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Model for motivating learners with personalized learning objects in a hypermedia adaptive learning system

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ABSTRACT

A number of weaknesses were demonstrated in the E-learning platforms during the Covid-19 pandemic despite the efforts invested. This has negatively influenced learners' motivation and consequently their performance. With the proliferation of technology and the revolution of information and communication technologies (ICT), learning objects have become new epitomes widely used, accessible, and implemented with educational resources and technological support. The integration of learning objects into E-learning has enhanced educational progress, but during critical periods, it is crucial to ensure pedagogical continuity and learner motivation. Based on this observation, we will propose architecture of a personalized learning object model in the context of an adaptive hypermedia learning system (AHS). The objective of our model is to increase the motivation factor which is a determining element in the success of E-learning, our model aims to improve the performance of the learners in order to avoid the abounding of learning and to promote the attendance of the learners. This will be useful later for any design or development of learning objects in hypermedia learning systems that are adaptive to the needs of the learners and in line with their preferences and profiles throughout the learning process offered by the system.

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1. INTRODUCTION

Traditional E-learning platforms are not tailored to the specific needs and preferences of each learner, which means that the learning experience can be less effective for some students. Moreover, traditional E-learning courses usually follow a one-size-fits-all approach, which may not be suitable for all types of learners. In order to address these limitations, modern E-learning platforms must incorporate personalization and adaptation features that allow each learner to progress at their own pace and in their own way.

The field of E-learning has considerable potential to improve teaching and learning through the use of intelligent online technologies, methods and techniques. One of the fastest growing areas of research is adaptive hypermedia, which aims to provide content that is personalised to online users according to their individual needs. Adaptive hypermedia learning systems (AHS) have been successfully applied in various fields, such as educational systems, online information systems, online help systems and information retrieval systems.

The popularity of AHS has encouraged researchers to focus on various new issues. One of the most important issues is the development of new techniques for providing personalized resources, materials, and

learning objects to capture the attention of learners. A successful adaptive E-learning system must engage learners, increase their satisfaction, and develop their motivation factor to be effective.

In our paper, we propose a methodology aimed at enhancing learner's motivation. Our approach involves the integration of learning objects in AHS. This integration allows dynamically composed content to be created for each individual learner based on their profiles. By customizing the content for each learner, we aim to increase their engagement with the materials, and ultimately, improve their learning outcomes.

2. THE COMPREHENSIVE THEORETICAL BASIS

In this section, we will delve deeper into the topic of personalized learning objects and their characteristics. Personalized learning objects are designed to cater to the individual needs of learners and provide a customized learning experience. These types of objects can take various forms, such as interactive simulations, videos, or quizzes. Understanding the characteristics of personalized learning objects is essential for creating effective and engaging learning experiences.

2.1. Definition of personalized learning objects

Hodgins (1994) introduced the term "learning object" when he named the CEdMA10 working group "Learning architectures, application programming interface (API) and learning objects" [1]. According to Wiley (2002), learning objects are defined as "any digital resource that can be reused to support learning" [2]. They are designed to be modular and flexible so that they can be combined in different ways to meet the needs of different learners and learning contexts. Learning objects continue to be an important concept in educational technology and are used in many different types of E-learning content.

The IEEE Standard for learning object metadata provides a clear definition of what constitutes a learning object. According to this standard, a learning object is a digital or non-digital entity that has been created specifically to facilitate learning [3]. These objects are designed to be reusable and interoperable, and they may contain multimedia resources such as text, images, audio, and video. Furthermore, learning objects are modular and self-contained, which means that they can be used and reused in different learning contexts without requiring significant modifications or adaptations.

The definition is excessive, hardly useful in practice and shows the difficulty of clearly defining what a learning object is? [4], [5]. Learning objects can be anything from a video projector to a lecture hall. A learning object is defined by Strijker as a digital entity that can be used and reused in a variety of educational situations, and it excludes entities that are not digital, such as books in a library [6], [7].

The University of Wisconsin defines them as "Small, self-contained online learning units. They are small enough to be integrated into an instructional activity, lesson, module or course" [8]. This definition is even more restrictive because it excludes anything that is not "small". David Wiley goes so far as to say that there are as many definitions of the term "learning objects" as there are people who use it.

