Recommendation of Educational Resources in a Blended Learning Environment

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Abstract: Blended learning environments are those that combine face-to-face instruction with computer-mediated instruction and have gained space in the means of discussion about new educational methodologies. Several benefits are observed in the use of this methodology, among them: an increase in academic performance and students' social skills, an increase in teaching and learning flexibility, an increase in student satisfaction, à decrease in dropout rates, and an increase in school retention. Recommender systems are useful in these environments, providing the suggestion of content and activities personalized to users; here, we present a model for recommending learning activities in a blended learning environment. To evaluate the model, SWRL rules were used through the Pellet inference engine. The approach was evaluated through a case study that represents the situation of a student in a blended learning environment, with several options of activities, in which the choices may vary according to their general and academic profiles, in addition to their context. The recommendation rules are executed, resulting in the activity suggestion for the student. Thus, it was verified that the developed model fulfills the proposed objective of enriching the recommendation of learning resources in a blended learning environment through the modeling of the learner's profile and of the educational resources with context awareness through ontology.

1 INTRODUCTION

The educational environment has undergone several digital changes in recent years, mainly due to cultural evolution and increased access to technological advances by the general population. Most students use mobile devices in the classroom, even when these devices do not comply with established norms. Often this movement is an attitude of an initiative to search for information, which shows an opportunity for development in computing and education. In this context, hybrid teaching has regained strength in the spaces of discussion about new educational methodologies. Blended learning has been studied and disseminated for several years (Oliver, 2005) (Graham, 2006). As early as 2003, the American Society for Training and Development (ASTD) already identified blended learning as one of the ten most significant trends in the knowledge industry (Rooney, 2003). In current work, researchers have been investigating both the implementation and the effects of blended learning in different educational environments (Rafiola et al., 2020) (Vo et al., 2020) (Anthony et al., 2020) (Bruggeman et al., 2021).

More recently, Agarwal (2021) dealt with some trends in educational practices in the coming years, pointing out blended learning as one of the most promising practices in the near future. It shows that recent events, such as the COVID-19 pandemic, accelerated the process of change in several educational practices that were already being thought of, highlighting the role of hybridity in this movement. Among the practical advantages of blended learning, some stand out, according to the

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study carried out by Ali (2019): increased academic performance and social skills of students, increased flexibility in teaching and learning, as well as increased student satisfaction. There is also a decrease in dropout rates and an increase in school retention.

According to Graham (2006), there are three frequently mentioned definitions concerning blended learning: à combination of teaching modalities, a variety of teaching methods, and à combination of face-to-face instruction with computer-mediated instruction. It then shows that the first two definitions are so comprehensive that they would encompass all education systems. Graham then defines blended learning systems as combining face-to-face and computer-mediated instruction. A broader definition where the expression blended learning is strongly linked to blended education, in the sense that there is no single way of learning and in which learning is a continuous process, occurring in different ways, in different spaces. This approach expands opportunities for unified work between these areas.

Recommender systems are systems that generate suggestions of interesting items for users to use, with the greatest benefit of reducing the overload of information on the user, making the interaction of the user with the system a more attractive activity. and personalized, considering that the suggestions guide users towards the existing options (Ricci et al., 2015). Consequently, other benefits can be pointed out in the use of recommendation systems, such as decision-making support, customer loyalty, and increased revenue, among others (Jannach and Adomavicius, 2016). The items to be recommended can be the most varied, such as movies, music, books, videos, etc. The development of recommendation systems has been the object of companies in order to please and retain their customers, such as Netflix when recommending a series, YouTube when recommending a new video, or even recommending friendships through Facebook. The work of Ko (2022) points out that about 21% of the papers published in the last ten years on recommender systems are intended for use in social networking systems. Education appears as a growing purpose, with about 12% of publications.

Thus, the objective of this work is to present a development of a semantic model for context-aware recommending educational resources applied to blended learning environments..

This work is organized as follows: in addition to this introduction, section 2 presents some related works; section 3 presents the approach developed; section 4 presents the ontology developed; in section 5 a case study is presented through a scenario of use to evaluate the proposal developed; finally, section 6 presents the conclusions and future work.

