetermined standards for the qualities of OERs, or on a combination of the two.

The systems intended for students are more numerous and more widespread than the systems intended for teachers only. In the future, we hope to fill the literature gap by outlining a framework for an OERs-based recommender system for the teaching community. The system will take into account educational and pedagogical features, adhere to quality approaches, and be context-aware. The future system would, indeed, be interactive and is using a chatbot to provide specific recommendations tailored to teachers' most specific demands and preferences.

6 Limitation

This study provides scholars and practitioners with actual research views on the use of recommender systems of open educational research for accessibility and functional diversity in educational contexts, by identifying gaps in the field that should be studied. However, the review results are restricted to the search terms used; thus certain papers may be excluded. This study provides a good foundation for further investigation into the use of open educational materials and activities in this setting.

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Article submitted 2022-05-03. Resubmitted 2022-08-07. Final acceptance 2022-08-07. Final version published as submitted by the authors.