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# RESEARCH TRENDS AND METHODS FOR RECOMMENDATION SYSTEM IN EDUCATION: A REVIEW

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**ABSTRACT**

This paper presents a review on the research trends and methods used in recommendation systems for the education domain over the last five years (2017 – 2022). The sources of literature were taken from 8 digital libraries where 29 papers were then selected for review using the PRISMA technique. This systematic literature review finds that the most widely used method is collaborative filtering (53%), followed by content-based (29%). It also reveals that researches in recommendation systems for education are still being carried out in 14 countries. These results show that there are still many opportunities for informed development and utilization of recommendation systems in learning engagement within virtual environment.

**Keywords:** *Recommendation System(RS), Education, Trends*

## 1. INTRODUCTION

In the near future, education is likely to experience a change in the use of technology as a learning medium. E-Learning, that relies heavily on the use of Learning Management System (LMS) has become the mode of delivery for teaching worldwide during the past three years due to the Covid-19 Pandemic that has affected every country. This new normal in education has not only created new demands and expectations from the various stakeholders, but also has opened new opportunities for innovations in E-learning per se. For example, to ensure smooth running of online learning and optimal use of the student's learning space, a recommendation function can be incorporated into the learning ecosystem to help the administrators, lecturers, and heads of departments in optimizing the content load on the LMS [1].

A recommendation system seeks to provide and assist a user in determining choices that suit his needs based on item information provided by the user so that data can be presented according to personalized criteria and convey learning objects with student tendencies [2]. Research on recommendation systems has been carried out quite extensively in various fields including education. An overview of personalization in education using recommendation system [3] presents important ideas about how and why students can benefit from such a system in an E-Learning environment.

Other researches include classifying learning outcomes based on self-assessment data on student potential and providing recommendations for curriculum development in universities that conduct online learning [3], providing proposals in the design of a recommendation system for new high-quality curriculum resources for educational technology specialization [5], and improving the utilization of open access scientific research information resources in the university's institutional knowledge base[6].

In this paper, we shall present our review on approaches to recommendation systems and opportunities based on educational trends. In particular, this systematic literature review gives special attention on the characteristics and methods used by recommendation systems.

From the results obtained, it will be known how far the system recommendations have progressed regarding some of the questions posed in this study.

The data obtained from the selected articles can be used as either references or expected contributions to the development of recommendation systems in the education sector. This is so because there are wide ranging elements that need attention in building a recommendation system that is appropriate and has good performance. Furthermore, there are still many ways to improve recommendation systems, such as through machine learning or deep learning. All these have become the motivation behind the systematic review presented in this paper.

## 2. BACKGROUND STUDY ON RS

Recommendation System (RS) is a program or technology that tries to predict the items that users may be interested in, presenting recommendations that represent the most appropriate items that offer products, services, or topics to users, taking into account the user's preferences, thereby facilitating decision-making processes [7].

In the beginning, RSs started as a tool that processes several sources of information with the purpose of increasing business profits in bidding and sales. The recommendation system can be seen as a useful information filtering technology in helping to predict the preferences of a user and which items are of interest to him [8], widely used by the domains of education, entertainment, tourism, commerce, and so on. In the education system, the main aim is to improve services to users so that they can stay motivated in the process of continuous learning through content-aware recommendations [9].

The study conducted by A.Khan *et al.* [10] describes the challenges and problems of RS as follows:

1. Cold-Start

Potential problems in computerized information systems include those involving levels of automated data modeling. In this case, it concerns the issue that the system cannot conclude about a user or an item that has not collected sufficient information in the database, which a new user usually enters into the system.

2. Scalability

Various users, items, and recommendations are made in different fields and environments. It takes a lot of resources to get perfect and efficient recommendations.

3. Sparsity

There are many items related to education. Most active users are a small part of the database, so the items are popular but probably the lowest. Therefore, the existing limitations are due to a lack of information.

