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ARTICLE

Recommendation System model integrated with Active Methodologies, EDM, and Learning Analytics for dropout mitigation in Distance Education

Um modelo de Sistema de Recomendação integrado a Metodologias Ativas, MDE e Learning Analytics para a mitigação de evasão em EaD

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Abstract: Distance Education enabled educational practices based on digital platforms. Despite its wide adoption, the high dropout rates are a reason for concern for teachers and institutional managers. There are initiatives to mitigate this situation, such as Educational Data Mining (EDM), Learning Analytics (LA), and the use of Recommendation Systems (RS). Although effective in specific aspects, these techniques lack mechanisms for students' motivation and pedagogical intervention by teachers, as they do not present methodological proposals to encourage learning. Therefore, this article describes an RS model that shows a differential integration of the pedagogical approach of Active Methodologies with the support of Educational Data Mining and Learning Analytics techniques to identify students with dropout risks and enhance permanence. For this, a prototype was implemented, and a case study was carried out with professors from two universities to assess functionality and acceptance. According to the TAM Model, more than 87% of teachers agree with the ease of use, and 77% agree that RS can be helpful in students' teaching and learning process. Therefore, the model contributes to teaching practices, encourages collaborative learning, and favors monitoring this process and the activities developed by the students.

Keywords: Recommendation System, Active Methodologies, Educational Data Mining, Learning Analytics, Dropout.

Resumo: A Educação a Distância possibilitou práticas educacionais baseadas em plataformas digitais. Apesar de sua ampla adoção, os altos índices de evasão são motivos de preocupação de professores e gestores institucionais. Existem iniciativas para mitigação desta situação, como a Mineração de Dados Educacionais (MDE), Learning Analytics (LA) e o uso de Sistemas de Recomendação (SR). Apesar de efetivas em aspectos específicos, estas técnicas carecem de mecanismos para a motivação dos alunos e intervenção pedagógica dos professores, pois não apresentam propostas metodológicas para incentivar a aprendizagem. Diante disso, esse artigo descreve um modelo de SR que apresenta como diferencial a integração da abordagem pedagógica das Metodologias Ativas com o suporte das técnicas de Mineração de Dados Educacionais e de Learning Analytics para identificar os alunos com riscos de evasão e potencializar a permanência. Para isso, foi implementado um protótipo e realizado um estudo de caso com docentes de duas universidades para a avaliação de funcionalidade e aceitação. De acordo com o Modelo TAM, mais de 87% dos docentes concordam com a facilidade de uso e 77% concordam que o SR pode ser útil no processo de ensino e aprendizagem dos alunos. Portanto, pode-se concluir que o modelo contribui para as práticas de ensino, incentiva a aprendizagem colaborativa e favorece o acompanhamento desse processo e das atividades desenvolvidas pelos alunos.

Palavras-Chave:: Sistema de recomendação, Metodologias ativas, Mineração de dados Educacionais, Analítica da aprendizagem, Evasão.

1. Introduction

The high dropout rate of students in courses offered in the Distance Education modality worries educational institutions managers and teachers, who are looking for alternatives to identify situations likely to give up and motivate students to remain in their studies. In this context, some studies use Educational Data Mining (EDM) and Learning Analytics (LA) techniques to identify students likely to drop out of the course (Marques et al., 2019). However, they are restricted to identifying these possibilities without subsequent effective action in this scenario (Widyahastuti & Tjhin, 2018). After identifying the dropout tendency, the decision-making to mitigate this problem usually depends on the teacher or manager, who needs to use educational methodologies to rescue and encourage the student to remain in the course.

Active Methodologies are pedagogical approaches in which students participate as protagonists of the learning process, encouraged to relate to colleagues for the development of activities, and collaborating for the intellectual growth and improvement in the performance of those involved (Guo et al., 2018). One of the dropout prevention hypotheses in Distance Education is the use of Active Methodologies integrated with Recommender Systems (RS) and Virtual Learning Environments (VLE) in order to help teachers in the teaching and learning process and reduce the dropout rates, enhancing permanence (Chandrasekaran et al., 2016; Leite & Ramos, 2017; Lima & Siebra, 2017; Leite et al., 2019).

Studies performed by Chandrasekaran et al. (2016) and Leite & Ramos (2017) assess that the integration of Active Methodologies to RS can be an effective retention mechanism, expanding the potential for student engagement and learning sharing (Lima & Siebra, 2017; Leite et al., 2019). Once the cases associated with dropout risks due to EDM and LA are identified, the Active Methodologies encourage student collaboration through various resources, from recommended reading materials to interaction with the virtual environment, engaging and stimulating them and regarding your learning. Therefore, this would be a resource that, according to Cunha & Siebra (2016), can contribute to collaborative learning and act to mitigate dropout. However, according to Leite et al. (2019), the use of Active Methodologies still needs to be observed in Distance Education.

Given this context, this article presents a proposal for integrating Active Methodologies with EDM and LA to mitigate dropout risks and enhance student permanence. To this end, an RS model was developed, which stands out for integrating the pedagogical approach of Active Methodologies with the support of EDM and LA techniques. The main difference of this work is integrating a motivational step into the students' work, using Active Methodologies for this.

This article is organized into 4 sections. Section 2 proposes an RS model integrated with Active Methodologies with support from EDM and LA, the tools for development, and the case study. Section 3 presents the results obtained from the evaluations and the critical analysis of the proposal. Finally, section 4 includes conclusions and suggestions for future work.

1.1. Related Works

This section presents works by other researchers who address the use of Active Methodologies, EDM, LA, and RS in the context of Distance Education courses. Given the study, the possibility of expanding the use of technologies and methods in this area was verified.

According to Ferreira et al. (2017), Moraes & Stiubiener (2019), and Leite et al. (2019), it is possible to verify a growth in scientific productions on RS, which is justified by the difficulty of selecting resources for teaching-learning in the face of excellent availability. Campos et al. (2017) cited several examples of RS, such as PMoodle, Broad-RSI, CA-Learning, LORSys, Dica, Mobile, e-Lors, RecoaComp, and RS Collaborative Móvel, among others. Rolim et al. (2017) presented a system capable of classifying, through machine learning, student postings in VLE forums and recommending auxiliary study material available as YouTube videos. Acosta et al. (2018) developed a system that uses Project-Based Learning as a teaching method focusing on the student and collaboration between peers, capable of suggesting complementary materials from activities proposed by the teacher in that same environment. Ferreira et al. (2015) developed a content recommendation model called UbiGroup for learners to recommend Learning Objects (LO) according to the profiles and context that are inserted, supporting the teacher in the search and selection of materials.

