World Academy of Science, Engineering and Technology
International Journal of Educational and Pedagogical Sciences
Vol:18, No:7, 2024

OSEME: A Smart Learning Environment for Music Education

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***Abstract*—**Nowadays, advances in information and communication technologies offer a range of opportunities for new approaches, methods, and tools in education and training. Teacher-centered learning has changed to student-centered learning. E-learning has now matured and enables the design and construction of intelligent learning systems. A smart learning system fully adapts to a student's needs and provides them with an education based on their preferences, learning styles, and learning backgrounds. It is a wise friend and available at anytime, anywhere, and with any digital device. In this paper, we propose an intelligent learning system, which includes an ontology with all elements of the learning process (learning objects, learning activities) and a massive open online course (MOOC) system. This intelligent learning system can be used in music education.

***Keywords*—**Intelligent learning systems, e-learning, music education, ontology, semantic web.

I.Introduction

NOWADAYS, developments in the field of Information Technology affect the methods, practices, and tools of education and training. The increase in the speed of the Internet and the data storage space, in connection with the progress in cloud computing technologies, make information available at any time, through any digital device, to every person [1]-[3].

The new terminology now taking shape in the digital world is any learning, on any device, at any time. In addition, creative and critical thinking is necessary for the development and completion of the learning process. Each person has his way of learning, while the changes of the person through the process of learning take place in the field of knowledge, skills, and opinions that he has on various subjects. In this way, the need has now been created to teach individuals using new technologies [4].

The traditional methods of education and training where the instructor explains the subject in the classroom and the students complete the assignments at home have now been replaced by new learning approaches such as mobile learning, blended learning, games, etc. [5]-[12].

E-learning has now invaded our lives and promises a variety of research and methodology tools, but also a variety of educational resources, and tools [13]. The development of e-learning is a consequence of the development of the global information web, which enabled teachers to have access to rich educational material, to design teaching scenarios, and to be able to quickly and easily receive the appropriate information. On the other hand, students can easily and quickly search for information and thus increase and enrich their knowledge and skills [14].

Information and communication technologies now offer the possibility for more personalized, more autonomous, and more interactive learning. We are now moving from traditional education to smart education [15]. Smart devices and new technologies now offer the possibility of developing intelligent learning systems based on educational platforms such as the Moodle platform and semantic web technologies such as ontologies [16].

An intelligent learning system plays the role of a wise friend who advises students in their daily lives. It aims to help students acquire new knowledge even while doing leisure activities. It takes into account their needs and preferences and suggests suitable learning items [17].

On the other hand, Semantic Web technologies seem to be a promising technological foundation for the next generation of e-learning systems. Ontologies, one of the key components of the Semantic Web, can be integrated into the backbone of an e-learning system [18].

Many authors have proposed the use of ontologies in different aspects of e-learning, such as adaptive hypermedia, personalization, and learner modeling. Information and communication technologies create the possibility for more autonomous, interactive, and personalized learning. As new information and technologies are introduced, we are moving from traditional education to smart education [17], [18].

This article is structured as follows: in Section II, we present related work and research methodology. In Section III, we provide adequate background on intelligent learning systems as well as the relationship between the Semantic Web and learning systems, ontologies, learning objects, and learning styles. Section IV presents the architecture of the proposed system. Section V discusses the proposed framework, and Section VI presents the conclusions and future work.

II.Related Work - Research Methodology

The World Wide Web is the largest repository of information available in the form of text, images, videos, etc. However, searching and locating the information we need on a subject is not an easy task. In recent years, the international scientific community with the help of the semantic web has made significant efforts to improve the identification, retrieval, and

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reuse of information, which is stored on servers scattered on the Internet.

Metadata, ontologies as well as technological developments in the field of Artificial Intelligence contribute to the exchange and semantic understanding of information not only from the perspective of humans but also from the perspective of machines by changing the current web into a semantic data web. Often, there is also a Massive Open Online Course (MOOC) that helps shape people capable of understanding and collaborating in this process of technological change.