Moreover, the use of the terms "learning objects", "educational documents", "resource", and "educational material" adds to the confusion. This large number of definitions can be explained by the tensions surrounding the concept of learning objects [9], [10]. At the economic level, the aim is to reduce production costs without reducing quality. This implies having reusable and shareable components. At the pedagogical level, the consequent development of lifelong learning and the setting up of individualized, tailor-made courses require reusable and, above all, adaptable components [11], [12]. Finally, at the technical level, the interest of the object-based approach, widely used in Information Technology development, is no longer to be demonstrated, it makes it possible to reuse components in multiple contexts.

2.2. Characteristics of personalized learning objects

2.2.1. Pedagogical intent

In order for the learning object to be personalized, it is essential that the designer include a pedagogical intention that expresses the expected direction that the teacher or the trainer formulates for the learner [13]. Pedagogical intentions are an orientation from which a teacher can construct a pedagogical model that aims to acquire competences in a non-contradictory manner and which will give meaning to the educational sequence [14]. Intention and objective represent two complementary notions. The objective materializes the intention. The intention gives meaning to the objective which needs to be put in perspective in a medium or long-term global vision.

2.2.2. Granularity

The concept of granularity was introduced through the LEGOTM set analogy, which highlights the significance of small learning objects or granules. These granules can be as simple as a sentence, paragraph, figure, or animation. It raises the question of when a personalized learning object can be considered to be at its largest size. According to the IEEE Learning Technology Standards Committee (IEEE LTSC), learning objects

can range in size from small granules to an entire curriculum [3]. Autodesk defines 5 different levels of granularity,

- Raw data elements correspond to content elements that are purely data-based;
- Information objects focus on simple information. It can be used to explain a concept, illustrate a principle or describe a procedure;
- An application object is a group of information objects that pertain to a single learning objective;
- The assembly extends to broader pedagogical objectives; it corresponds to lessons or chapters;
- At the very highest level of granularity, the collection corresponds to courses or even curriculums.

2.2.3. Reusability

As early as 1965, Nelson established a context for creating content from reusable objects in interconnected electronic libraries [15]. Reusable components can be applied to the world of education, where a personalized learning object once created can be adapted for use in a variety of educational contexts to suit the learning specifics of individual learners. Self-contained components can be produced separately, but they must be able to be modified to meet the needs of learners [16]. According to Cisco reusable learning objects are built on reusable information objects. Reusable learning objects consist of a combination of content items, exercises, and assessments. Reusable learning objects are composed of 5 to 9 reusable learning objects and each is based on a single objective [17]. Usually, a reusable personalized learning object corresponds to a lesson that can be integrated into a module. The user can assess their readiness to engage with reusable learning objects through a pre-test, while a post-test can be used to confirm the knowledge acquired. Reusable personalized learning objects can be reused across multiple modules, similar to how a module can be utilized in various reusable personalized learning objects [18]. Personalized learning objects with small granularity are not context-dependent and can be easily reused, whereas those with high granularity are highly contextualized for pedagogical purposes and are challenging to reuse.

2.2.4. Accessibility

Efficient access to personalized learning objects is crucial, and proper tagging with metadata is necessary for their storage and retrieval from a database. This process, known as indexing [19], facilitates easy and quick location of the required learning object. The accessibility of a learning object is deemed efficient when the cost of finding it for reuse is lower than that of creating a similar one. To enable wide dissemination of the learning object, effective exchange and communication between storage systems must be possible. The quality and quantity of metadata associated with the learning object also significantly impact its accessibility.

3. METHOD

The use of learning objects in the context of E-learning can be distinguished in three dimensions. The first is pedagogical use based on representation associated with a pedagogical approach that emphasizes knowledge of learning objects. The second involves the use of mastery in pedagogy, along with the pedagogical approach centered on the learner, the pedagogical model of evaluation, and the pedagogical mode of proactive representation, if one uses this last term in general to mean manipulating the world and making representations of it. Finally,the third dimension is the socioconstructivist pedagogical use, characterized by a learner-centered pedagogical approach and interactive communication tools.