Regarding EDM and LA, research approaches such as techniques, algorithms, and attributes are the most frequent themes in the studies studied. Classification and prediction techniques are widely used to analyze students' learning behavior and performance, as presented in the works by Ramos et al. (2018), Kostopoulos et al. (2019), and Queiroga et al. (2019), enabling timely and effective interventions to mitigate dropout. Regarding algorithms, Random Forest and Logistic Regression are used for predicting and detecting dropout risks in the works of Ramos et al. (2017), Queiroga et al. (2019), and Waheed et al. (2020). Finally, regarding search attributes, Kostopoulos et al. (2019) investigated demographic data, which represent the profile characteristics of students; Santos et al. (2016), Ramos et al. (2018), and Brito et al. (2019) explored performance data, such as grades obtained in questionnaires and assessments.

The use of Active Methodologies is expanding in face-to-face teaching and distance education, as it has the potential to make classes more exciting and modern (Almeida et al., 2020; Leite & Ramos, 2017; Fernández-Robles et al., 2019). Lima et al. (2020) found that 76.7% of teachers sought to improve their teaching methods using Active Methodologies. Chandrasekaran et al. (2016) showed that 67% of respondents felt comfortable using the methodology in the learning process, as it offers the student the opportunity to express individual experiences, share ideas in groups, promotes the development of social skills for those who have difficulty teacher-centered learning, assigns much of the responsibility for learning to the teacher, and enriches them with aspects of critical thinking and problem-solving. In addition, it stimulates autonomy and interaction, encouraging them to learn from each other and to perceive and develop self-learning and communication in work groups. As for the teacher, he helped in the teaching and learning process, making him more proactive and capable of improving student performance with actions that minimize the dropout risk.

No examples of Active Methodologies integrated with EDM and LA techniques were found. Consequently, none of the works considered integrating these techniques into Active Methodologies in an RS that could help the teacher in teaching and benefit student learning. Given this and to propose practical actions to mitigate dropout, it is considered that the insertion of these methodologies together with RS, EDM and LA techniques allows for an advance in the process of personalization and improvement of teaching and learning since students are identified according to their work history and with that the RS carries out a process in which it recommends and instigates the use of LO and the reading of complementary materials, encouraging communication and interaction between users and the virtual environment, autonomy and self-learning, and in groups, stimulating collaborative and pedagogical practices.

2. Method

In order to qualify to learn and contribute to mitigating dropout risks in Distance Education, an RS model was developed that integrates Active Methodologies with EDM and LA techniques.

2.1. General description of the proposed model

The proposed model involves a set of steps that are performed in an integrated manner and differ in resource availability, supporting students and teachers. Figure 1 illustrates the overview of the RS model from the professor's point of view, which involves integrated functioning with Active Methodologies, EDM, and LA.

The Course and Discipline module registers the name of the course, discipline, academic period offered, and the number of enrolled students. The Connection module has two functionalities to be chosen by the teacher. The first, EDM, integrates the VLE database and the Academic System (AS) to access demographic data, academic profile records, and average performance in student activities. Once obtained, the supervised learning technique is used with the Random Forest (Breiman, 2001) and Naive Bayes (Lewis, 1998) algorithms to generate trend patterns to be observed. The second feature makes it possible to use the scoreboard extracted from the VLE with demographic and performance data.

The Ranking module involves classifying students in descending order according to the average of the evaluation activities. The Active Methodologies module allows the teacher to choose the number of students per group and the learning strategy. Some of the possible examples are: (i) Problem-Based Learning – PBL (Silva & Silva, 2020), (ii) Flipped Classroom – FC (Bergmann & Sams, 2016), or (iii) Peer Instruction – PI (Araújo & Mazur, 2013). The choice must be made at each performance of the evaluative activities since it directly interferes with the average of the discipline and, consequently, the formation of the groups. This module aims to assist in developing various skills and abilities that are increasingly required in the contemporary world.

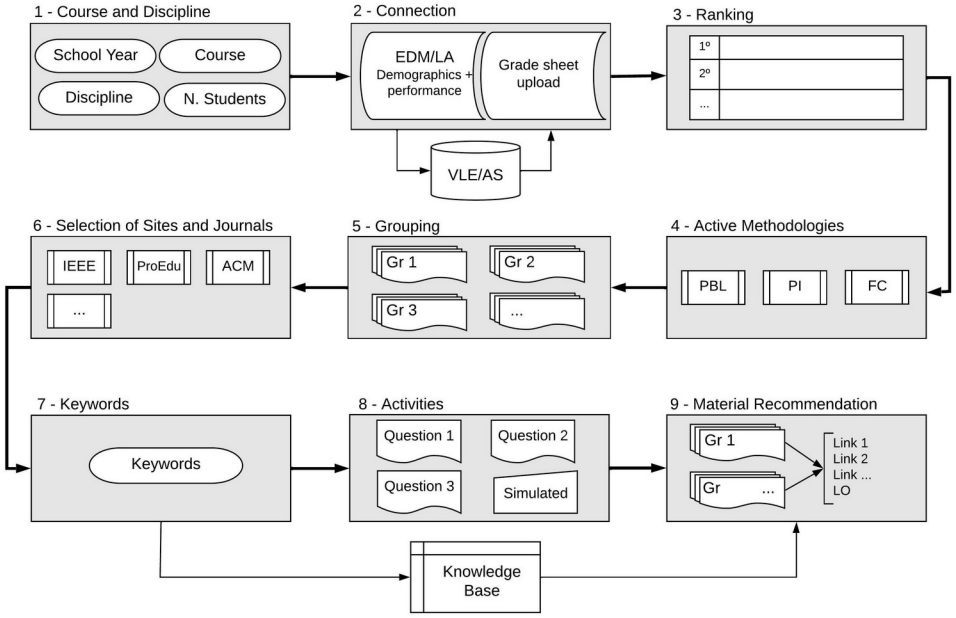

Figure 1. RS model integrated with Active Methodologies, EDM, and LA, from the teacher's point of view

The Grouping module allows the teacher to obtain support in forming groups of students, and according to Pallof & Pratt (2002), when students work collaboratively, they tend to produce more profound knowledge as they cease to be independent to become interdependent.

The Sites and Magazines Selection module allows the teacher to choose magazines or national sites such as Public Domain Portal, International Bank of Educational Objects, ProEdu, EduCAPES, and the international ones IEEE, ACM, Scielo, Merlot, Google Scholar, for the search of complementary materials for reading and improvement, such as articles, videos, and LO. The Keywords module consists of registering keywords related to the subject's content, used to search for complementary materials. The Activities module proposes the registration of research questions or problems for the resolution of the formed groups, with support through the reading of the complementary materials and the performance of the simulated activities registered in this stage as reinforcement activities.