4. Trust

Irrelevant comparisons between infrequent and active user access to profiles and item ratings will lead to trust issues when evaluating.

5. Privacy

One thing that is found most often is data privacy. In terms of providing the best for users with appropriate recommendations, the system will use data about users such as personalization criteria, demographics, and related to education.

Therefore, reliability, security, and user confidentiality are needed. Formal and non-formal institutions in education use specific algorithms to protect user privacy data from being misused.

6. Loss of neighborhood transitivity

At the relationship stage between users connected with other users, the recommendation system cannot be understood in this type of relationship. Still, it can be understood by knowledge of ontology.

7.Synonymy

Several words have the same meaning, which will cause problems with synonyms. In this case, what will have an impact, is the inability to make predictions on the recommendation system in representing similar items.

In overcoming this problem, a different approach is used with Latent Semantic Indexing (LSI) and Singular Value Decomposition (SVD) techniques.

8. Latency Problem

This problem is collaborative filtering, where new items are added directly to the database. Still, unused items must be reviewed before being recommended, so the system only recommends older items. To mitigate this problem, one should combine filter categories and user stereotypes.

Any recommendation system must have an impact on the behavior of a user with the provision of appropriate recommendations that make the user comfortable with the system.

In the development of a recommendation system, there are several methods being used,

including user-based collaborative filtering, content-based filtering, and hybrid. The content-based method provides recommendations by building user profiles. The hybrid-based method combines two or more methods. Merging is carried out with the aim of complementarity the lack of the methods used. Meanwhile, the knowledge-based method uses knowledge patterns to provide recommendation results.

A recommendation system provides several suggestions in one of the given types of techniques shown in figures 1[10], [11].

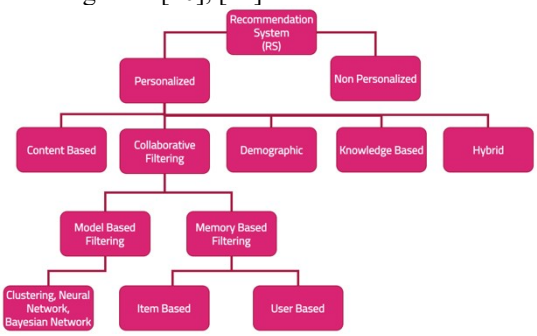


*Figure 1. Types of RS*

## 3. REVIEW METHOD

Systematic Literature Review (SLR) is a research by itself that follows a certain methodology for collecting knowledge about a certain topic by identifying, evaluating, and integrating findings from all relevant and high-quality studies that discuss one or more research questions of interest. SLRs are referred to as secondary studies where the studies they analyze are primary ones. According to B. Kitchenham *et al.* [12] there are two main phases carried out in SLR. The first, phase involves collecting results related to specific research questions. The second phase involves mapping studies. In reviewing the articles in this study, we have used the PRISMA technique (see Figure 2) to drive the review process based on research questions, research objectives, and relevant knowledge criteria.

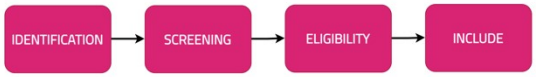


*Figure 2. Flow Diagram (PRISMA) adapted*[13]

The research questions (RQ) are determined to create focus in the research. It can be structured according to population, intervention, comparison, outcome, and context criteria[12]. We use this structuring concept in Table 1. below to formulate the research questions for our SLR.

*Table 1. PICOC*

| | |
|---|---|
| **Population** | RS Approach, Education, Course, Application |
| **Intervention** | Techniques, methods, models |
| **Comparison** | - |
| **Outcomes** | Successful RS education, RS development |
| **Context** | Studies education |

The procedure will be divided into several stages: determining research questions (RQ), determining research sources, determining index term patterns for the search process, determining inclusion and exclusion criteria, data mining, answering research questions described in the introduction analyzing the results.