Studying the literature, we find that many researchers propose e-learning educational systems based on ontologies and Semantic Web technologies [19]-[29]. In addition, many researchers propose smart learning systems and educational frameworks where the student is an autonomous and effective user of technology, while the role of the instructor is very important as he facilitates the learning process and provides technological and technical assistance when needed [30]. In addition, the literature is rich in connecting an ontology to a MOOC, which involves integrating the structured knowledge representation of the ontology with the content and data of the MOOC. This integration enables the semantic analysis, organization, and retrieval of information within the MOOC [31]-[40]. In addition, in the field of music education, the use of ontologies contributes to better quality learning and contributes to the search for information about music. An ontology that defines concepts and relationships in the domain of music and which constitutes a formal framework is Music Ontology.

In this paper, an ontology is linked to a MOOC to implement the OSEME smart learning environment for music education, which provides students with a learning package that includes various components of the learning process (learning objects, assessments, feedback).

The steps followed to design and implement OSEME include mapping the ontology to the MOOC content to establish the link between the structured knowledge representation (ontology) and the actual course content. Metadata and comments are added to the MOOC ontology and content to add semantic tags or tags to different parts of the course material to indicate the concepts they represent.

In addition, search and navigation capabilities are added to OSEME, personalization, and recommendations added, where a framework is developed to detect the learning needs of the student based on the learning needs and learning style for the learning system to recommend the appropriate learning objects. Also added is data integration, where the ontology database is connected to the MOOC database with appropriate tools. Ontology maintenance is also added, where the ontology is periodically updated and enhanced with changes that may exist in the MOOC content so that it continues to support accurate semantic analysis and information retrieval.

Regarding the research, the descriptive method was chosen and a search was made for articles about ontologies and their use in a learning environment, while the research issues for the development of the intelligent learning system include knowledge modeling for music education and the extraction of knowledge flows for the design and implementation of educational plans.

III. Smart Learning Environments

Since the early 1980s, researchers have been developing intelligent tutoring systems (ITS), in which they integrate artificial intelligence technologies and pedagogical techniques into educational applications; a ubiquitous learning perspective, based on new technologies [41].

New smart devices and educational software provide an engaging personalized learning experience and rich digital content that encourages students to participate in the learning process. New smart learning environments have emerged and students are beginning to experiment with them since they have grown up with the use of electronic devices and thus are familiar with them [42].

Essentially, an intelligent learning system can be understood as a technology-enhanced learning system that is capable of advising students to learn in the real world with access to the resources of the digital world. It enables learners to access digital resources and interact with learning systems at any place and at any time [43]. Additionally, an intelligent learning environment is a learning environment that is based on intelligent pedagogical models, adapts to the user's learning needs, and provides the appropriate support (guidance, feedback, advice, digital tools) at the right time, analyzing the learners' learning behavior, their performance and the environment (online or real) in which they are located (Fig. 1).

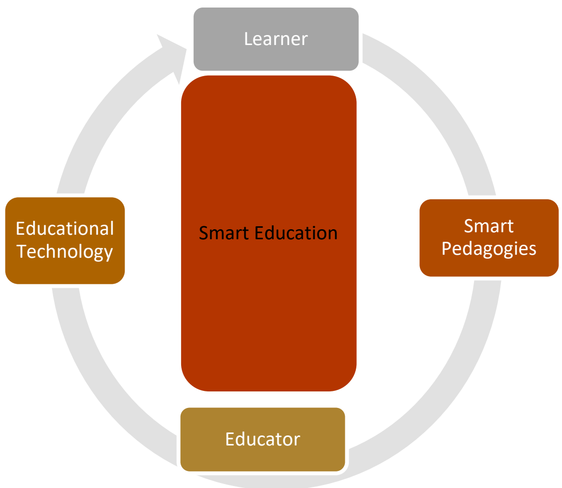

Fig. 1 Smart Education

In addition, the learning environment can engage the student in dialogue or facilitate a group dialogue about a relevant topic or problem. It can create a self-assessment based on the student's progress and suggest activities and applications that help overall learning effectiveness. It can rearrange learning resources and provide appropriate mechanisms to improve student performance and the way students interact with the learning environment [44]. It provides an interactive learning environment where students are actively involved, interactive classroom course management tools, and interactive whiteboards. It uses smart devices, new teaching approaches, and new technologies as presented in Table I, thus providing a new form of learning.