The Material Recommendation module selects complementary materials and Learning Objects returned by the search algorithms implemented through the BeautifulSoap technology, according to the registration of keywords and an indication of websites and magazines. The teacher can mark among the results the material that will be presented in the RS at the student's level of vision, forming a knowledge base for future suggestions. The RS allows viewing and extracting reports that demonstrate the participation and execution of activities by members of the groups through access log data and verification of completion of activities. In this work, the Hybrid RS model is used, which collects user information for explicit or implicit recommendations, records, and interactions. A definitive collection of user data occurs when users know they are providing their information, which is what is used in this work. Implicit user data collection indirectly accesses information about the user.

Figure 2 shows the components available to the student, composed of a set of integrated modules displayed in a single interface.

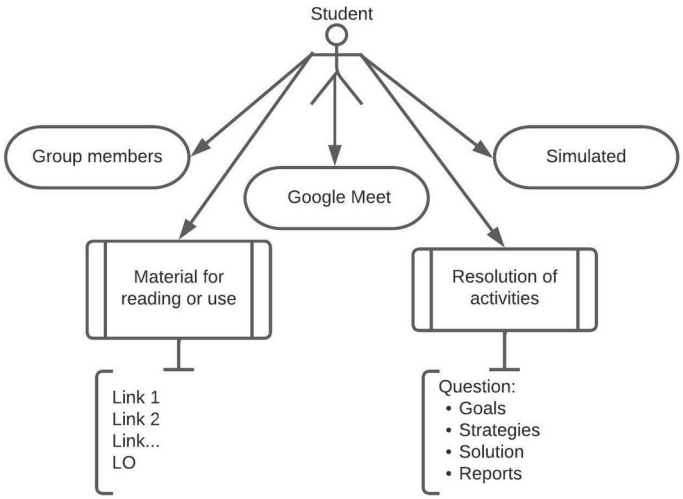

Figure 2. RS integration model, from the student's point of view.

The Group Members module displays the name and contact e-mail of all participants in the group, defined according to the criteria established by the teacher and groupings performed by the RS. The Online Meetings module allows web conferences to be held at any time via a communication platform (for example, Google Meet), which can be shared by group members and other guests, including the subject's teacher, in order to monitor development and encourage the exchange of experiences, learning, and discussion of doubts.

The Simulated module allows access to activities registered by the teacher to reinforce learning. For this, students can also count on the Online Meetings module, which allows web conferences to resolve and share knowledge. The Materials for Reading or Use module presents links to articles or LO previously selected by the teacher on websites and national and international magazines. These serve as a theoretical/practical basis for solving the activities.

The Activities module for realization presents questions or problems the teacher defines for the group to solve. It is required to fill in the objectives, strategies, and solutions and post a descriptive report of the activities carried out. It is emphasized that these can be carried out individually and at any time. However, it is essential to highlight that the reports present access records via log that demonstrate the participation and execution of activities by group members.

2.2. Implementation

Based on the proposed model, an RS prototype was developed following the Model-View-Controller (MVC) architectural pattern, with the Python programming language, the Django and BootStrap Frameworks, the JQuery and BeautifulSoap Libraries, and, as a database, SQLite.

Figure 3 shows the RS components with the teacher and student module based on the integration models in Figures 1 and 2. The teacher's interface needs to connect the VLE and AS database to collect demographic and performance data right after the first evaluation of the subject offered. In this interface, it is necessary to consult the databases of websites and national and international electronic journals to identify complementary materials and learning objects that will be recommended to students. In the student's interface, the data presented are the results of registrations made by the professor and queries to external databases.

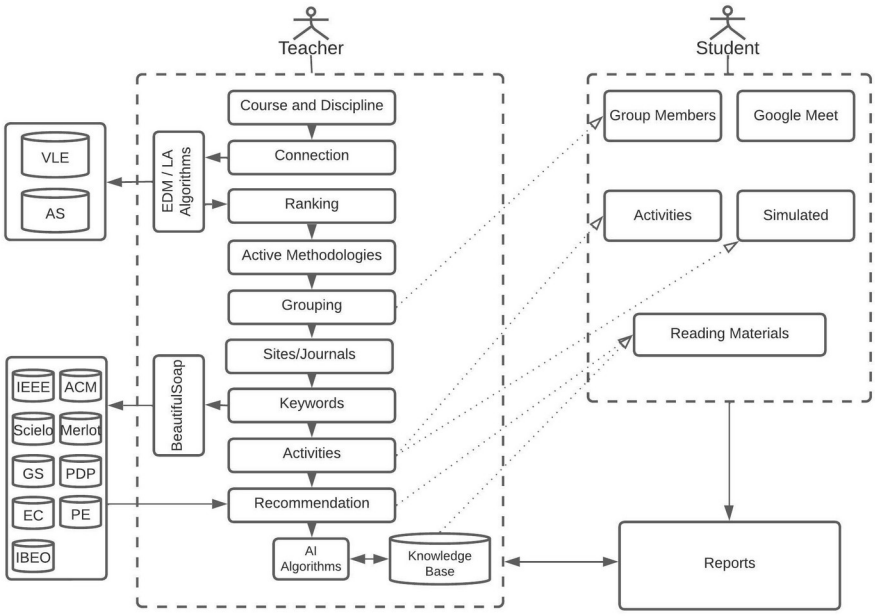

Figure 3. RS Components.

Initially, a standard interface requires registration and authentication for faculty or student users, followed by filling in personal data and identifying the profile. After access, in the professor's interface, it is possible to register, view and edit the data of the discipline offered; in the student's interface, view the linked disciplines and contents registered by the professor. For the demonstration, a case study was carried out.

2.3. Case study

After the development of the RS prototype, a case study was carried out with professors from two universities in Brazil to obtain the application's evaluative results. "It is a research method that generally uses qualitative data, collected from real events, to explain, explore or describe current phenomena inserted in their context" (Yin, 2015).

The first evaluation consisted of verifying the functionality and presentation of the RS interfaces by a guest professor from the Bachelor of Science in Computer Science course. The second they were focused on acceptance of the RS. For that, a video with examples of application use and a questionnaire containing ten statements with a quantitative approach was made available to professors from different areas of

knowledge at two universities invited by email. The answers were collected through the Google Form tool. The evaluation was based on the concepts of the TAM Model - Technology Acceptance Model (Marangunié & Granié, 2014; Pinto et al., 2019), which evaluates: a) Perceived Ease of Use - the degree to which a person believes that using an information system will be effortless; b) Perceived Usefulness – the degree to which a person believes that using a system can improve their performance. According to Pinto et al. (2019), the TAM Model is considered one of the essential methods researchers use to describe the acceptance of a given technology, as it indicates the influence of human factors on adopting new tools.