2 RELATED WORKS

In the work by Hoic-Bozic et al. (2015), the implementation of a blended learning environment was presented using the ELARS system (E-Learning Activities Recommender System) to recommend educational resources. The ELARS system recommends four types of e-activities: optional activities, potential collaborators (other students), web 2.0 tools, and mentoring. Wonoseto and Rosmansyah (2017) developed a knowledge-based recommendation system applied to a school in Indonesia. Learning style knowledge and collaborative learning theory were considered, performing the modeling in two stages: identification of learning styles and recommendation based on learning style and collaboration.

To identify learning styles, based on Flaming's theory, the authors applied a VAK (visual, auditory, or kinaesthetic) questionnaire (Visual, Auditory, and Kinaesthetic) in order to model students based on VAK learning styles. Then, in the second step, the learning objects were grouped into characteristics to be recommended to students according to their learning styles. Each student also received an indication of a collaborator with the same learning style, but with a difference in school performance.

A blended learning model supported by recommendation systems was proposed by Saied and Nasr (2018), who performed a recommendation based on the correspondence between the student and the recommended resource. The authors performed two modelings: group modeling and content modeling. For the group modeling, a two-level collaborative filtering approach was applied in order to group the students according to the similarities and differences between their preferences, while in the content modeling, indexing, and text mining techniques were used, using Nutch, an open-source search engine[4]. As a recommendation strategy, content-based filtering was adopted, by mining student models, mining association rules, tracking and indexing learning resources, and extracting user preferences.

In the work of Bouihi and Bahaj (2019), architecture was proposed for recommending learning objects for distance learning. Based on the

[4] (http://nutch.apache.org).

classic 3-layer architecture (presentation, business, and persistence), it was proposed to insert a semantic layer between the business and persistence layers. The proposed layer is composed of two semantic subsystems: an ontology-based system and an SWRL rule-based system. The ontology-based subsystem is used to model the content and context of the learning object, in order to make it reusable and shareable. The rule-based subsystem, in turn, is used for recommendations, made based on the relevance of the learning object. These rules have been organized into four categories: Learning History Rules, Learning Performance Rules, Social Network Learning Rules, and Learning Path Rules. The authors defined values 5, 10, and 20 as relevance weights for recommending learning objects (low, medium, and high). These values are updated with each run of the SWRL rules.

Mendes et al (2017) presented SADE (Student Performance Monitoring System), a system that makes recommendations for learning objects based on student performance profiles. The modeling of the student's profile is carried out in two stages: first, their personal data are collected in a registration form; then, during use, the system collects information from the student's performance in the evaluations carried out by the teacher, classifying it in 5 levels (A, B, C, D, and E). For recommendation, the content-based technique was used, making use of information from the student's database as a function of their development in the assessments.

Tarus et al (2018) proposed a hybrid recommendation approach based on context awareness and sequential pattern mining to recommend learning resources to students in ODL environments. The authors used context awareness to insert contextual information about the student, such as knowledge level and learning objectives. With the use of contextual information, Collaborative Filtering was used in the recommendation strategy, through Pearson's correlation coefficient and the kNN (k Nearest Neighbour) algorithm. To filter the recommendations according to the access patterns, sequential mining of patterns was used, through the GSP (Generalised Sequential Patterns) algorithm in order to mine the web logs.

In Jeevamol and Renumol (2021), an ontology-based e-learning content recommendation system was proposed to solve the cold start problem. The proposal is composed of 3 main components: interfaces, ontologies, and unit of measure of similarity of student and learning object. In the ontology component, 3 ontologies were built: student, to model personal information and learning style according to FSLSM (Felder - Silverman Learning Style Model); student log, to model the student learning path and; material, to model the learning objects, from the LOM standard. In the similarity measurement unit, ontology is used to generate recommendations under cold start conditions, combined with collaborative and content-based filtering techniques.

In Harrathi et al. (2017), a proposal for a learning activity recommendation system was presented in the context of MOOC (Massive Open Online Course), with the objective of helping the student to follow the learning process and reduce evasion. A knowledge-based recommendation was used as a technique to carry out the recommendation of distance activities, based on ontology. The system uses ontology to model and represents domain knowledge, student, and learning activities.