TABLE I
SMART EDUCATION FRAMEWORK TECHNOLOGIES

1. Smart/ virtual/ Ambient Intelligent Rooms 2. Learning Management Systems	Essential Transforming Technologies
1. Extended Reality (XR) 2. Serious Games Educational Robots 3. Educational data mining/ Learning and Academic Analytics	Enriching Technologies
1. Gesture Based Computing 2. Mobile Technology 3. Cloud Computing Technology 4. Web 2.0+ 5. Social Networks	Supporting Technologies

A. Pedagogical Models in SLE

Smart learning systems' success depends largely on the pedagogical models they use. Pedagogical models are the theoretical frameworks and principles that guide the design and implementation of educational processes and activities. These models describe how the material is presented, methods for student assessment, and the way feedback is provided [45].

Some of the pedagogical models applied to intelligent learning systems include the personalized Learning model, Collaborative Learning model, Game-based Learning model, and Inquiry-based Learning model. These pedagogical models are integrated into intelligent learning systems to provide personalized and impactful education to students. The combination of technology and pedagogical models helps promote interaction, collaboration, and active participation of students in the learning process [46]-[51].

B. Semantic Web and SLE

The Semantic Web (SI) and Smart Learning Environments (SLE) are two distinct but interrelated concepts that have the potential to revolutionize education and knowledge sharing. They combine the World Wide Web and educational technology to improve the educational process, offering personalized, advanced, and more effective learning.

The SI is not a new World Wide Web, but an extension and improvement of the current Web with the goal, mainly, of structuring information so that it is accessible by computer programs. In SI, digital documents (web pages) are replaced by entities where they can be described in a structured way and linked to other entities, creating a giant global network or graph of concepts and data. In this way, information acquires well-defined meaning, enabling a more effective collaboration between humans and computers, since there will now be a common language of communication between them (the semantic description) [52]-[55].

In the context of education, the Semantic Web can enhance learning experiences by organizing and connecting educational resources in an intelligent and interconnected way. It enables the creation of a knowledge web where concepts, themes, and relationships between different learning materials can be represented using standardized ontologies. This facilitates personalized learning, intelligent learning systems, and the discovery of relevant educational resources based on individual preferences and learning objectives [56], [57].

SI, in combination with SLE, can be used to create and organize educational content, as well as to retrieve and exchange data on education. This allows for the creation of strong ties between information and automatic knowledge extraction. SLEs, on the other hand, use this knowledge to provide personalized educational experiences, taking into account the individual needs and preferences of learners [58].

C. Ontologies

The term ontology was first used and defined by Tom Gruber in the 1990s. In his view, an ontology "is an explicit specification of a conceptualization". It also provides a fertile ground for understanding, capturing, representing, and interpreting the concepts of a domain [59]-[62].

In the Artificial Intelligence (AI) community, ontologies have been a popular research topic for a long time, but their significance has grown even more with the emergence of the Semantic Web in recent years. Ontologies have grown in popularity and the concept of ontology is now widespread in the field of e-learning, allowing for a richer description and retrieval of learning objects within a learning environment, thus facilitating the personalization and recommendation of learning content, curriculum design, and assessment of learning objects.

The use of ontologies in education allows the representation of a learning domain and supports the creation of a new generation of intelligent learning systems that are personalized and tailored to the preferences and needs of learners. Furthermore, it improves the learning process, supports interoperability between different objects, achieves effective personalization, and supports different elements of the learning process (learning objects, teaching methods, learning activities). It can also be considered a knowledge base that is further used to extract useful knowledge and generate personalized views of an intelligent learning system [63]-[71].