Table 1. Assessment Questionnaire

Assessment	Affirmation
Perceived Ease of Use	1. RS is easy to understand
	2. RS interface information is clear
	3. It is possible to use little effort the resources available in the RS
	4. RS reproduces material recommendation functionality
	5. RS service integration provides a more agile and enjoyable way of working
Perceived Usefulness	6. RS facilitates the use of Active Methodologies
	7. The RS favors the formation of groups of students for the practice of collaborative teaching
	8. The use of the RS facilitates the teacher's work in the task of recommending complementary materials
	9. The use of RS can help to mitigate the risks of dropping out of school
	10. I would use RS for the teaching and learning process

Responses were standardized on a five-point Likert scale, ranging from "Strongly Agree", "Agree", "Neither Agree nor Disagree", "Disagree", and "Strongly Disagree". Table 1 presents statements from 1 to 5 about ease of use and 6 to 10 about perceived usefulness.

Assessments involving students and teachers in a regular context were not carried out due to the impossibility of the period of the Covid-19 pandemic that occurred in 2020 and 2021.

3. Results

In order to show the results, the answers were divided according to evaluation criteria. The first, which consisted of checking the functionalities and interfaces, was carried out by a professor who teaches Introduction to Databases to a class of 30 students. The second evaluation, referring to the acceptance of the RS, involved 13 teachers.

3.1. Evaluation of RS functionality and interfaces

Figure 4 shows the first stage of the RS, which consists of registering data for the course and discipline offered by the teacher. The academic period defined was 2021/1, Bachelor's Degree in Computer Science, subject Introduction to Databases, and the number of 30 students.

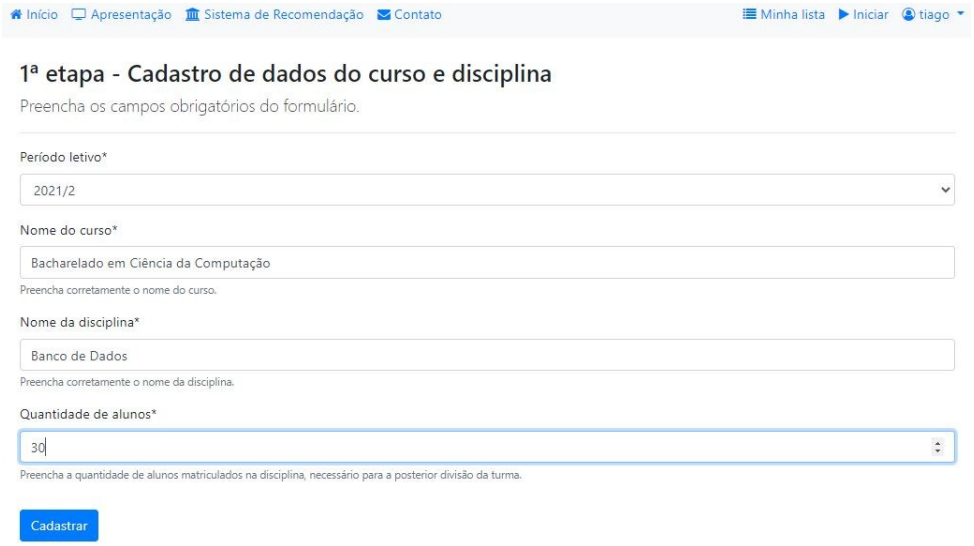

Figure 4. Course Data Registration module interface.

Figure 5 shows the Connection module interface, the second stage of the RS, in which the teacher can choose between searching for demographic and performance data in the institution's AS and VLE for the EDM and LA or uploading the VLE grade table. In this case, an upload containing enrolled students' demographic and performance data was carried out.

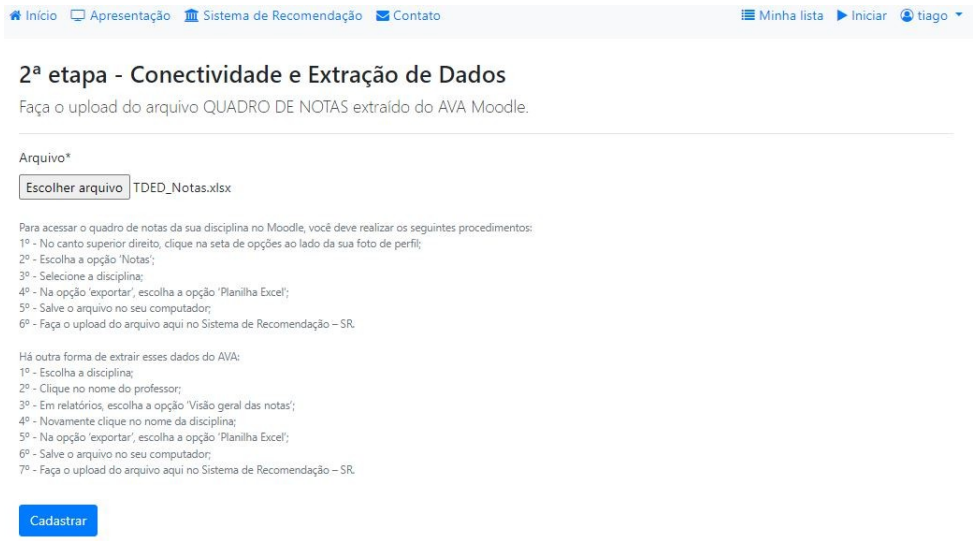

Figure 5. Connection module interface.

In the third step, the Ranking module, students were classified in descending order and displayed in a list to the teacher containing first name, last name, email address, and student grade before and after classification, as shown in Figure 6.