The architecture is composed of 3 layers: user interface, system operation, and database. The User Interface layer is responsible for sending the data to feed the student model module and presenting the recommendations coming from the system operation layer. The system operation layer contains 4 modules: student model module, domain model module, recommendation generation module, and recommendation display module. The database layer of the system abstracts 3 databases used by the system: the student model database, the rules database, and the learning activities database. The domain model was based on an ontology related to the IMS-LD specification to specify the structure of a MOOC course. The student profile is composed of 4 subclasses: knowledge level; student characteristics; learning style, and; preferences. The ontology of learning activities has 6 subclasses: difficulty, type, start time, duration, and priority.

Labib et al (2017), focused on distance learning, presented an ontology to model the student profile based on the creation of interconnections between the different dimensions of the learning style model, learning style, and the relevant characteristics of the student. The authors selected the most used learning style theories in recent years and surveyed how some student characteristics relate to each learning style that has some compatibility. The theories used were: Gregorc's Mind Styles model, Honey and Munford's model, Riding Styles, Myer Briggs Styles, Felder Silverman Styles, and Kolb Styles. The dimensions explored in the ontology were: decision, understanding, access mode, lifestyle, organization, and process.

The authors used the On-to-knowledge methodology, presented in Sure et al (2009), which has 5 phases. In phase 1 - Feasibility Study, information was collected on scientific databases related to learning styles models. In phase 2 - Departure, the process of extracting the characteristics of the student was carried out. In phase 3 - Refinement, 3 sub-phases were performed: definition of a base taxonomy to formulate the application-oriented ontology; elicitation, where many knowledge entities are defined and; formalization, where entities are organized into hierarchies. In phases 4 and 5 - Evaluation and Maintenance, after using the reasoner, several example queries were applied to test the consistency and verify the usefulness of the ontology.

Obeid et al (2018) presented a proposal for an ontology-based recommendation system for undergraduate students. The approach uses improved ontology with machine learning techniques to guide students in higher education, in order to assess vocational strengths and weaknesses, student interests and capabilities, in order to identify students' interests, requirements, preferences, and ability to recommend the appropriate course and university. The authors conducted the survey among French and Lebanese students through university portals.

The proposed system has four main parts: 1 - explicit and implicit data collection, through the data filled in their profile (explicit) and the proposal of a survey to the students to collect information about their interests (explicit); 2 - ontology, which supports the system by modeling domain knowledge, through the creation of three ontologies, educational institution, job, and student; 3 - machine learning, which processes information, creating and grouping student profile models and sending the results to the hybrid recommendation engine; 4 - recommendation, through compatibility between students and interests, performs recommendations and saves student recommendation information for later use.

Ouf et al (2017) carried out a detailed study on works that use ontology in teaching environments, verifying that most studies are focused on personalizing learning objects, ignoring other factors. The authors then propose a framework for distance learning environments, using ontology and SWRL. The proposal's architecture is composed of four layers: 1 - Interface, which presents the results of the recommendations; 2 - Semantic Reasoning Engine, responsible for personalization through the use of reasoners, using SWRL; 3 - Semantic Layer, which contains the semantic representations of the components of the learning process and; 4 - Semantic Metadata, notes the concepts and their relationships.

The approach contains four ontologies, which form the semantic layer: student model, learning objects, learning activities, and teaching methods. The student model has several categories: personal, knowledge, behavioral, preferences, learning objectives, and safety. The ontology of learning objects consists of different modules. A module includes a set of domains, and each domain is made up of one or more subjects, which include knowledge of different subjects associated with the student. The ontology of learning activities defines activities such as brainstorming, case study, and group work, among others. The ontology of teaching methods defines methods such as reflection, project-based learning, and workshops, among others.

Agarwal et al (2022) proposed a hybrid recommender system that utilizes cluster-based collaborative filtering and rule-based recommendation using SWRL for recommendations applied to MOOC platforms in order to recommend internal course elements along with the learning path in addition to learning tips. apprenticeship.