D. Learning Objects

Learning objects refer to discrete, autonomous units of learning that can be used and reused in different educational contexts. They are digital or multimedia resources designed to facilitate learning and can include various forms of content, such as text, images, videos, simulations, interactive activities, and assessments [72], [73].

By using learning objects, teachers can assemble personalized learning experiences for their students while the students can access and engage with specific learning objects that meet their learning styles, preferences, and needs. This modular approach to learning supports flexibility, adaptability, and effective use of educational resources [74], [75].

There are several metadata standards for learning objects that are used in object repositories for various domains and disciplines (Dublin Core metadata, IEEE Learning Object Metadata - LOM, SCORM metadata). On the other hand, ontologies can be used to structure and organize knowledge in the context of learning objects. An ontology can describe the concepts, links, and relationships between different learning objects. In our system, we use the LOM metadata category which includes information about the title, description, keywords, author, creation date, educational level, type of learning object, and other elements that help search, organize and evaluate learning objects [76]-[80].

E. Learning Styles

Learning styles refer to the different preferences and ways in which people perceive and process information, as well as how they prefer to learn. The term 'learning styles' comes from the works of Honey and Mumford, who proposed a classification of learning styles based on four main approaches: observation, experimentation, perception, and reflection [81], [82].

It is important to note that preferences in regards to learning styles are unique to each individual and there may be a combination of different styles. Identifying personal learning styles can help students adapt their approach to learning and thus increase the effectiveness of that learning [83], [84].

There are different learning style models, including the Myers Briggs Learning Style, Kolb's Learning Style Model, the VAK Learning Style Model, the Honey and Mumford model, and the Felder Silverman (FSLSM) model which has become the appropriate model for computer-based learning systems [85], [86].

We have chosen FSLSM to capture the learner's characteristics in this paper. Selecting a MOOC can involve factors such as prior knowledge, innate interest, work requirements, etc. However, once an MOOC is selected, navigating through it requires different course elements from any learner based largely on their learning style.

IV. Architecture of Proposed System

In this section, we provide an overview of the architecture of the proposed OSEME intelligent learning system, which aims to integrate heterogeneous data and provide an appropriate interface to the final users (Fig 2). Our system integrates an ontology and a MOOC designed with the help of the Moodle platform.

A. The Proposed Ontology

The ontology of the proposed model includes five classes that cover different characteristics for each user (learner or instructor), but also learning objects, teaching methods, educational activities, student assessment, and feedback (Fig. 3).

The ontology of the proposed model has been presented in a previous article and includes five classes that cover various characteristics for each user (student or instructor), but also learning objects, teaching methods, educational activities, student evaluation, and feedback [87].

The User class includes two subclasses (student and instructor) where information about a user, student, or instructor, is collected. This information includes the user's learning background, learning goals, learning style, difficulty level, and time spent studying. The user's personality category stores their personal information, preferences, interests, language spoken, social style, and means of communication.