### 1. Research Question(RQ)

Some of the research questions will be discussed in this study, therefore the scope of this discussion, which includes the extent of research on system recommendations in education. There are four questions as follows:

*Table 2. RQ & Purpose*

| Research Question | Purpose |
|---|---|
| RQ1: What approach does RS use in education field (formal and non-formal)? | Identify the most significant articles on the RS education approach. |
| RQ2: What algorithmic techniques are used to design RS? | Identification of algorithmic use techniques in RS |
| RQ3: How is evaluation of RS being done? | Identification of the evaluation methods carried out |
| RQ4: What platform proximity is used in development? | Platform identification done for development (web,mobile,desktop) |

### 2. Search process

In determining the articles to be selected according to the criteria, this study used several digital libraries as follows:

*Table 3. Digital Library*

| Source | Found |
|---|---|
| ACM (dl.acm.org) | 30 |
| Google Scholar (scholar.google.com) | 55 |
| IEEE Xplore (ieeexplore.ieee.org) | 124 |
| Pubmed (pubmed.ncbi.nlm.nih.gov) | 27 |
| Science Direct (www.sciencedirect.com) | 87 |
| Scopus (https://www.scopus.com/) | 106 |
| Springer Link (https://link.springer.com) | 93 |

| | |
|---|---|
| Wiley (https://www.onlinelibrary.wiley.com) | 47 |
| **Total** | 569 |

Search this article in the digital library using the following keywords:

1. ("recommendation* system*" AND Education OR eLearning OR student OR course)
2. ("recommendation* system*" AND methods OR issue)

The next stage in this application uses inclusion criteria and exclusion criteria to filter articles based on the research questions.

*Table 4. Inclusion and Exclusion*

| ***Inclusion*** | ***Exclusion*** |
|---|---|
| Educational Research. | Duplicate Paper from the same study will be automatic remove. |
| Past five years (2017-2022) | Irrelevant Topic |
| Title and Abstract Considered relevant. | There is no mention Of a recommendation system education and methods. |

## 3. Data Extractions

In this process, article screening will be carried out according to the criteria of the first stage of collecting all articles that have been entered. Then automatic deletion is carried out on the article where identification is based on the title and abstract as illustrated in Figure 2. Further screening is carried out according to the articles found and reviewed again as a critical review study as in Figure 3.

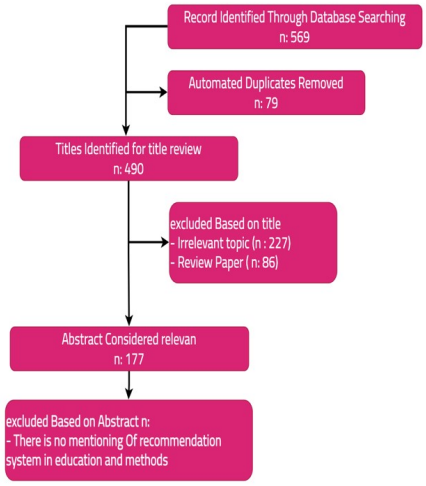


*Figure 2. Search Flow (A)*

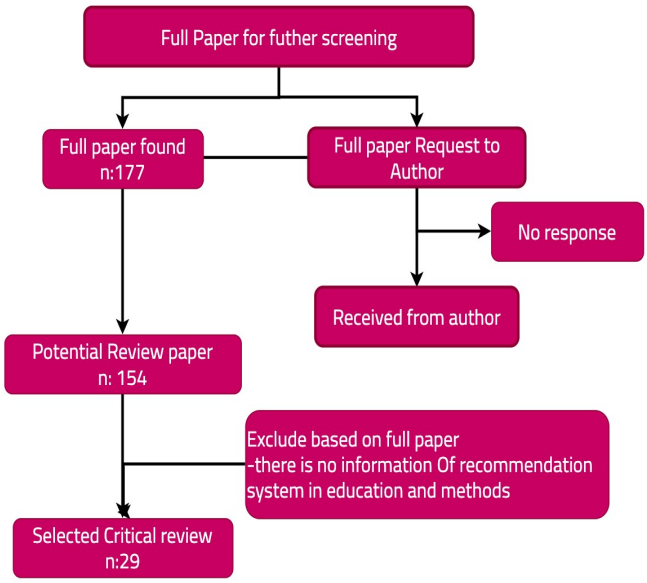


*Figure 3. Search Flow (B)*

## 4. Result

The following stages are the results of the study screening in the digital library as follows:

