Developments in Educational Recommendation Systems: a systematic review

1st Paulo Cesar Ramos Pinho
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
paulopinho@furg.br

2nd Regina Barwaldt
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
reginabarwaldt@furg.br

3rd Danúbia Espíndola
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
dmtdbe@furg.br

4th Márcio Torres
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
marcio.torres@riogrande.ifrs.edu.br

5th Marcelo Pias
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
marcelo.pias@cl.cam.ac.uk

6th Luiz Topin
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
ltopin@gmail.com

7th Albano Borba
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
albano@furg.br

8th Myke Oliveira
Centro de Ciências Computacionais (C3)
Universidade Federal do Rio Grande (FURG)
Rio Grande, Brazil
myke.oliveira09@gmail.com

***Abstract*—This abstract refers to a full paper in the research category. This paper presents a Systematic Review (SR) that aims at characterising the current scenario of Educational Recommendation Systems (ERS). ERS has recently attracted the attention of researchers in developing methods that contribute to the educational environment. Recommendation systems capable of searching and selecting relevant contents are one of the core technological resources offered to the education sector. Such systems which were initially designed for commercial applications (e.g. e-commerce) have now been used in educational application-driven research. For instance, a teacher might rethink methodologies and practises tailored to a set of pedagogical needs. These resources are enablers for the tools development that contribute to better educational practices. The goal of this SR is to provide an analysis of the current research efforts in the field of educational recommendation systems. With the string search of "educational support" AND "recommendation system" used in four academic databases (Brazil and International) 2016 and 2018. The SR returned 439 papers of which 54 were selected for further analysis. The results show that the profile-based filtering technique for recommendation is the most used, occurring 27.78% of the studies. In 44.44% of these studies, the target audience has been the students. Furthermore, the usual evaluation method was experimental achieving 41% of the selected papers. The results demonstrate applications in learning situations as the recommendation of digital resources, related to learning styles and based on ability and performance.**

***Index Terms*—Educational Recommendation System, Pedagogical Context, Personalized Recommendation**

I. Introduction

With the evolution of information and communication technologies, we approach an increasingly connected society, people are faced with an extensive diversity of options, and often an individual has very little, or almost no personal experience to make choices among the various alternatives presented to you [1]. Access to information and interaction is becoming more agile and dynamic, and distances are getting smaller and smaller. This impact can be seen in changes in behavior, consumption, and communications. Today's users are increasingly inserted and familiar with the technologies, setting themselves up as a generation that establishes new relationships with knowledge [2]. For these reasons, the motivation for the use of customization mediated by the use of Recommendation Systems (SR) arises.

SR helps increase the capacity and effectiveness of the product and service indication process and is already well known in the social relationship between humans [3]. Its purpose is to assist users in accessing data relevant to their

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profile and interest amidst the growing swirl of available information [4]. In this way, knowing the user profile, you can suggest resources based on your preferences, expectations, and needs. The scope of this recommendation allows it to apply 23 in many areas, such as e-commerce, e-learning, eScience, tourism, education, marketing, investments, among others. In the literature, it is possible to identify several factors that combine to define an SR, which are: types of resources to be recommended, filtering algorithms, methods, techniques, extraction and enrichment models of profile and context, performance and quality of results for the process recommendation.

The objective of this work is to understand the methods, techniques, and indicators used in the articles produced during the period from 2013 to 2018, in 2 national repositories and 2 international repositories; size the evolution of the publications, characterize the target audience, obtain the recommendation techniques used and determine the validation strategies of the selected articles, using Systematic Mapping.

This article is the first methodological step of ongoing research that aims to develop a framework for the educational context that monitors, evaluates and recommends books for students based on the university library collection.

Sections organized as follows: Section II details the research method used, results are discussed in Section III; threats to validity described in Section IV; and finally, Section V presents the conclusions and future works.

II. RESEARCH METHOD

In this section, the steps to perform a Systematic Review (RS) are described, structured based on the original guidelines proposed by [5]. RS is a method used to carry out bibliographic reviews in an organized way, with distinct stages, providing more magnificent scientific foundations and credibility [6]. In this method, the definition of research questions is essential for the establishment of the study focus of interest. Answered the issues, it is possible to conclude and analyze specific questions regarding the research problem. Another important consideration is to determine, at the beginning of the research, inclusion and exclusion criteria, whose purpose is to select the articles that will be analyzed. The set of questions and rules is called the research protocol [6].