Using personalized learning objects can greatly benefit the learning process. For example, learners may be more engaged and motivated when they have access to materials that are tailored to their specific needs and interests. Additionally, qualitative studies have shown that the use of learning objects can lead to improved learning outcomes, such as [20],

- Motivation, pleasure of learning
- Self-esteem
- ICT skills
- Collaborative work skills
- Knowledge in each discipline
- Data processing skills
- Metacognitive skills

Personalized learning objects provide learners with easy access to information, a new communication practice, and adaptation to their learning needs [21]. This type of learning object presents a certain efficiency for teaching and learning. They allow us to take into account individual differences, favor the individualization of teaching and thus represent an alternative solution to manage heterogeneity and favor the motivation of the

learners. The uses are developed from the different functionalities of the learning objects and according to the technological environments.

Barbeau's research [22] suggests that one of the most important factors for success in learning is the motivation of the learners. This motivation can be influenced by the teaching strategies used by teachers. Therefore, it is crucial for educators to create a learning environment that fosters a high level of motivation among students. By doing so, students are more likely to be engaged in the learning process and achieve better learning outcomes. The Figure 1 illustrates the links between our strategy, which is based on the use of personalized learning objects, learner motivation and success.

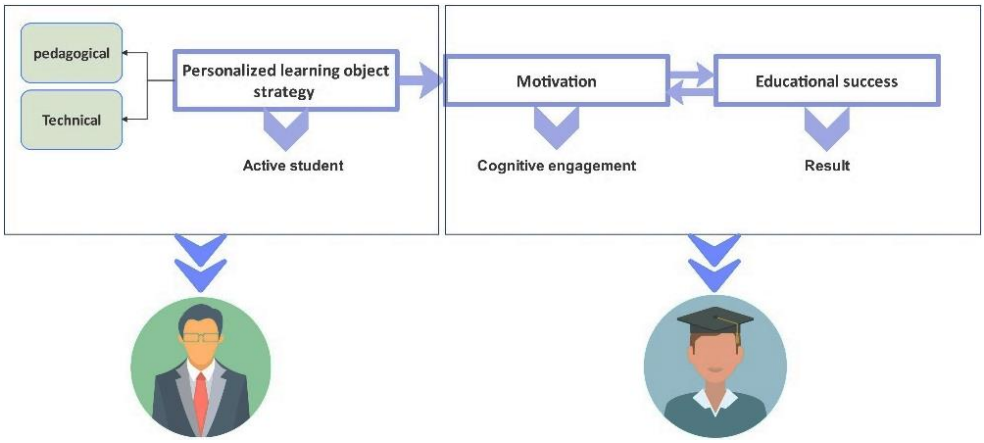

Figure 1. The links between the use of personalized learning objects, learner motivation, and success

In this study, we use a pedagogical strategy that allows the student to be active through the integration of a personalized pedagogical object. From a theoretical point of view, this pedagogical strategy should influence students' motivation, cognitive engagement and autonomy which, in turn, should influence learning success. Obviously, there are many other factors where instructional strategies influence learner motivation. Among the perceptions that most influence motivation are learners' perceptions of their competence and their perception of the importance of the task at hand [23]–[25]. The influence of educational success on motivation is manifested in particular by the modification of a learner's perceptions and skills according to the results he/she obtains in the assessments to which he/she is subjected. Our objective was to develop and test a pedagogical strategy based on the use of a personalized learning object in adaptive learning to increase the motivation factor. In the following section, we detail our approach in a pedagogical way and other techniques.

In the realm of information and communication technologies (ICT), the fundamental building block for educational resources is the "learning object". It can be a digital or non-digital entity that is designed to be used, reused, or referenced as a technological aid to learning. These learning objects can be employed in various settings, including computer-based systems, interactive learning environments, distance learning tools, or collaborative learning platforms. Teachers, developers, and digital learning engineers create these learning objects by drawing upon the content of their courses, with the intention of integrating them into teaching activities, training sessions, or distance learning programs, among others. At this stage, our proposal to integrate personalized learning objects into an AHS is based on two layers, the pedagogical layer and the technical layer.

3.1. Pedagogical layer

The learning object model used in this particular context is based on the motivation, ability, role perceptions (MARS) model developed by Jean-Philippe Pernin in 1996. The MARS model stands for model-associations-representation-scenario, and it provides a framework for organizing and structuring learning materials [26]. In this personalized learning object model, the MARS model is used as a basis for creating customized learning experiences for individual learners. Figure 2 provides a visual representation of the personalized learning object model, which illustrates how the MARS model is applied in this context. The figure demonstrates how the various elements of the model interact with each other to create a personalized and effective learning experience.