To carry out the grouping of students, the use of the learning style Felder Silverman's Learning Style Model (FSLSM) was incorporated through the detection of traced usage parameters. The authors use contextual knowledge to deal with the cold-start problem and SWRL to perform rule-based recommendations with ontologies. Two ontologies were used: learner and course. The learner ontology is used to represent the static (such as SHA-256 key, platform used, browser, etc.) and dynamic (courses currently enrolled, learning style, grades, return visits, the fraction of completion, etc.) attributes of the learner. The course ontology also contains static and dynamic attributes. Static attributes include the course name, course duration, and course fee, along with the set of all course elements regarding video lectures, reading material, etc. Dynamic attributes include current enrollment, current completion, etc. Then, after grouping according to the FSLSM learning style, the model makes recommendations through SWRL rules.

Ezaldeen et al (2022) proposed a framework called Enhanced e-Learning Hybrid Recommender System (ELHRS) for E-learning recommendation that integrates adaptive profiling and sentiment analysis.

The authors developed a semantic model to deduce the learner's profile automatically and used the DBPedia (http://www.dbpedia.org/) and WordNet (https://wordnet.princeton.edu/) ontologies as a semantic-based approach for term expansion so that the learner's profile is updated according to their behavior and different navigation actions. . As part of the recommendation system, custom constructions of

Convolutional Neural Networks (CNN) and the hybridization of Natural Language Processing (NLP) methods were developed by thirteen CNN-based models of sentiment analysis to predict the ratings of textual reviews on a resource specific learning.

It is noted that there are many research efforts in the sense of recommending learning resources that perform the modeling of the learner profile, such as the work of Mendes et al (2017). Some works use semantic web and ontology, such as the works by Wonoseto and Rosmansyah (2017), Jeevamol and Renumol (2021), Harrathi et al. (2017), Obeid et. al (2018), Ouf et al (2017) and Ezaldeen et al (2022). The works by Hoic-Bozic et al. (2015) and Saied and Nasr (2018) address hybridism, while the works of Tarus et al. (2018) and Agarwal et al (2022) use context awareness, but without addressing hybridism.

Thus, the present work is able to collaborate with what has already been done by exploring the sensitivity to the student context applied to the hybrid education environment, by modeling physical and digital learning resources, with their respective usage requirements and the student context in the location and technology dimensions, which make it possible to enrich the recommendation process.

3 DEVELOPED APPROACH

The problem of information overload, already known in educational environments, is potentiated in blended learning environments, because, in addition to the numerous options that the student has to deal with to choose an educational resource that helps him/her in the teaching process, there are specific limitations due to the context in which the student lives and is at the moment. For example, the student may have a residence with high-speed connection support and a high-processing computer, or a residence with no connection, and only have a smartphone with a mobile data connection. This work proposes an ontological model for recommending learning resources applied to blended learning.

In everyday life, an example that can be used is a student who is at home and wants to use a learning resource to help him/her perform a task for the next week. It has numerous search options, and the search for resources does not take into account your conditions of use. This generates what is called cognitive overload and reduces the efficiency of your study.

To deal with this problem, a model was developed that includes aspects of the user profile (general and academic), in addition to considering three dimensions of context: technology, location, and data from learning resources. Thus, it is expected to help the student in the process of choosing the available resources, reducing the time of searching for them, and helping the learning process. The model will be further detailed in the next subsections, with the presentation of the modeling of each of the contextual aspects. There are several ways to model a domain; that is, there is not only one alternative considered correct. The methodology used in the construction of the ontological model proposed in this work was the “Ontology development 101”, proposed by Noy and McGuinnes. The methodology proposed by the authors presents a simple and interactive way, as step-by-step, for the construction of an ontology, which justifies its choice in this work. The process is divided into seven steps to be followed during model development.

4 DEVELOPED ONTOLOGY

Protégé (Stanford, 2022) stands out as the most used ontology editor by the international community. In this work, Protégé version 5.5.0 was used to build the ontology. Figure 1 presents the overview of the model developed, with the information aspects used to achieve the recommendations of learning resources to the student. The student is the center of the model, which has two profiles: general and academic. It relates to the aspects of location, technology, and subject of interest, in order to have the recommended learning recommendation. Technology refers to the technological aspects that concern the student, such as the type of connection, the screen size of the equipment, the presence or absence of GPS, and processing capacity. Location describes the student's physical location perspective.