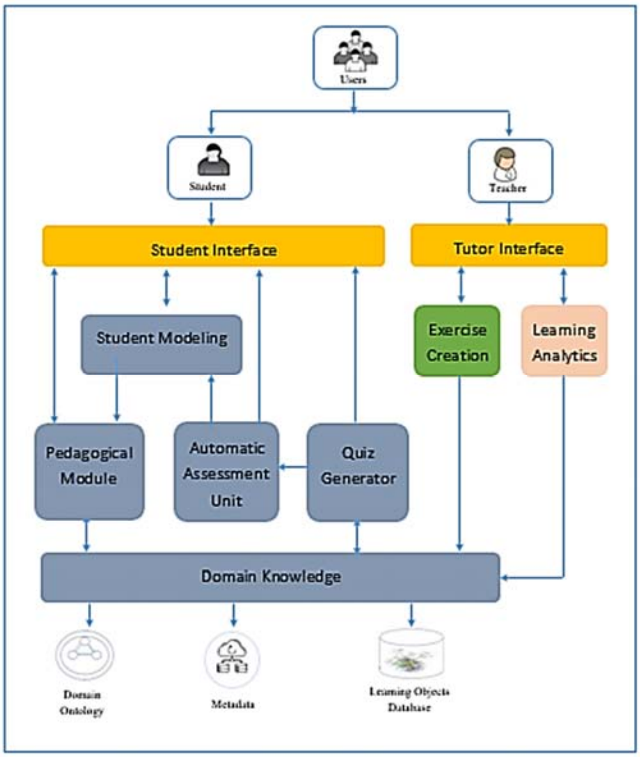

Fig. 2 Architecture of OSEME

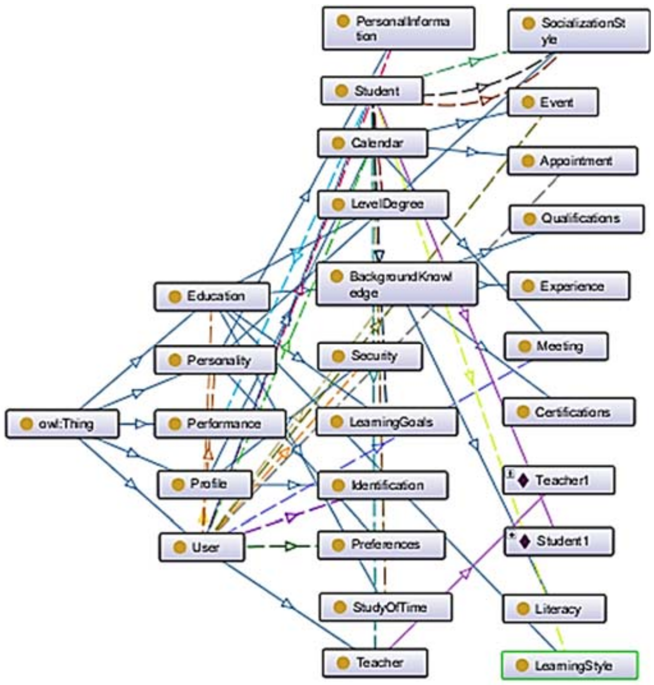

Fig. 3 Ontology

Of the previous characteristics, personal information is a key feature when describing a learner model, while basic knowledge, learner performance, preferences, learning goals, and interests are of an important yet secondary nature.

The learning object class consists of different courses, where each course consists of different modules. Each module introduces information about the content of the course and includes a set of domains. Each domain consists of one or more topics that include the knowledge that each learner needs to complete the module.

Assessment is a core part of a smart learning system. Especially in the field of music education, assessment is particularly difficult and often requires feedback.

All the required concepts related to the domains of an e-learning system were defined in the previous sections. Our ontology includes data properties that have to do with the assessment of students in the context of music education, which is a very challenging task. In addition, giving feedback to students is quite a difficult task yet at the heart of learning a musical instrument. It provides vital information about student performance and can come from a variety of sources, both physical and social [88], [89].

The ontology we have developed can be used for feedback and assessment of students in the context of music education, but it can also contribute decisively to the positive impact on students' learning and final performance.

Finally, based on research from international literature and after extensive discussions with music education teachers, we concluded that the evaluation of students can be based on a Likert-type scale (1 = Poorly, 2 = Moderate, 3 = Good, 4 = Very Good, 5 = Excellent) [90]-[93].

B. MOOC

The above properties contribute to the formation of the student's profile, which will then form the basis for an intelligent learning system, tailored to a student's learning needs and learning goals.

The MOOC built for the needs of the OSEME system includes the following elements: modules, participants, grades, discussions, lessons, resources, additional material, and it was uploaded to the Moodle platform. Testing was carried out on a small sample of students and experienced teachers. Fig. 4 is a screenshot of the History of Music lesson.