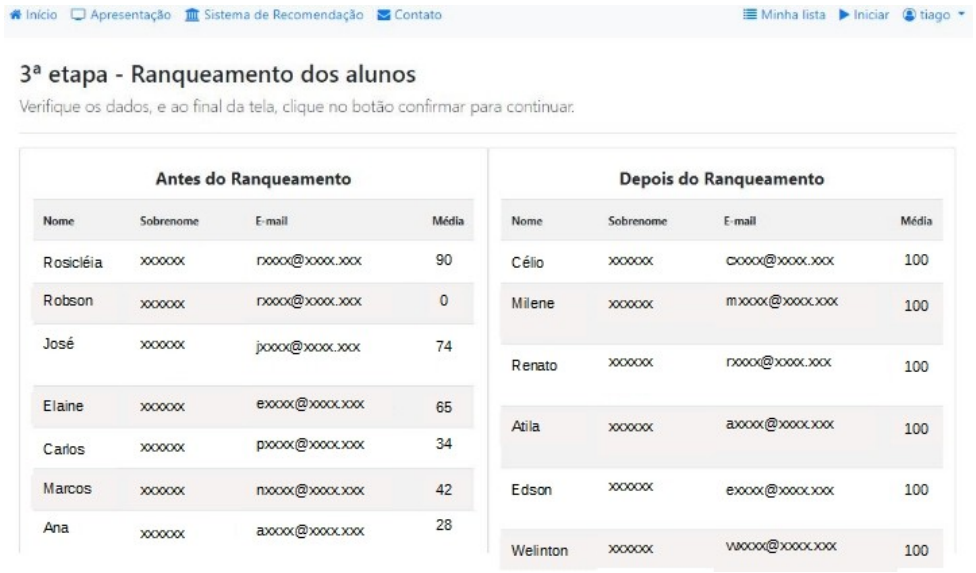

Figure 6. Ranking module interface.

The Active Methodologies module allows the teacher to choose the teaching method. In this case, the methodology chosen was Problem-Based Learning (PBL), and the number of 5 students per group, as shown in Figure 7, which according to Alves et al. (2020), tends to privilege students' prior knowledge, encouraging an investigative learning environment through the construction of hypotheses and experiments.

Figure 7. Active Methodologies module interface.

After ranking the students, the Grouping module shown in Figure 8 is responsible for forming groups as defined in the previous step by the teacher, with the presentation of the members and their respective contacts, who will have activities to be carried out and will have the indication of materials for reading and LO.

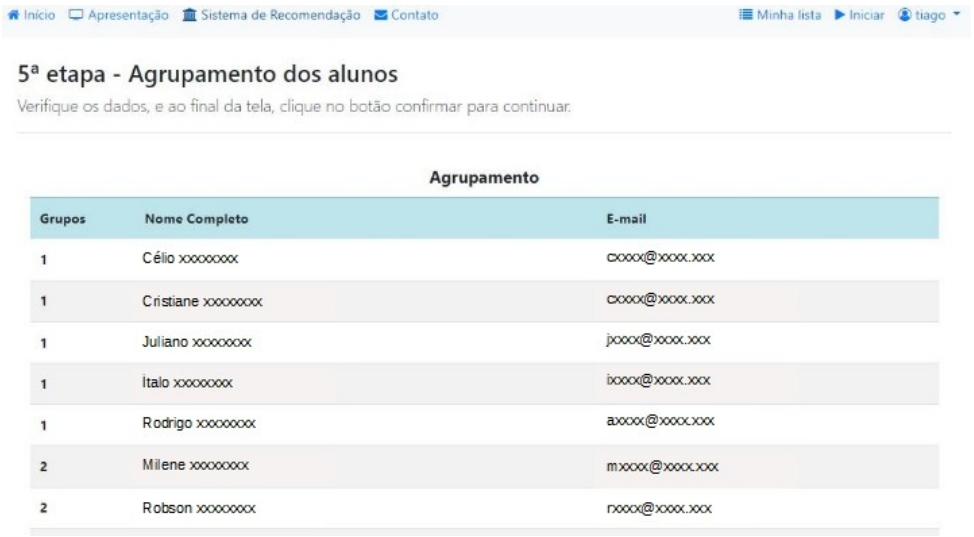

Figure 8. Grouping module interface.

Figure 9 shows the interface of the Sites and Magazines Selection module, in which the teacher can choose which databases the RS should search for complementary materials that will be recommended for reading or learning. This choice can be from one or several websites and magazines, at the teacher's discretion, and in English or Portuguese. In this case, Figure 9 shows the selection of the IEEE – Institute of Electrical and Electronics Engineers database.

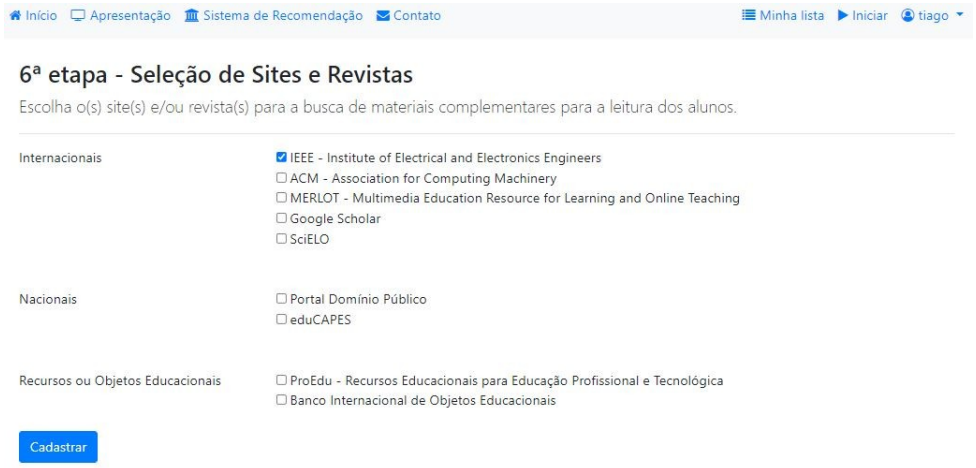

Figure 9. The site and Journal Selection module interface.

About Figure 10, the Keyword Registration module allows the inclusion of three terms that will be used for the search for materials. In this case, the words "education data mining," "dropout," and "distance education" were registered by the teacher in the RS.

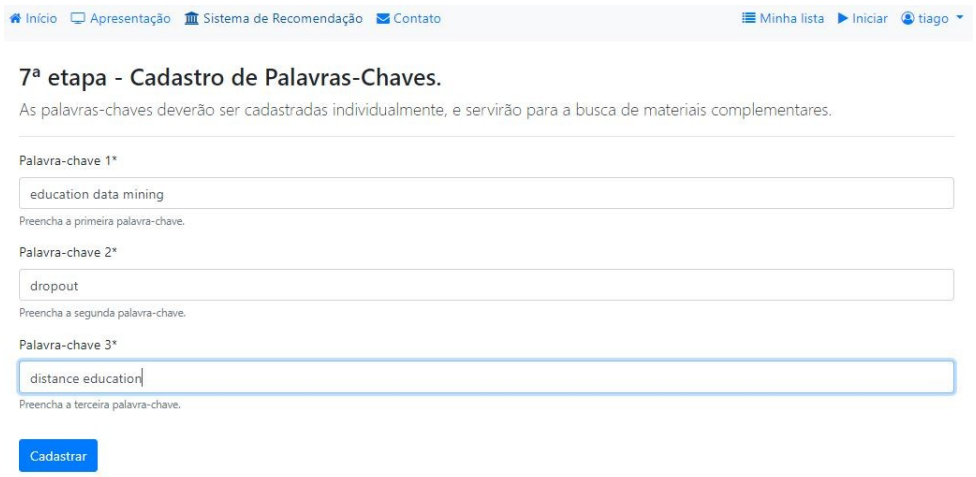

Figure 10. Keywords module interface.