The location has spatial points that describe it (latitude and longitude) and can be automatically captured by the student's device or manually entered depending on the context. In the model, specific subclasses were described for the purpose of the recommendation, which are: home, campus, and academic environment.

The learning resource is the class that defines the objects that will be recommended to the student based on their profile, and their relationship with aspects of technology and location. Two subclasses were modeled: physical learning resources and digital learning resources. This definition is important because, in a blended learning environment, this factor is decisive for the recommendation or not of a certain resource at a given moment of the student's study.

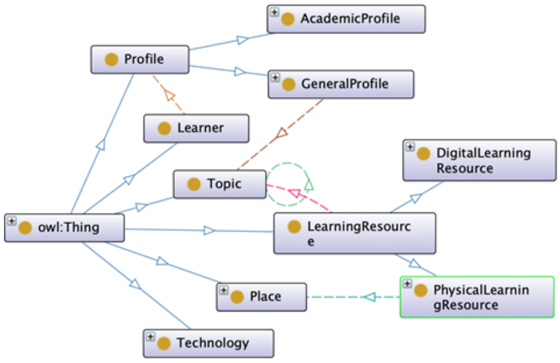

Figure 1: General Model Classes Developed.

The general model defines the central concepts of the ontology, with which all the other classes are related, which is shown in Figure 1. Some object properties were omitted to allow better visualization of the classes.

The Learner class relates to the Profile class through the *hasProfile* object property. *AcademicProfile* and *GeneralProfile* are subclasses of the Profile class, which model, respectively, the Academic Profile and the General Profile of the student. It is worth noting that the student relates to a certain subject, Topic class, through the *h-sInterestIn* object property in his *GeneralProfile*. The *LearningResource* class relates to the Topic class through the *coversTopic* object property and has two subclasses *DigitalLearningResource* and *PhysicalLearningResource*. The PhysicalLearningResource class is related to the Place class through the *hasPlace* object property, as it has a storage location, for example, a Book that is stored in a library. A Topic can have a prerequisite that is another Topic, modeled through the *hasPreRequisite* object property.

A more detailed relationship between the learner profile, technology, location, and learning resources is shown in Figure 2. The overall learner profile relates to technology through a *hasTechnology* object property. On the other hand, the learner's class relates to technology through the usesTechnology property, which defines the technology the student uses when the recommendation is made. This was modeled in this way since a student who is at home, even using a smartphone with a small screen, can receive a recommendation for a resource that requires greater computing power if he has a computer in his home that meets the minimum requirements of the resource.

It is also possible to notice the relationship that the learner has with a location through the *hasLocation* object property, which is essential for the recommendation of physical resources. The *PhysicalLearningResource* class is related to the *Location* class through the *hasStorageLocation* object property, as it has a storage location, for example, a Book stored in a library. The *Location* class also has an object property for defining one location to be close to another, *isNearOf*, which can also be used to make a recommendation.

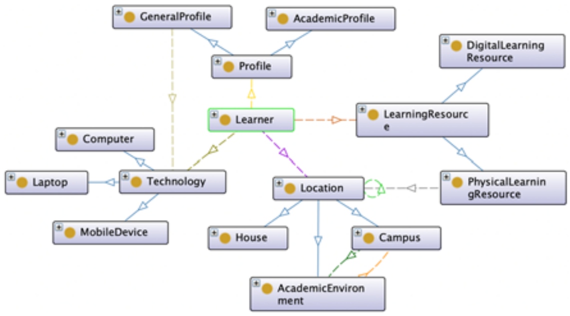

Figure 2: Relationship between models of the learner, location, technology, and learning resources.

5 CASE STUDY

A case study is presented in order to evaluate the approach developed in this work. A case study is characterized as an empirical investigation that investigates a contemporary phenomenon in depth in its real-world context, especially when the boundaries between the phenomenon and the context may not be so clearly evident. In this sense, the case study is developed from the possibilities of use of the proposal, where recommendations made from the student's profile and the context in which he is, within a blended learning environment are reported. First, the possibility of using the developed model is presented. Then, a presentation is made on the inference mechanisms used in the proposal. Finally, a usage scenario is presented with the application of SWRL rules, in the situation of use by the student from his/her house.