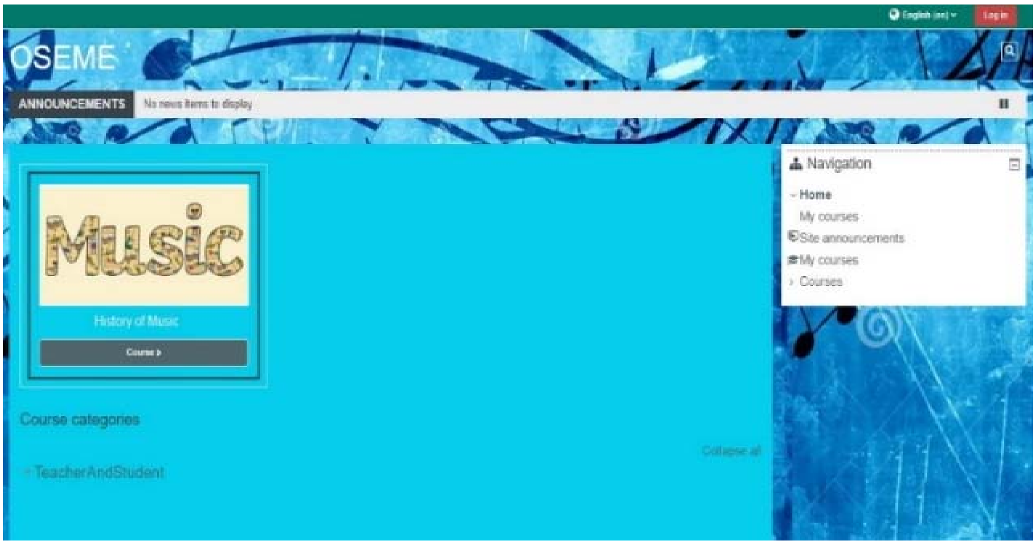

Fig. 4 MOOC

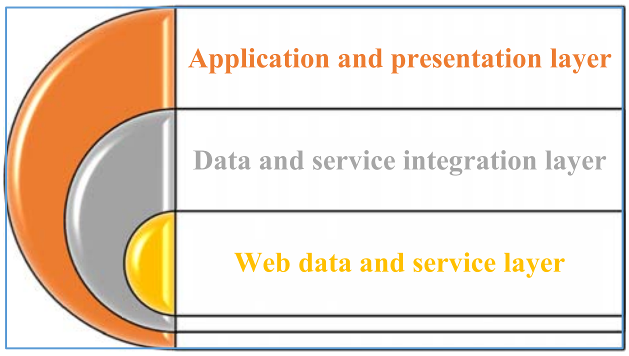

Fig. 5 Layers of OSEME

C. OSEME

The overall proposed architecture of our system includes three layers: the data and web services layer, the data integration and service integration layer, and the application and presentation layer as shown in Fig. 5.

Application and Presentation Layer

In an intelligent learning environment that integrates an ontology and the Moodle platform, the application layer and the presentation layer play important roles. The application layer refers to the software components and functions that facilitate the operation of the intelligent learning environment while enabling the creation of a coherent learning environment. It is responsible for user authentication, registration, and access control to the learning environment. It also manages users' accounts, roles, and permissions, ensuring that learners, instructors, and administrators can interact with the system securely and efficiently. Finally, it deals with the management and delivery of training materials such as courses, assessments, and resources.

The presentation layer on the other hand focuses on the user interface and the way information is presented to students, instructors, and administrators. It includes the visual design, navigation, and interaction elements of the intelligent learning environment. It defines how the learning environment is presented to users. It includes organizing course materials, providing navigation menus, and integrating multimedia elements to effectively engage learners and support personalized learning experiences. It can dynamically customize content, recommendations, and interface based on individual learner preferences, needs, and performance; it can present progress indicators, badges, or dashboards that allow learners to track their progress and achievements in the learning environment. This helps learners monitor their performance and motivates them to achieve their goals.

Data and Service Integration Layer

In an intelligent learning environment with an ontology platform and Moodle, a layer of data and service integration plays a critical role in connecting different elements and facilitating seamless communication and interoperability. By incorporating a data and services integration layer, an intelligent learning environment with an ontology and Moodle platform can leverage the power of seamless data exchange, interoperability, and intelligent services to enhance the learning experience, personalize instruction, and enable advanced analytics and insights.