According to [7], an RS has the following steps:

- Collection of potentially relevant publications on the analyzed question, usually being a search in services of indexation of papers in a particular area;
- Selection of the collected publications that meet the eligibility criterion specified by means of the reading of the abstracts and the articles, being able to be executed in different sub-steps, increasingly selective, and also, these readings can be carried out by two or more people independently, as a way of arriving at a consensus in the analysis;
- Synthesis of the variations between the articles selected in the previous step, summarizing the results of these articles generally in tables;
- Optionally, aggregate the individual results of each publication into a single result, and may involve complex statistical techniques.

A. Definition of Research Questions

Four research questions were defined to look for evidence:

RQ1: How have SR publications on the four scientific vehicles evolved over the last five years?

RQ2: To which target audience these publications addressed are?

RQ3: What were the techniques used in the recommendation?

RQ4: What were the evaluation methods used in SR?

The RQ1 aims to provide a historical understanding of research involving RS. RQ2, RQ3 and RQ4 report which target audience, recommendation strategies and assessment methods, respectively, are useful in monitoring progress and guide the evaluation indicators of the knowledge gained from the use of SR.

B. Conducting the Search

In this section, [6] defines the strategy for designing an appropriate search string, presents guidelines on defining it, to narrow the search scope. Thus, we select the keywords related to the research questions, to compose the search string, defined by [8]. The Table I shows the results of applying different strings, a large number of articles returned in the first and second string, the third string merges terms by using the logical "AND" operator, returning more relevant results and reducing the risk of excluding essential results.

TABLE I
SPECIFICATION OF THE STRING SEARCH

#	String	Total
String 1	Recommendation Systems	958
String 2	Educational Support	258
String 3	((educational support) AND Recommendation Systems)	439

The research strategy included only digital reference libraries in the area of computing, merging national and international repositories described below: The Brazilian Symposium on Computers in Education (SBIE) [1], Brazilian Journal of Computers in Education (RBIE) [2], IEEE Xplore Digital Library (IEEE)[3], Web Of Science (WOS)[4]. The RBIE and SBIE repositories chosen because they are part of the Special Committee on Computing in Education (CEIE) of the Brazilian Computer Society (SBC) and are related to the Brazilian Conference of Computers in Education (CBIE), one of the leading conferences in the area of educational technologies in the country. The IEEE and WOS repositories were selected considering their extensive coverage of Congress and journal annals.

[1] www.br-ie.org/pub/index.php/sbie)
[2] www.br-ie.org/pub/index.php/rbie
[3] www.ieeexplore.ieee.org/Xplore/home.jsp
[4] www.isiknowledge.com/

"The IEEE and WOS repositories were selected considering its extensive coverage of conference proceedings, journals, and training courses.

C. Screening of Papers

The definition of the inclusion and exclusion criteria identify key documents that provide content that is directly linked to search queries. To guide the selection of studies, exclusion criteria were defined:

- Articles not accessible in full;
- Summary articles, tutorials, workshop reports;
- Secondary and tertiary studies;
- Duplicate studies: only the most current included;
- Articles expressing personal views or expert opinions;
- Articles that do not address the recommendation of educational resources, or those in which this functionality is not the focus, or at least a prominent part, of the selected studies, and
- Studies dealing with ERS only as future work,

If the study met at least one of the criteria listed below, it would exclude from the process.

The Table II shows the number of studies retrieved and relevant after the application of String 3, following the analysis steps of the articles that are:

1) Use of the string mentioned in the search for publications;
2) Application of exclusion and inclusion criteria and
3) Further reading of articles.

Below are the values per step and search source in each chosen base. This process was carried out between June and December 2018, and 439 documents collected.

TABLE II
RETRIEVED AND SELECTED STUDIES

Digital Library	Stage 1	Stage 2	Stage 3
Xplore IEEE	136	74	23
Web of Science	224	54	5
RBIE	13	7	3
SBIE	66	44	23
Total	**439**	**179**	**54**

The studies selected in step one (stage 1) submitted to the inclusion and exclusion criteria defined in section 2 (stage 2). In this process, 54 documents remained (stage 3).

D. Data Extraction

After the search, the articles reviewed, and their summaries, keywords and publication dates analyzed and their relevance identified about the research objective. Relevant data were extracted from the research questions and separate evidence to support the RS results. These have compiled, and your information will present in Table III.

III. RESULTS AND DISCUSSION

The results statements of selected articles will be presented below.

TABLE III
RETRIEVED AND SELECTED STUDIES

Digital Library	Study	Amount
Xplore IEEE	[9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31]	23
RBIE	[32], [33], [34]	3
Web of Science	[35], [36], [16], [22], [37]	5
SBIE	[38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60],	23

A. Answers to Research Questions

In this section, we present the results grouped by research questions.

- **RQ1:** How have SR publications on the four scientific vehicles evolved over the last five years?