The Activities module allows the teacher to register questions/problems and simulations for the students to solve according to the defined Active Methodologies. As the case study chosen was PBL, the teacher defined 3 questions/problems and a simulation referring to the content addressed for the students to solve, as shown in Figure 11.

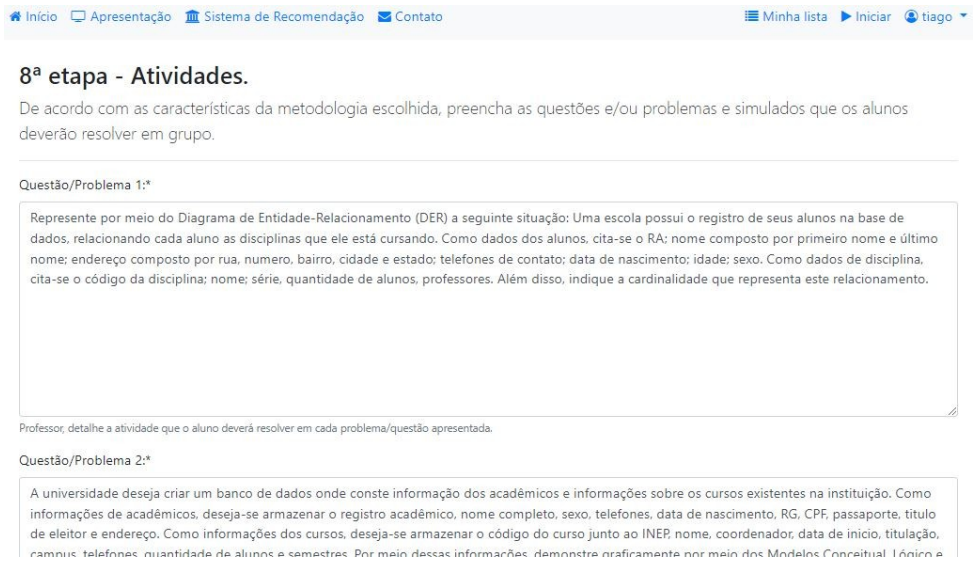

Figure 11. Activities module interface.

Finally, Figure 12 shows the result of the complementary materials for reading or learning objects obtained through the BeautifulSoap Library and keywords registered by the teacher in the indicated websites and magazines. Note that each material contains the name of the consulted database, the title of the work, and the access link, as well as a functionality that allows the teacher to choose whether or not to display the material returned to the groups of trained students.

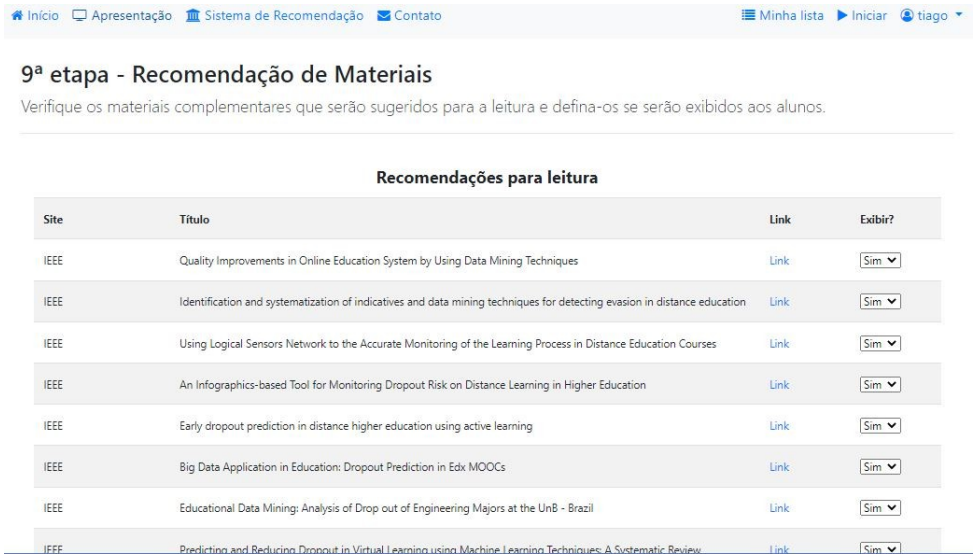

Figure 12. Material Recommendation module interface.

Given this, through the case study, it was possible to use and test the functioning of the model according to the proposed objectives, promoting the indication of complementary materials for the study of groups of students formed after

the identification by EDM and LA rules and that, as a pedagogical practice, it proposes the use of Active Methodologies with potential for collaboration and exchange of experiences and knowledge among students.

Figure 13 shows the student's interface, where the other members of the group are introduced to him; the Google Meet link for holding online meetings; simulated testing activities; materials for reading or use, such as articles and learning objects; and the activities proposed by the teacher for the accomplishment.

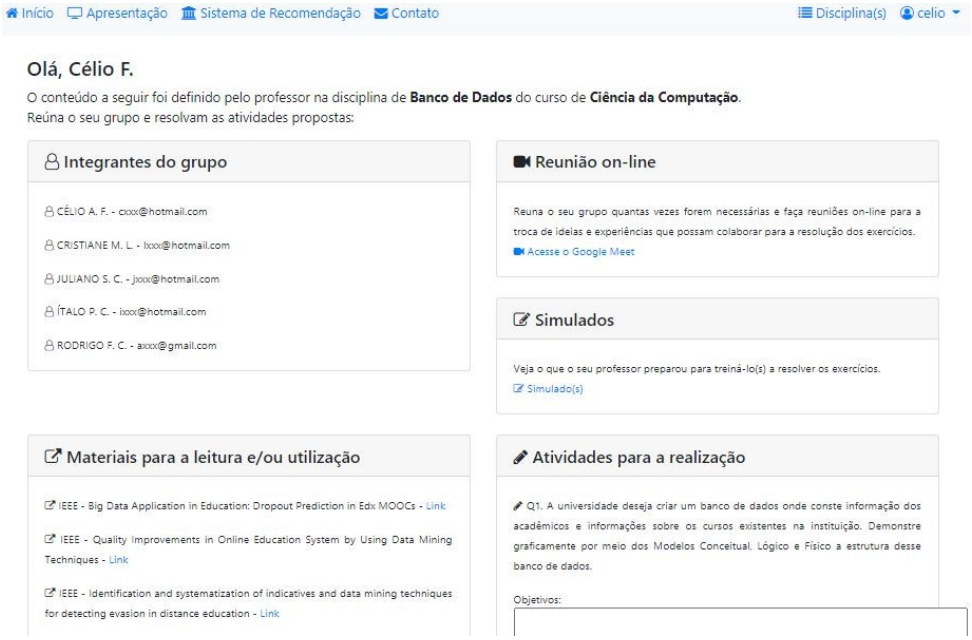

Figure 13. Student module interface.