In a blended education environment, there is a demand for recommending educational activities to a student based on their characteristics, knowledge, and context. As for their characteristics, the student can have a general profile and an academic profile. In the academic profile, the educational characteristics of the student are considered, such as previous knowledge of a certain subject and the student's learning objectives. In the general profile, the characteristics that the student has, regardless of their school situation, are taken into account, such as housing, subjects of interest, and work. The system also stores the student's knowledge through the subjects with which he has already interacted and the classes he has attended.

To perform the filtering that makes the recommendation of learning resources effective, SWRL rules are used. SWRL was proposed in Horrocks et al. (2004) as an OWL syntax extension language by combining the OWL DL and OWL Lite sublanguages with RuleML. Thus, SWRL extends OWL's semantic representation capacity through first-order logic rules, being recommended by the W3C for this purpose. The rules are constituted by antecedent => consequent, where, from the satisfaction of the antecedent's criteria, the consequent is generated. To execute the SWRL rules, an inference engine, or reasoner, is used. There are several reasoners available for use and compatible with the Protégé software, used in this work, among which the following stand out: FaCT ++, HermiT, ELK, Pellet, and Racer. In the construction of the ontology developed in this work, we chose to use the Pellet, because, in addition to being Open Source, it offers a set of functionalities such as rule support, total incremental classification, and greater expressiveness of descriptive logic combining two native profiles.

"*The scenario considers Johan, a student of the Computer Engineering course, which is taught in the hybrid learning mode. The course program adopted the enriched virtual model; that is, the course mostly takes place online, with some regular face-to-face meetings. In the Introduction to Artificial Intelligence discipline, after the presentation of the content, the teacher requests that a practical activity to implement the k-means algorithm be carried out, which will have its conclusion and debate in the next face-to-face meeting. After the teacher enters the class in the system with the subject and the task to be performed, "k-means" is added as a subject of interest to Johan.*

In the next access to the system, it appears that Johan is accessing through a mobile device and that he is at his residence. Johan does not have a computer with high processing capacity, and his connection is not high-speed. From there, the system infers the recommendation rules in order to return some suggestions of learning resources in order to help Johan in carrying out the task".

In Figure 3, it is possible to see how the learning resources related to the student profile and the characteristics of the technology in use. Within the model, several aspects can be taken into account to make the recommendation. In this case study, it is considered that if the student is at home, only digital learning resources will be presented.

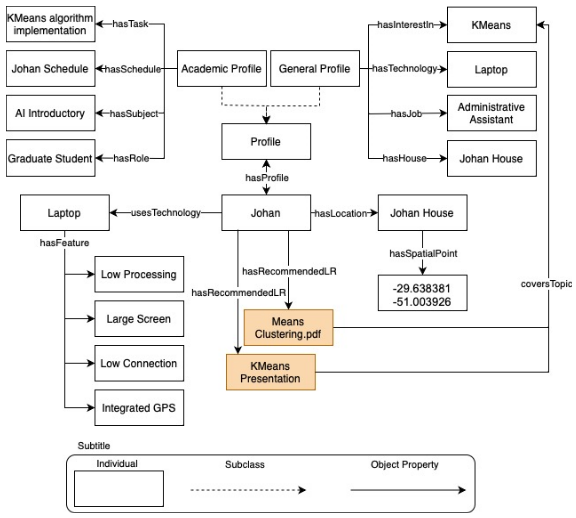

Figure 3: Model Instantiated with a student at home.