The first analysis classified the articles considering their temporal distribution. The figure ref fig1, shows that the SBIE and IEEE, considered the most representative in the IE area in their countries, had the peak of publications in the years 2017 and 2018. WOS and RBIE did not present significant values, were analyzed. In conclusion, the figures show, even with a drop in publications in 2018, that the subject is still relevant. Note that even adopting a period of 5 years, when applying the criteria, only studies from the 2016 to 2018 period were selected, suggesting that SR subject is relatively recent.

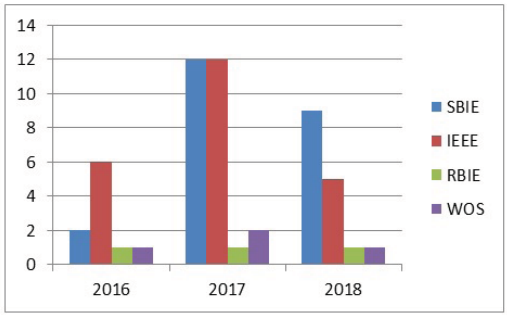

Fig. 1. Temporal Evolution of Studies.

- **RQ2:** To which target audience these publications addressed are?

The target audience's indicators for which the surveys are intended divided into five groups: Teachers, Students, Tutors, Other Professionals, and Unspecified the distribution of the studies in these categories presented in Table IV.

Most studies have Students as the primary target of content recommendations. Secondly, we have jobs that not geared towards any specific group or target group. This result shows

TABLE IV
DISTRIBUTION OF STUDIES BY CATEGORY

Target Audience	Amount	%
Teachers	9	16,67
Students	24	44,44
Tutors	2	3,70
Other Professionals	2	3,70
Not Specified	17	31,48

that student interaction as the content is one of the priorities for researchers and can best be visualized by looking at Figure 2.

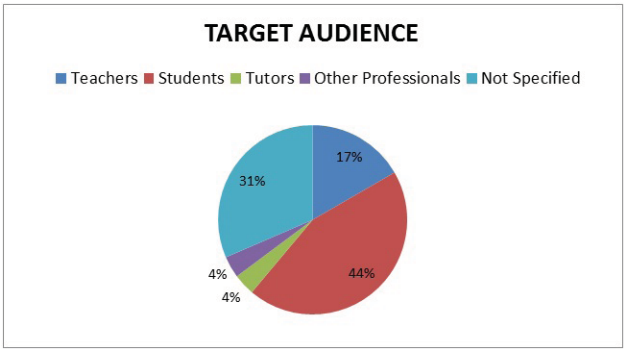

Fig. 2. Target Audience.

- **RQ3:** What were the techniques used in the recommendation?

This question aims to map the main techniques and methods used in the selected articles. Starting from the concepts of recommendation, we see that SR needs two factors to function correctly:

1) Information about user preference;
2) A method for determining whether an item is interesting to a user.

In the Table V we show the results found in the selected articles:

TABLE V
DISTRIBUTION OF STUDIES BY RECOMMENDATION TECHNIQUE

TECHNICAL	AMOUNT	%
Hybrid Filtration	5	9,26
Collaborative Filtration	6	11,11
Context-Based Filtering	9	16,67
Profile Based Filtration	15	27,78
Peer Filtration	0	0,00
Diagnostic Analysis	3	5,56
Learning Styles	4	7,41
Metadata Based Filtering	3	5,56
Content-Based Filtering	9	16,67

The analysis of these results demonstrates that the use of the Profile Based Filtering technique is predominant. Typically, user preferences include information about your profile, such as personal characteristics (age, gender, location, etc.), history of interactions with the portal in question, and product and service reviews.

The way to determine if an item is attractive to a user also highlighted in the articles since Context-Based Filtering and Content-Based Filtering techniques second in the researchers' preferences. Figure 3 shows the comparative panorama between the results.

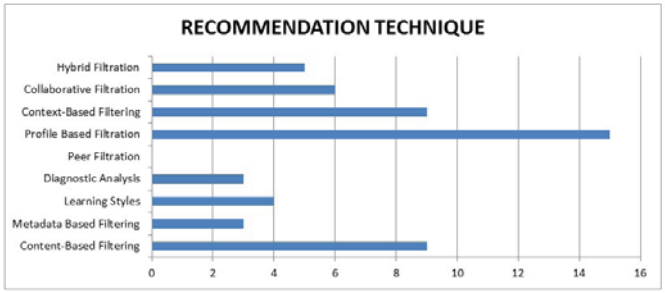

Fig. 3. Recommendation technique.

- **RQ4:** What were the evaluation methods used in SR?