*Table 5. Inclusion Criteria*

| ***Digital Library*** | ***Paper Founded*** | ***Potential Paper*** | ***Selected*** |
|---|---|---|---|
| Acm | 17 | 12 | 1 |
| Google Scholar | 21 | 15 | 1 |
| IEEE Xplore | 31 | 26 | 9 |
| Pubmed | 9 | 9 | 0 |
| Science Direct | 15 | 15 | 2 |
| Scopus | 58 | 58 | 13 |
| Springer Link | 17 | 10 | 3 |
| Wiley | 9 | 9 | 0 |
| Total | 177 | 154 | 29 |

Based on our findings, we conclude that the development of recommendation systems in the field of education continues to be in demand, with many research papers that contribute in various forms such as conducting surveys, design and development, as well as investigating the use of technologies like web services, big data, and personalization.

*Table 6. Selected Article*

| Studies | RS approach | Techniques | Evaluation | Platform |
|---|---|---|---|---|
| Obeidat [14] | Content-based Filtering, hybrid-based Filtering | k-Means, k-NN | A priori algorithm association rule mining and SPADE algorithm sequential pattern mining | Web |
| Ali [15] | Content-based | k-Means | Not mentioned | Web |
| Wu [16] | Not mentioned | k-Means | Not mentioned | Web |
| Pariserum [17] | content-based, collaborative Filtering | Fuzzy Logic | Harmonic mean (HM) | Web |
| Nhi [18][18] | collaborative Filtering | Nlp | Kruskal-Wallis Test and Friedman | Web |
| Zhang [19][19] | collaborative Filtering | k-NN | DBNCF | Web |
| Shi [20][20] | content-based | Fuzzy Logic | Not mentioned | Web |
| Tong [21][21] | Collaborative Filtering | Not mentioned | MAE and RMSE | Not mentioned |
| Kurniawan [22][22] | Not mentioned | genetic algorithm | Not mentioned | Web |
| Amane[23][23] | Content-Based Filtering, Collaborative Filtering and Hybrid | LCRO ontology and MRO ontology | Not mentioned | Web |
| Khomeiny [24][24] | Not mentioned | Fuzzy k-Means | Not mentioned | Web |
| Lin [25][25] | collaborative Filtering based, content-based, knowledge-based | k-NN, SLIM | HR and (ARHR | Not mentioned |
| Lazarevic[26][26] | Content-Based | Not mentioned | Not mentioned | Web Mobile |
| Gulzar[27][27] | knowledge-based | Clustering | calculate precision, confusion matrix | Web, Desktop |
| Murad [28][28] | Collaborative Filtering | k-NN | mean squared error (MSE) | Web |
| Wang [29][29] | Collaborative Filtering | Bayesian estimation, neural network, SVM, k-NN, decision tree | Not mentioned | Web |
| Benhamdi [30][30] | Content-based Filtering, Collaborative Filtering, Hybrid | Not mentioned | Not mentioned | Web |
| Irish [31][31] | Content-Based | TF-IDF and decision tree | Not mentioned | Web |
| Emon [32][32] | Collaborative Filtering, Hybrid | Not mentioned | Not mentioned | Web |
| Adilaksa [33][33] | Content-based Filtering | TF-IDF | mean accuracy | Not mentioned |
| Bhumichitr [34][34] | Content-based Filtering | Not mentioned | Pearson Correlation, and Alternating Least Square (ALS) | Web |
| Ren [35][35] | Hybrid | Not mentioned | Not mentioned | Not mentioned |
| Paytaren[36][36] | Collaborative-Filtering | Not mentioned | mean accuracy | Web |
| Tahir [37][37] | Collaborative Filtering | Rf SVM | precision, recall, F1-measure and mean accuracy | Web |
| Tennison [38][38] | Collaborative Filtering | Not mentioned | precision, recall | Not mentioned |