3.2. RS acceptance assessment

This section presents the results of the verification of acceptance of the RS by teachers who were invited to participate in the survey. The participants were 13 professors from different areas of knowledge from 2 Brazilian universities, who promptly answered the questionnaire with 10 statements prepared according to the TAM Model, which evaluates the ease of use and perceived usefulness. A text box for teachers' comments was also provided.

The results obtained in statements 1 to 5 indicate that 49.2% strongly agree, 38.5% agree, and 12.3% neither agree nor disagree about the ease of use of the RS, as shown in Figure 14, demonstrating the satisfaction of more than 87% of participants. There are no responses that disagree with these statements.

Regarding question 1, which deals with the ease of understanding the RS, 53.8% of teachers strongly agree, 38.5% agree, and only 7.7% neither agree nor disagree. There were no responses that disagreed with the statement. In question 2, 69.2% of the professors strongly agree, and 23.1% agree that the information on the RS interface is

straightforward, totaling more than 92% of the responses. Only 7.7% of teachers neither agree nor disagree. There were no responses that disagreed with the statement.

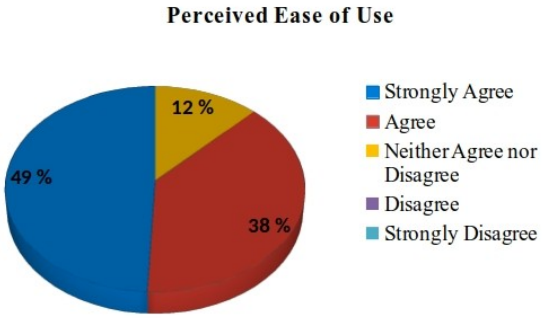

Figure 14. Result of questions about ease of use.

Regarding question 3, which states that it is possible to use the resources available in RS with little effort, 46.2% of teachers strongly agree, 38.5% agree, and 15.4% neither agree nor disagree. There were no responses that disagreed with the statement. Regarding question 4, which states that the RS reproduces the material recommendation functionality, 38.5% of teachers strongly agree, 53.8% agree, and 7.7% neither agree nor disagree. There were no responses that disagreed with the statement. In question 5, which deals with the integration of RS services by providing a more agile and pleasant way of working, the percentages of 38.5% of teachers were obtained in agreeing and strongly agreeing, and 23.1% did not agree or disagree. There were no responses that disagreed with the statement.

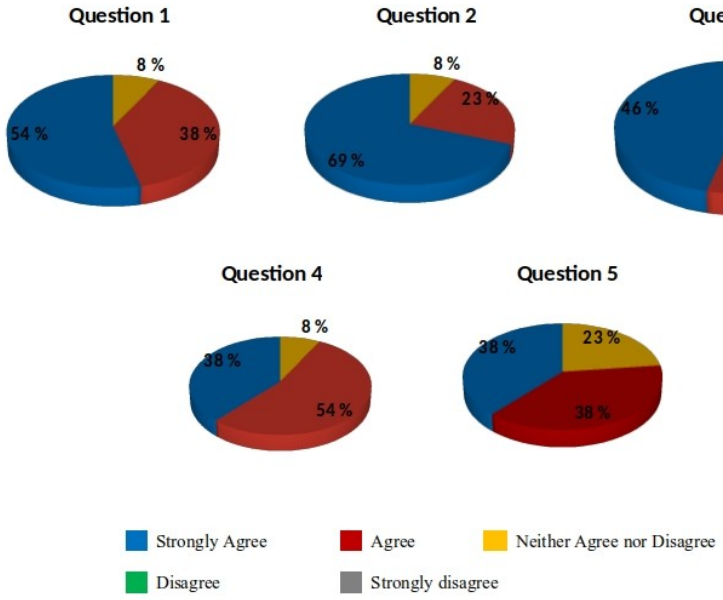

Figure 15. Resultados detalhados das questões de 1 a 5 que trata sobre a facilidade de uso

Regarding statements 6 to 10, which deal with the usefulness of the RS, 38.5% of teachers strongly agree, 38.5% agree, 18.5% neither agree nor disagree, 3.1% disagree, and 1.5% strongly disagree. The percentages show that 77% agree that the RS can be valid for the teaching and learning process and is well accepted. Figure 16 shows the result of the questions about perceived usefulness.

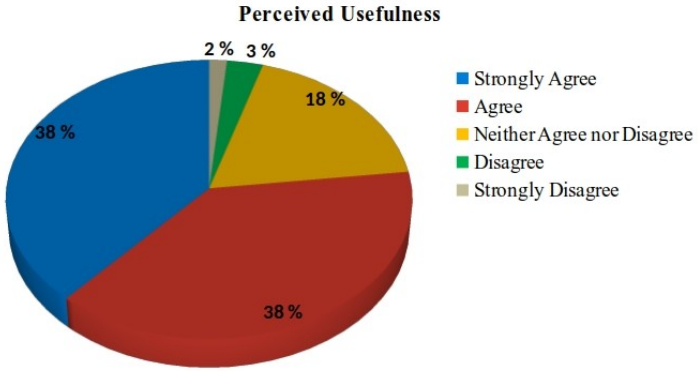

Figure 16. Result of questions about perceived usefulness.

Regarding the integration of Active Methodologies to an RS, the results of statement 6 demonstrate how much the RS facilitates the use of this methodology by teachers since the percentages of 38.5% were observed in the answers agree and strongly agree, reaching 77% to the opinion of the public participating in the research.

Regarding question 7, which states that the RS favors the formation of groups of students for collaborative teaching, 61.5% of teachers strongly agree, and 23.1% agree. The percentages of 7.7% were observed in neither agree nor disagree and disagree. There were no responses that strongly disagreed. Therefore, more than 84% of teachers agree that RS favors the formation of groups.

In question 8, the results indicate that 38.5% of the teachers strongly agree and 53.8% agree. This shows a high degree of satisfaction with the RS when recommending complementary materials for the students to read, reaching the objective of the model development, and assisting in the learning process.