When creating a learning object, it is important to ensure that the learning activities presented within it are well-structured and easy to access. This means that the content must be presented in a way that is visually

diverse, interactive, and clear. These three aspects are essential for creating an effective learning experience that engages the learner and facilitates their understanding of the material. Table 1 provides a clear overview of these three aspects, highlighting the importance of each one and providing guidance on how to incorporate them into the design of a learning activity. By focusing on these key elements, educators and instructional designers can create learning objects that are engaging, effective, and accessible to learners of all backgrounds and abilities.

Table 1. The three aspects of a personalized pedagogical object

Aspect	Description	Example
Visual diversity	Good graphic design and layout, relevant and attractive images.	Presentation of learning activities in the form of scenarized techno-pedagogical resources
Interactivity	the communication process that takes place between humans and the learning object	Take a quiz, solve a problem, complete a project, interact with a tutor or mentor,
Clarity	Clarify for the learner the totality of the elements presented in the educational activity	Explicitly describe the tasks to be completed, their nature, the stakes, the concepts being worked on, the lexicon used, and the strategies that will be employed.

To make the idea of learner motivation through the integration of learning objects more explicit in an AHS, it is necessary to consider these three elements according to the Technological Pedagogical Content and Knowledge (TPACK) model: pedagogy, technology and content [27]. The integration of personalized learning objects is based on a balanced combination of technology and content corresponding to the hypermedia system, pedagogy according to "how to teach=the learning scenario" [20]. Our personalized learning object architecture is defined as the interaction of three elements: the teacher, the learner and the system, which includes, among others, pedagogical intent, granularity, reusability and accessibility. three elements are necessary components of the learning object ecosystem in order to improve interest and learning outcome, i.e. learner satisfaction and motivation. These elements are illustrated in Figure 3.

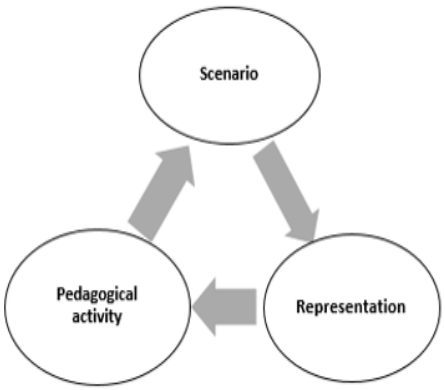

Figure 2. Personalized learning object model

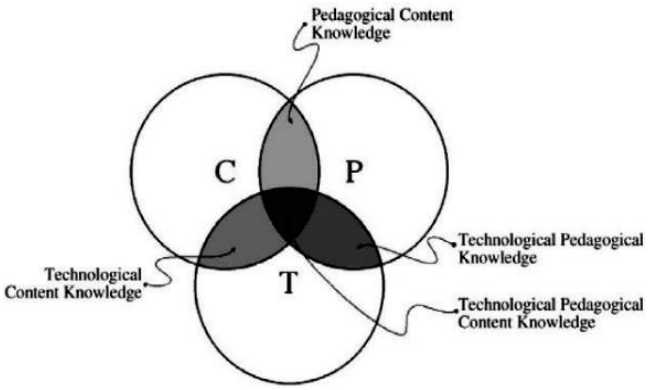

Figure 3. The technological pedagogical content and knowledge (TPACK) model model [27]

3.2. Technical layer

To ensure ease of access and usage, the personalized learning object should be structured into three entities, as shown in Figure 4: (Input entity, learning entity, output entity).

- The input entity provides a brief introduction to the module, course, or part of the course for the learning object. It helps learners understand the general context, objectives, and necessary prerequisites for following the learning object. It also creates a positive first impression for learners.
- The learning entity aims to simplify the content, learning situations, and activities to promote learning based on the objectives and the level of learners. The content of the learning object should be communicated in a direct, simple, and precise style.
- The output entity highlights the key concepts and fundamental ideas of the learning object, enabling learners to assess their comprehension and retention of the acquired knowledge.

The transition from the input entity to the learning entity requires the mastery of certain prerequisites. For instance, in mathematics, a student must have a solid understanding of basic arithmetic before moving on to algebra. In addition, feedback from the output entity to certain elements of the learning entity is necessary for the learning process to be successful. If the final evaluation is failed, it may be necessary to provide feedback to the learning entity in order to address any gaps in knowledge or understanding.