Since digital resources have minimum requirements defined for their good use, satisfaction with the technology available to the student will also be considered, in order to recommend only those that can be used effectively. For this, having the device information available to the student, the system checks what its processing standard is and what is the minimum processing requirement for each digital learning resource. Then, it does the comparison through the built-in function swrl:lessThanOrEqual(), to check if the processing requirement is less than or equal to the device's processing standard. The same process is repeated to check the screen size and connection patterns. Finally, the relationship between the learning resource and the student's profile is demonstrated through the correspondence between the subject of interest to the student and the scope of the resource to be recommended. The SWRL rule developed to effect the above recommendation is described below:

```
   Learner(?l) ^
   House(?h) ^
   Profile(?p) ^
   Topic(?topic) ^
   DigitalLearningResource(?resource) ^
   hasProfile(?l, ?p) ^
   hasLocation(?l, ?h) ^
   usesTechnology(?l, ?technology) ^
   hasConnectionPattern(?technology,
?connection) ^
   hasConnectionPatternRequirement(?res
ource, ?connectionRequirement) ^
   swrlb:lessThanOrEqual(?connectionReq
uirement, ?connection) ^
   hasProcessingPattern(?technology,
?processing) ^
```

```
   hasProcessingPatternRequirement(?res
ource, ?processingRequirement) ^
   swrlb:lessThanOrEqual(?processingReq
uirement, ?processing) ^
   hasScreenSizePattern(?technology,
?screenSize) ^
   hasScreenSizePatternRequirement(?res
ource, ?screenSizeRequirement) ^
   swrlb:lessThanOrEqual(?screenSizeReq
uirement, ?screenSize) ^
   hasInterestIn(?p, ?topic) ^
   coversTopic(?resource, ?topic) ->
   hasRecommendedLR(?l, ?resource)
```

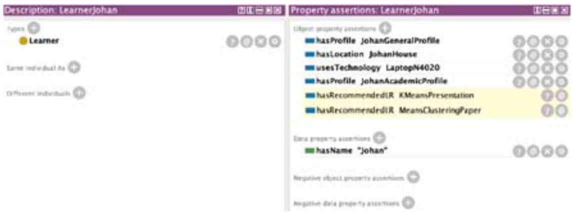

Figure 4: Result of the Rules Inferred by Pellet in the case study.

Figure 4 shows an image of the Protégé screen where the result of the recommendation is displayed. The object properties in yellow are those obtained by reasoning about the presented rule, used by the Pellet inference engine, from the model instance.

It is noted that from the characteristics presented (location, technology used, and learner interest), the model was able to infer that the learner Johan will have the digital article Means Clustering and the slide presentation KMeans Presentation recommended in order to assist in the execution of your task of implementing the k-means algorithm, within the discipline of Introduction to Artificial Intelligence.

An evaluation of the model developed through the use of a case study was carried out, with the presentation and use scenario, where situations were simulated in which a student in the hybrid learning modality is using a system developed from this model to receive recommendations of learning resources in different contexts. In the scenario, a student is at home and receives recommendations from the technology available for study. In this case, the student's interest is considered, based on the modeled profile.

The advantage of using the knowledge-based recommendation technique is noted, since, from the semantic descriptions, it is possible to obtain better results in a situation of new users, as they can receive recommendations based on their location and the technology in use, which helps to solve the cold start problem. Another advantage is that by using application semantics at a higher conceptual level, domain knowledge becomes understandable by computational and human agents.

6 CONCLUSIONS

In this paper, an evaluation of the model developed through the use of a case study was carried out, with the presentation of a scenario of use, where a situation were simulated in which a student in the blended learning modality is using a system developed from this model to receive recommendations of learning resources in different contexts. In that scenario, a student is at home and receives recommendations considering the technology available for study. In that case, the student's interest is considered, based on his modeled profile. The advantage of using the knowledge-based recommendation technique is noted, since, from the semantic descriptions, it is possible to obtain better results in a situation of new users, as they can receive recommendations based on their location and the technology in use, which helps to solve the cold start problem. Another advantage is that by using application semantics at a higher conceptual level, domain knowledge becomes understandable by computational and human agents, as suggested by Berners-Lee et al (2001).

This work presents the development of an ontology for recommending learning resources in context-sensitive blended learning environments. The main context dimension taken into account was location since, in blended learning, the student's residence becomes an extension of the school environment. Thus, physical and digital learning resources were modeled, to be recommended differently in a situation of use in an academic environment or in a residence. Another context dimension considered was the technology that the student has, and that is currently in use so that learning resources can be filtered according to the technological capabilities available to the student.

In future works, we intend to generate a module and integrate it into a Virtual Learning Environment. Subsequently, it is intended to carry out the validation through tests with students in a real environment of blended learning. Another future work will be to model different user and context characteristics, such as cultural issues., increasing the personalization of the recommendation. Finally, we intend to insert other context dimensions, such as activity and time.

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