| | | | | |
|---|---|---|---|---|
| Fu [39][39] | Collaborative Filtering | k-NN, | mean accuracy | Web |
| Piyawat [40] | Collaborative Filtering | Not mentioned | mean of the system quality and the standard deviation. | Web |
| [41] | Collaborative Filtering | Not mentioned | precision, recall, F1-measure and mean accuracy | Not mentioned |
| Yang [42] | Collaborative Filtering | SVM, logistic regression, ANN and naive Bayes | Preliminary evaluation | Not mentioned |

## 1. Recommendation System Approach

Table 6 presents approaches to recommendation system that are categorized based on the results of various domains. As shown in Figure 4, the most widely used approach is collaborative filtering (CF) which relies on feedback from similar users. This is followed by content-based filtering which presents similar attributes to the items selected by the user. Knowledge-based approach presents recommendations based on the condition of attribute values that the user has determined. Finally, hybrid filtering combines a few recommendation methods to produce measurable/accurate recommendations.

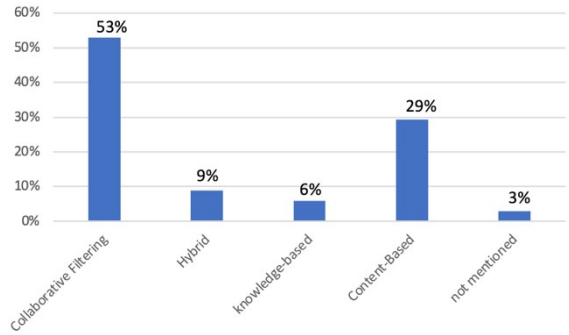


*Figure 4. RS Approach*

## 2. Technique

Various techniques used in recommendation systems in education, both formal and non-formal, are also shown in Table 6. From Figure 5 we can see that the most widely used technique is K-NN, which classifies objects based on data with the closest distance to other objects. This is so because it has the advantage in the classification of prospective student data that are unknown with the existence of training data and test data.

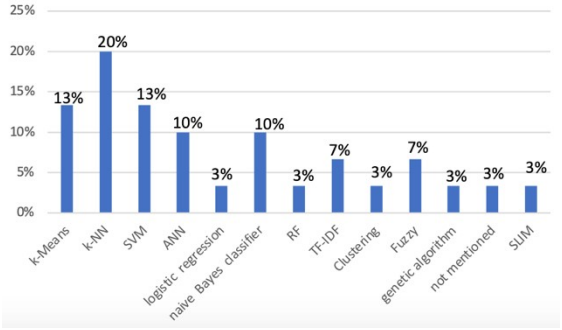


Figure 5. Techniques

## 3. Evaluation

Various evaluation approaches have been used in recommendation systems to determine their quality. Mean Absolute Error (MAE) is one of the methods used to measure the accuracy of prediction models. The result of the MAE will show an absolute error or mean absolute error between the predicted and actual values. The extent of usage of the other methods is shown in Figure 7 below.

In prediction, it is necessary to pay attention to the criteria to identify the size of the prediction error; in determining the requirements, it is expected to be used to obtain prediction results that minimize errors and avoid uncertainty in prediction data. The prediction results obtained are rarely really accurate because future situations and events are uncertain. However, if all the critical influencing factors are taken into account and the relational model of these factors is well defined, the predicted results will be close to the actual situation. This means special attention should be paid to choosing the method to be used. Nevertheless, in some instances, this situation may still prevail because no one predictive or forecasting process can be used universally for all situations.