This methodology focuses on the consideration of personalized learning objects as a motivating factor. Based on this methodology, In the next section, we will present an adaptive learning hypermedia system architecture that facilitates the dissemination of personalized learning objects during learning activities. This architecture has the potential to enhance learners' motivation, satisfaction, understanding, speed, and overall learning outcomes.

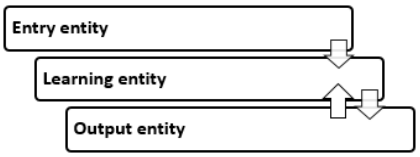

Figure 4. The three entity of personalize learning object

4. RESULTS AND DISCUSSION

The integration of learning objects into an AHS as a means of motivating learners is a multifaceted research area that has garnered significant attention from researchers and has been the subject of numerous studies. In fact, the term "motivation" refers to a state of cognitive as well as emotional stimulation that has led to a voluntary decision to act and entails a phase of mental and/or physical work to achieve previously set goals [28]. This is the set of forces and factors that determine the action and behavior of an individual to achieve a goal or perform an activity.

In Figure 5 we propose a general architecture for the integration of a personalized learning object corresponding to increasing the motivation factor for learners in an AHS (MPLO). Our learning object is divided into two essential layers, as shown in the Figure 5 and mentioned before. The diagram we have created depicts various structural models that illustrate the attributes and primary operations required to establish the system's structure. Within this model, we have identified 17 classes, each containing the essential attributes and potential operations.

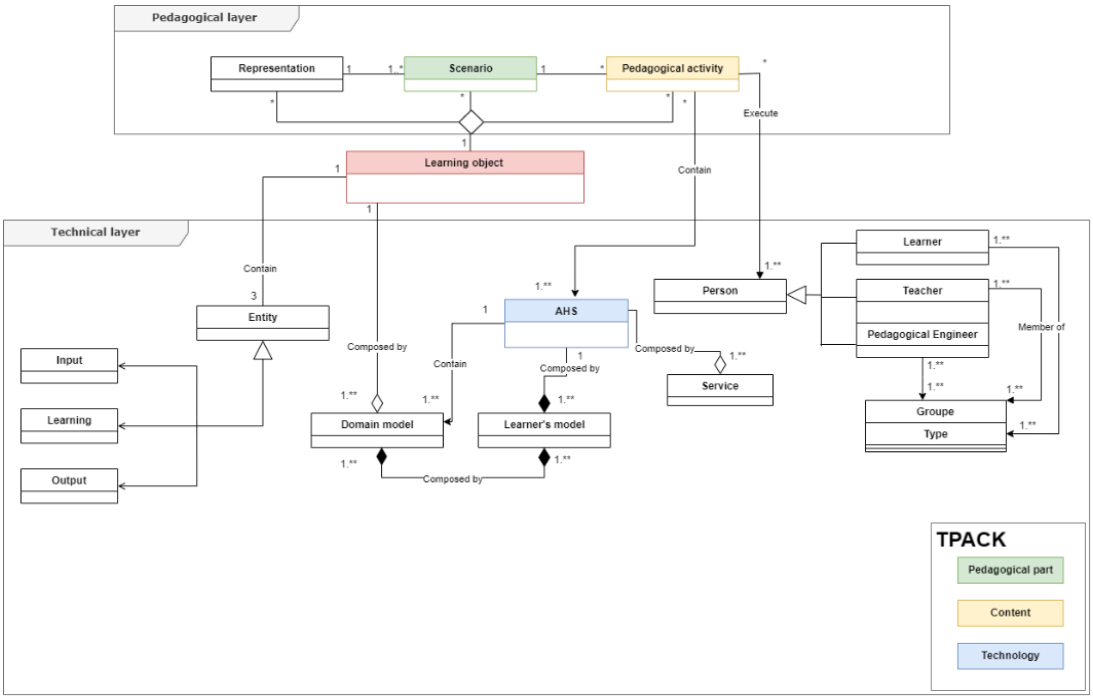

Figure 5. Class diagram of the integration of a personalized learning object

The classes «Representation», «Scenario», and «Pedagogical activity» are part of the pedagogical layer in the system. They are designed to represent the pedagogical content in a personalized and scenarized way. The purpose of these classes is to create a more engaging and interactive learning experience for users.