In this question we try to verify how the authors tested the proposals of a recommendation of their works; for this, we group the methods of validation in 3 categories

1) Case Study: These are qualitative studies that generally answer questions that the researcher does not have much control over the phenomenon studied.
2) Experiment: which are tests where only one (or few) factors are changed each time, while all others are held constant;
3) Functional Tests: tests are designed to identify the faults in their programming by observing the structure and behavior defined by the proposal.

The results were compiled in the Table VI.

TABLE VI
DISTRIBUTION BY EVALUATION METHOD

EVALUATION METHODS	AMOUNT	%
Case study	22	40,74
Experiment	20	37,04
Functional tests	12	22,22

It is possible to identify that in 40.74 % of the researches they used Case Study, and that controlled experiments have a very close frequency, representing 37.04 % of the investigations. Functional tests were also performed, in 22.22 % of the works used. As can be seen in Figure 4, the analysis of the categories shown demonstrates a tendency among researchers in the case study as a process of validation and measurement of the quality of their proposals.

The purpose of this study was to bring together state of the art on SR, approaches, peculiarities, and orientations. According to the results of the research questions, it was

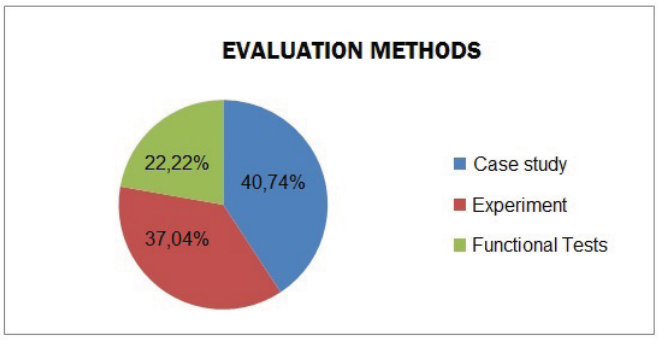

Fig. 4. Evaluation methods.

possible to notice that in 2017 the peak of publications on the subject was high, since fundamental topics were high, such as neural networks, machine learning, deep learning, data mining, computer-aided, artificial intelligence, have made possible more useful recommendations. The drop in publications highlighted in the chart is a natural process. Another significant result is the predominance of the student as the main target of the recommendations, not surprising since academic training needs many readings and studies and because of the diversity of information, recommending reliable content optimizes study time and effectiveness. Following the trend of commercial recommendations, the recommendation using the profile-based technique was an expected result, as it is widely used in e-commerce applications on the web, for example: bookstores, cinemas, news, advertisements, sponsored links, etc., where knowing the customer profile, based on their previous actions, has a positive effect on sales. The case study as a method of evaluation was also not surprising because, within the academic environment, this technique is widely used and diffused. The seven most recurrent terms presented in Table VII.

TABLE VII
DISTRIBUTION OF STUDIES BY RECOMMENDATION TECHNIQUE

Keyword	Recurrence
Recommender Systems	34
Computer Aided Instruction	13
Educational Courses	11
Data Mining	9
Education	8
Ontologies	6
Learning Objects	6

Figure 5 was generated to aid in the visualization of alternatives and trends using the 144 keywords used by the authors in the selected articles.

IV. THREATS

SM used a formal investigation process and conceptualized it as a more accurate approach than other methods in the literature review. However, elements may arise posing a threat to its validity. Fundamentally, the selection of repositories, the

Fig. 5. Word cloud showing keywords frequency

construction of the search string, and the research question deserve special attention.

In the process of constructing the search string, the individual use of each term presented great results; another appropriate point was to use repositories that did not present duplicate results, we chose to search for the most representative of the area. The correct choice of the repository and the search string increases RS's degree of reliability, allowing the researcher to be sure that essential results were not excluded or not shown, thus compromising the search result.

V. CONCLUSIONS

This work had the objective of reviewing the literature on the application of SR in the national and international context. A total of 439 articles were analyzed in four repositories to measure the main characteristics that make up the research team under the educational aspect. With this review, it was possible to verify and to size that the technique of filtering based on profile, the target public students and the method of evaluation by experiment are the most used. SM is an instrument used to investigate pieces and evidence, become familiar with the areas of research, find gaps related to research questions. Thus, the presented results help in making decisions about which learning methods, techniques, and taxonomies are most appropriate in the modeling and specification of architecture for educational software. The results show that there is a significant research gap; in the retrieved works, no frameworks found that satisfy the needs of the educational context. Besides, retrieved articles show that tools are needed to assist teachers in the evaluation and recommendation of content. SR is still very efficient tools for the guidance of students, teachers, other professionals of education, its breadth, allows to develop applications focused on books, bibliographies, videos, articles, magazines and so on. Future work should explore the benefits of learning and broaden research on recommendation techniques in Virtual Learning Environments, Institutional Repositories, Educational Resources, and Books and articles from the University Libraries collection.

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