The data integration layer focuses on the integration of data from different sources within the learning environment. It includes data from the Moodle platform itself, such as course content, student profiles, and grades, as well as data from external sources such as learning analytics systems, student information systems, or educational repositories. The level of integration ensures that these different data sources can be accessed, processed, and shared efficiently.

The data and services integration layers should comply with interoperability standards to ensure compatibility and smooth communication between different systems and components. Common standards in e-learning include the IMS Global Learning Consortium standards such as Learning Tool Interoperability (LTI), Common Cartridge (CC), and Learning Information Services (LIS). These standards enable the exchange of data and functionality across different platforms and tools.

Application programming interfaces (APIs) and web services play a vital role at the integration layer by providing standardized interfaces for accessing and interacting with various services, systems, and data sources. APIs enable secure and controlled access to functions and data, allowing different components to communicate and share information efficiently.

Web Data and Service Layer

In an intelligent learning environment with an ontology platform and Moodle, the Web Data and service data layer plays a critical role in connecting and integrating different elements of the system. It acts as a bridge between different elements, facilitating data integration, communication, and interaction within the system. It enables a seamless exchange of information and provides a unified interface for users and external services to access and interact with the intelligent learning environment.

It facilitates data exchange and communication between different entities, such as the ontology, the Moodle platform, and other external services. It integrates the ontology and provides mechanisms for searching and reasoning on ontology data. It handles the integration of data from different sources, such as student profiles, course materials, assessment data, and learning analytics. It ensures that data from different sources are harmonized and accessible through a unified interface.

This layer includes a database or storage system for storing and managing learning data, ontology data, user profiles, learning resources, course content, assessment results, and other related information. It enables the seamless exchange of data and information between the intelligent learning environment and the Moodle platform. This integration could include synchronization of course content, user enrollment, grades, and other related data.

The web and services data layer allows communication and data exchange with external systems to retrieve data from the ontology, perform searches, update information, and integrate with other learning tools or services. It provides mechanisms for real-time communication and messaging between different components of the intelligent learning environment. It handles authentication and security measures to ensure that access to data and services is controlled and protected. It could also manage user authentication, authorization, and data privacy to maintain the integrity and confidentiality of the system.

Use of Proposal System

The internet as a technology provides students with various tools according to their needs and preferences. It offers new and more effective methods for students to use these tools, to communicate, collaborate, carry out research, interact with the learning environment, and receive the appropriate educational package (learning objects, learning activities).

This ontology can be used in OSEME and Fig. 6 illustrates a use-case scenario where it shows the actions and reactions between the system and the learner.

When a student accesses the platform for the first time, they are asked to register and fill in a form with personal details (name, demographic data, and contact details), passwords, qualifications, and interests, all of which constitute their data. He or she is then asked to answer a set of psychologically oriented questions adapted according to the Felder-Silverman model to identify his psychological characteristics such as his learning style, cognitive abilities, and preferences through a menu of options, where these constitute the cognitive data. For example, if the student is a sensory learner, facts, problem-solving, working with details, and making connections with the real world are suggested, while for visual learners, pictures, diagrams, films, and demonstrations are suggested, and for verbal learners, listening to information, discussion and video lectures are suggested.

Once the user has completed registration or if they already have an account, they can log in, they are asked to define their learning objective and answer a series of questions to assess their level of knowledge before accessing the course.

The system initializes the learner's knowledge of this field and assigns an appropriate learning objective. Based on the previously collected information, the system goes on to suggest the appropriate course through the selection, combination of, and relevant learning concepts, which will help the learner acquire appropriate skills to successfully pass a Conservatoire exam or national examinations.

Fig. 6 Use of OSEME

Finally, when the learning activities of the course are completed and all the individual objectives have been achieved, the student is assessed and the educational process is completed.

V. Evaluation and Validation

The validation and evaluation of an intelligent learning system is a very important task and consists of a series of steps to ensure the effectiveness and accuracy of the system while it is implemented based on specific criteria, which include various factors such as usability, effectiveness, efficiency, engagement, learner satisfaction and impact on learning outcomes [94], [95].