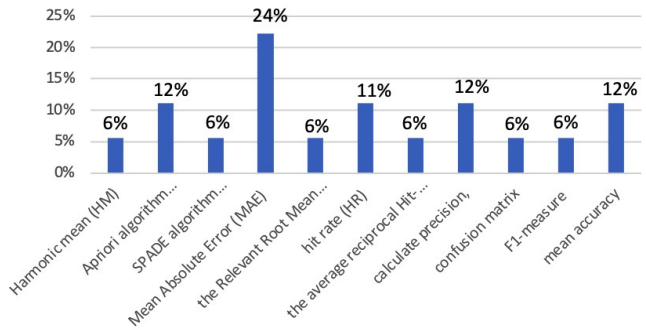


*Figure 7. Evaluation*

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## 4. Platform

Many recommendation systems for education have been developed on web platforms together with learning management systems and other relevant systems. In applying recommendation systems, the stages of predicting items are carried out, such as recommendations for students in selecting studies. In the process, the system will collect data directly or indirectly from the user.

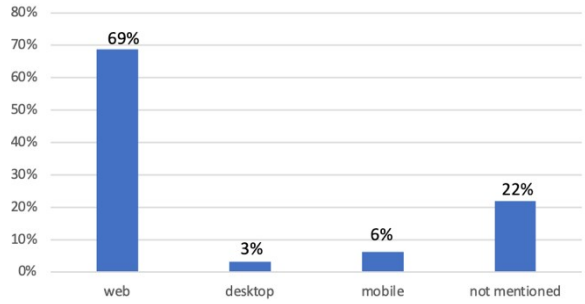


Figure 8. Platform

E-learning is a form of information technology applied in the field of education in the form of websites that can be accessed from anywhere that can be done, facilitating and customizing a user's interaction with e-learning. Users are exposed to many products online, making it difficult to choose the one that best suits their preferences. This prompted researchers to create a recommendation system that would suggest suitable destinations to users based on correctly filled-out profiles.

## 5. Trends RS in Education

From the 29 selected articles, we could see that there is an increasing trend in research on recommendation systems over the last five years. This also shows that the incorporation of recommendation features into the education system is still an important research problem among current researchers. In 2017, there were three papers; in 2018-2019, there were two papers; in 2020, there were four; and in 2021-2022, there were nine papers.

The data obtained shows increased interest in research regarding recommendation systems in the education sector, some of which are still yet to be implemented. The recommendation system is very helpful in various industrial fields and has proven to be efficient in the education sector [43]. Furthermore, a personalized recommendation system makes it easy to interact with, based on the specific criteria for the user.

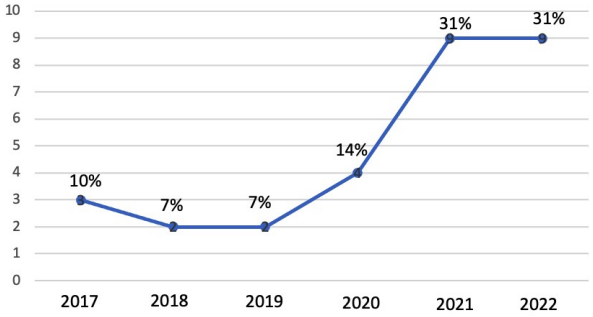


*Figure 9. Publication*

This review has also looked at the researches conducted on various topics that aim to improve the quality of recommendation systems in education that capitalize on the advancement of web 4.0 technology. Figure 10 shows the percentage distribution of authors in 14 countries.

Personalized Recommendations are based on some data about users that shows how users interact with the system, with the aim of these recommendations generating items specifically for each user.