Regarding question 9, which relates the use of RS with the possibility of helping to mitigate the risk of dropout by students, 46.2% of teachers answered that they neither agree nor disagree, 38.5% agree, and 7.7% strongly agree. The high rate of neither agree nor disagree may mean the need to make identifying students prone to dropping out more evident, the use of Active Methodologies for collaborative teaching, and the indication of complementary material for learning.

Finally, question 10 asked the teacher if he would use RS for the teaching and learning process. 46.2% strongly agree, 38.5% agree, 7.7% neither agree nor disagree, and 7.7% strongly disagree. There were no responses that disagreed with the statement. The results indicate that more than 84% of the teachers would use the RS for the student's learning process.

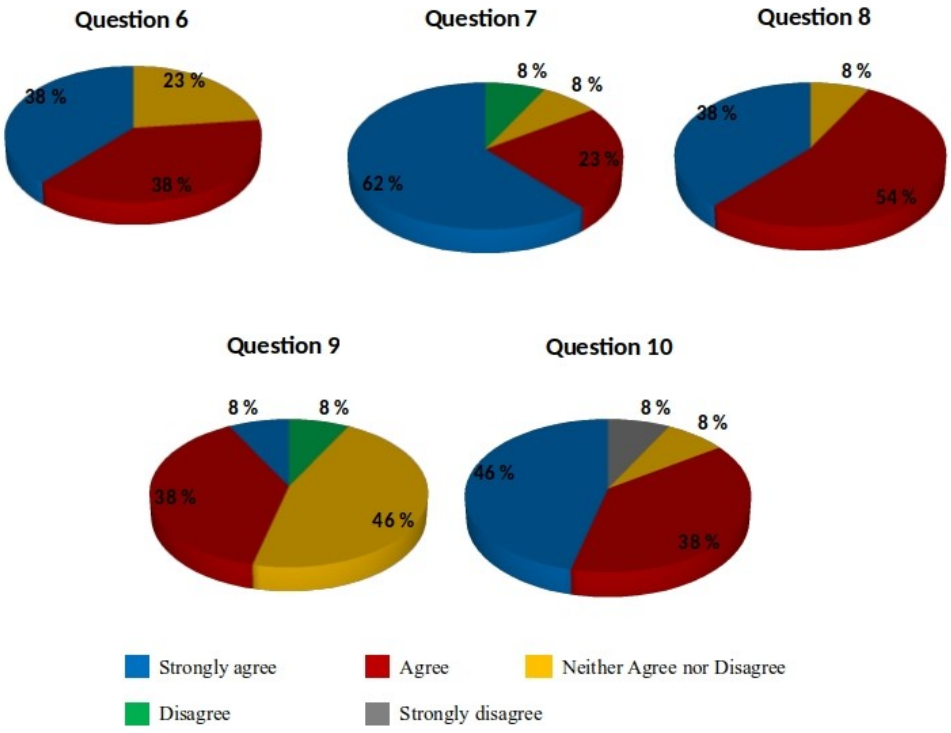

Figure 17. Detailed results of questions 6 to 10 dealing with perceived usefulness.

In order to obtain suggestions for improvements, a space was made available in the questionnaire for the teacher to write freely. Among the suggestions are: a) formation of groups: create opportunities to form groups manually, based on interest, personal affinity, and psychological and emotional profiles; b) selection of materials: manual indication of links.

3.3. Critical analysis of the proposal

According to research, none of the studies considered integrating Active Methodologies with EDM and LA techniques in an RS to reduce dropout risks and improve student learning. It is known that the EDM and LA techniques are widely used and have contributed significantly to teaching. However, the scope of the most significant contribution has been only in identifying students prone to dropping out of courses. In this sense, measures to contain this high index need to be taken in addition to this action. Using Active Methodologies integrated into the RS would favor the relationship between teachers, tutors, and students. It would make the process more attractive and updated, meeting the needs and expectations of a technologically inserted society.

Corroborating the proposal presented here, works such as Chandrasekaran et al. (2016), Leite & Ramos (2017), Lima & Siebra (2017), Leite et al. (2019), and Andrade et al. (2021) consider the possibility of adding Active Methodologies to the techniques to contribute to mitigating dropout and increasing student permanence.

Active Methodologies support teachers in teaching practices and monitoring the learning process and performance of activities developed by students. At the same time, it works with students, encouraging them to be more proactive and collaborative in a more engaging, participative methodology involving the group context.

The evaluation allowed the verification of functionality and integration between the developed components, indicating its viability as an RS model. The results are promising since the RS can help the teacher in the selection of complementary materials and encourage the relationship between students for the learning process, corroborating with the aspirations of Costa et al. (2013) when stating that, in most cases, RS have some limitations when used in educational contexts, and that therefore, additional requirements should be added in the design and development.

4. Conclusions

This work presented an RS model integrated with Active Methodologies, EDM, and LA to detect students prone to dropping out and mitigate this possibility. In order to help the student and the teacher in the process, several functionalities are proposed, such as the orientation of complementary reading materials to the student and the possibility for the teacher to choose the Active Methodologies to be applied to the groups formed by the tool in the teaching process and learning, in order to inhibit the possibility of evasion and increase the student's interest in the content and permanence.

Studies found no evidence of RS that integrate Active Methodologies, EDM, and LA. However, these studies point to the growth and importance of improving the ways of teaching and learning. The integration of these techniques and methods, as evaluated in the proposed RS model, provides a step forward for this process, not only in identifying students prone to dropping out of the course but also in supporting and improving learning. RS fosters this by providing opportunities for reading complementary materials, autonomy, and individual experiences, sharing ideas in groups, developing social skills for those with learning difficulties centered only on the teacher, and responsibility for learning and problem-solving. With Active Methodologies and innovative techniques, the teacher can create mechanisms to engage and challenge the student, generating more chances to encourage the student to stay in the course.

The results obtained are promising since, in the evaluation of the functionalities and interfaces of the RS model by a teacher, it was possible to certify its correct functioning. In evaluating acceptance by teachers from different areas of knowledge, the results indicated that more than 87% of teachers agreed with the ease of use and more than 77% with the usefulness in the teaching and learning process when teachers were asked if they would use RS in the teaching and learning process, more than 84% agreed with the statement, which may indicate the relevant contribution of RS.

Therefore, as future work, it is intended to experiment on a large scale with the proposed model with the highlighted technologies, which directly involve students and professors from different courses. It is also intended to monitor the academic life of students identified as likely to drop out to verify whether the use of RS with Active Methodologies was able to encourage them to continue their studies. Finally, improve

the features of group formation and selection of complementary materials suggested by the teachers.

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