Based on the above criteria, we collected relevant data such as quantitative (e.g. usage statistics, performance measurements, student evaluations, etc.) and qualitative data (e.g. surveys, comments from students and teachers, interviews, observations, etc.). We analyzed the data to evaluate the effectiveness of the SLE. We used statistical analysis and data visualization techniques to identify patterns, trends, and correlations, and this helped provide a benchmark for evaluation and validation.

On the other hand, to evaluate and validate our proposed ontology we used Hermit 1.3.8.413 software. It is a reasoning tool that offers a set of functions to identify conflicting axioms through the consistency function and offers data type verification, model evaluation, anomaly detection, and correction. The GraphDB Free software helped us visualize the data to thereby get a real sense of the power of the RDF model and the relationships between the data [96]-[98].

The evaluation verifies the syntax and semantics of the ontology taking into account the scenario and the end-users, to integrate the learner model into the smart e-learning system. The control performed with the help of Hermit software showed that there is no contradiction between the axioms and this means that the designed model is following the OWL language specifications. Finally, the structural elements of the ontology are presented in Table II.

TABLE II
Ontology Metrics

Metrics	Value
Axiom	864
Logical axiom count	591
Declaration axioms count	261
Class count	72
Object property count	55
Data property count	133
Individual count	25
Annotation property count	1

VI. Conclusion and Future Work

The integration of new technologies in education effectively helps both students and instructors to promote active learning. For this purpose, we implemented an intelligent learning system that can be used in a classroom in the field of music education and with the help of an appropriate pedagogical model to provide effective and cooperative learning. The literature review shows that many studies and research use ontologies in a learning environment. Most of them focus on personalization and provide students with appropriate learning objects based on their particular characteristics and preferences, ignoring some basic elements of the learning process.

This article reflects on the important role that ontology plays in an intelligent learning environment. It facilitates the way to search and chart a learning path. It ensures the effectiveness of a SLE and makes it more flexible and efficient.

In this article, we presented a SLE with the name OSEME oriented to music education, which can be used as an integrated unit in an intelligent learning system and will be easily accessible through a web-based application. The OSEME uses an ontology that consists of five classes (users, learning objects, teaching methods, learning activities, assessment) and the appropriate object and instance properties.

With the help of appropriate plugins within PHP script, we managed to connect the proposed ontology with the help of a Moodle platform to a set of MOOCs to implement in this way an intelligent learning system and provide a series of learning objects and learning activities to students in the field of music education

A SLE envisions making learning more accessible to everyone, regardless of location, learning status, and preferences. Students and teachers now use smart devices and this contributes to learning and transforms the way they solve problems, and acquire skills and knowledge [99].

Within the framework of designing and building an ontological adaptive model, we intend in the following work to search and analyze in detail all aspects of the "psychological state" dealing with learning styles, student interests, social skills, discussion groups, emotional characteristics, and cognitive abilities to enrich the proposed ontology.

In addition, we can take advantage of the semantics contained in metadata about students and implement a grouping of students with common characteristics. This fact will help us in more precise learning activities that will be based on cooperative learning and we will be able to have a coordinator of the group, but also the distribution of students with common interests and characteristics in different discussion groups and exchange of opinions.

Additionally, the most challenging part of our research was choosing which features of a learner to include in the ontology while being compatible with existing learner modeling standards. We plan to add more rules to cover as many student profiles as possible. There was also a difficulty in the way of evaluating students in the field of music education since here too there is a constant evaluation and feedback.

We also plan to collect relevant data such as quantitative (e.g. usage statistics, performance metrics, student ratings, etc.) and qualitative data (e.g., surveys, student and instructor feedback, interviews, observations, etc.). We analyze data to evaluate the effectiveness of the SLE and provide feedback to the administrator.

Finally, we intend to enrich the set of MOOCs with the help of the Moodle platform to provide more learning objects in the field of music education. We propose the use of the OSEME smart learning system in music schools to leverage shared knowledge among users, allowing learners to suggest and highlight content to others while providing feedback.

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