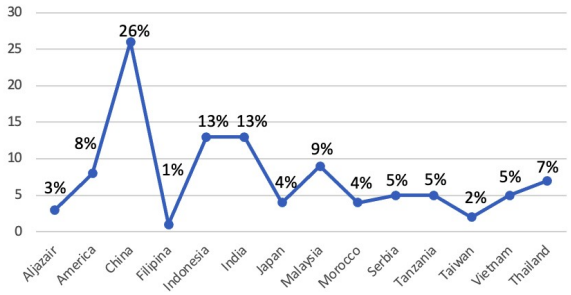


*Figure 10. Author's Country*

In 2020, the Minister of Education and Culture of Indonesia presented the Merdeka Belajar Kampus Merdeka (MBKM) policy; there are four policies (1) Autonomy for opening new study programs, (2) The re-accreditation process is carried out automatically and voluntarily, (3) The requirements to become a PTN-BH are made easier, (4) The right to study three semesters outside the study program and changes in the definition of credits. These three policies offer many opportunities to develop and implement RS on MBKM.

One of the Certified Independent Studies is part of the Merdeka Campus Program, which aims to provide opportunities for students to learn and develop through extracurricular activities. This program, however, is also recognized as part of the curriculum that is aimed at students who wish to equip themselves in the industry by acquiring relevant skills. The development of student

creativity in the industrial world creates entrepreneurs with the structure of a personalized recommendation system from several modules, such as input, output, and recommendation algorithms [29]. Furthermore, researches related to gaps and challenges are proposed to be explored from various perspectives, with significant implications being as follows:

- Based on the reviewed data on recommendation systems, the level of interest in this research will be significant in the future, given their novelty in the education sector.
- There is no known standard measure of system performance or the approach used in recommendation system development. Based on 42 papers with a performance evaluation of 24%, many use MAE in making predictions or forecasts, and the techniques commonly used are collaborative filtering and hybrid method techniques that can combine two or more recommendation techniques to improve recommendation performance.
- The use of platforms with the web in the development of recommender systems is still common because it is an information medium where everyone can provide and receive information. Only by making a connection that is connected to the internet will you be able to open a website address, and therefore, a user can find out the various kinds of information available on web pages.
- There is a fairly broad scope of recommendation system research in the education sector, and there are still opportunities for its development related to resources in educational activities and its use of machine learning or deep learning methods in its development. In the K-NN algorithm, classification is still commonly used, which looks for the value of K, or the nearest neighbor, in determining the class of new data.

This systematic review serves as a guide for conducting future research on the recommendation system domain in education. However, in this study, there were some limitations.

The first limitation is time constraints. We only examined eight digital library papers, all of which dealt with computer science and information systems - using the keywords "recommendation* system*," "education," "e-learning," "student," "course," and "issue" as search terms. They are chosen from the papers found based on the information in the papers that are related to this research. This research can be expanded again by adding keywords, digital libraries, problems, or research updates to recommendation systems, allowing for their diversity in the education sector.

## 4. CONCLUSION

In the development of recommendation systems, many different techniques are used and are of interest to researchers. In identifying them, we do this by reviewing papers regarding system recommendations that focus on the education sector. In order to provide a comprehensive understanding of the trend of system recommendation research, this paper provides insight to researchers about the extent of the future direction of recommendation systems.

This review provides four descriptive statistics( Approach, Techniques, Evaluation, Platform) on the research works done on recommendation systems in education field over the last five years. The approaches also touch on wide ranging topics such as education curriculum, personalized students, RS data mining, study selection, and E-learning educational resources. The results of this systematic literature review show that there are still many opportunities for informed development and utilization of recommendation systems in learning engagement within in a virtual environment.

In the future, an approach that uses a recommendation system in the world of education to manage learning management systems can increase performance and be explored with the development of machine learning and deep learning. Currently, recommendation systems are still being implemented in various industrial fields. By implementing the recommendations of the educational institution system, you can do two things. First, you can study historical behavior in learning activities for each user and what learning interests and talents they prefer. Based on this knowledge will be able to provide learning recommendations

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