The «Learning object» class contains the «Entity» class, which is composed of three entities in the system. This helps to organize and structure the content within the system for easier navigation and access,

- The class «Entry Entity».
- The class «Learning Entity».
- The class «Output Entity».
- The «Domain Model» class is a crucial component of the «AHS» as it defines the hypertext structure of the system. This class is developed by subject matter experts and guides the system in selecting the most relevant content to present to the user via the «Learner Model» class, which utilizes the tools provided in the «Service» class. In a pedagogical activity, the presence of the «Learner», «Teacher» and «Pedagogical Engineer» classes are indispensable in our AHS; this class inherits from the «Person» class which has a close relationship with the AHS.

In the general architecture of our learning object there are three main entities which are,

- An entry entity illustrated in Figure 6, which allows the learner to be oriented at the beginning either to a previous module or to a different module or to the module under consideration:

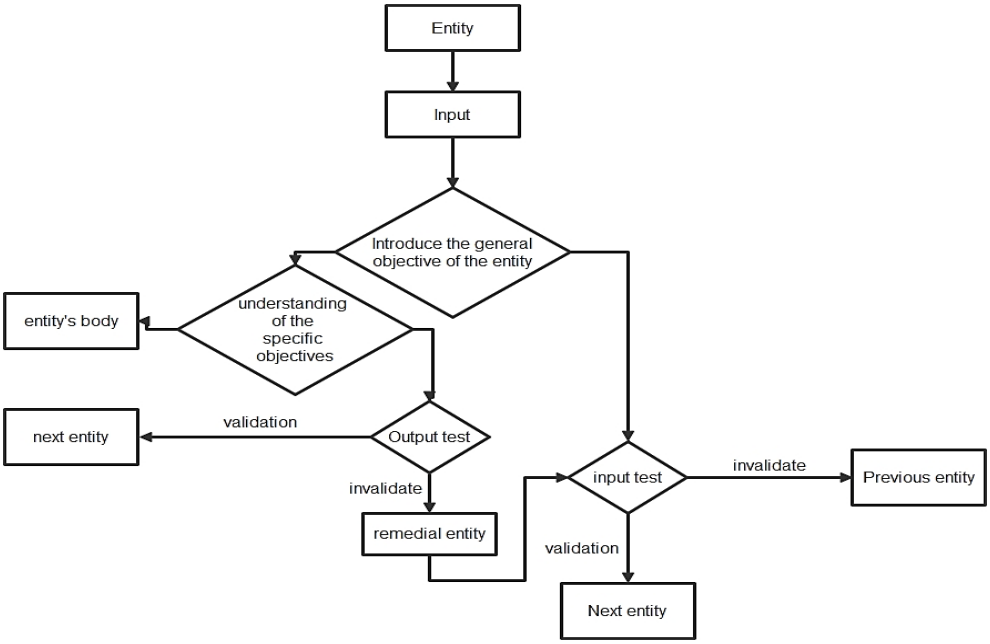

Figure 6. Entry entity of a personalised learning object

This entity normally includes,

a. Overall introduction.
b. Module components and table of contents, as well as an indication of the module's location within one or more modular packages with broader objectives.
c. The general and specific objectives, which allow the learner to decide whether or not he/she has the skills that are taught in the module. At this stage, the learner is asked to make a choice at the outset, for example by following instructions.
d. The exit test, designed to check whether the learner has mastered all or part of the objectives of the module. If the learner passes the exit test, he/she moves on to the next module. If the learner only partially passes the exit test, he/she is directed to catch-up tests before trying an equivalent exit or post-test again. The exit test can also be used as a pre-test, i.e. before the training, because if the learner passes it, he/she has already mastered the subject.
e. The entry test, designed to check whether the learner entering the module has mastered the prerequisites, i.e. whether he/she has the skills that he/she will have to use in the course and that will not be taught. If the learner fails the entrance test, he/she is directed to another module where he/she will learn the prerequisites, or, if he/she fails partially, to activities to catch up on the prerequisites.

– A learning entity as shown in Figure 7, that defines or specifies the learning and teaching activities necessary to achieve the specific objectives.

The learning activities within a learning object are presented to learners through a range of pathways tailored to their level, preferences, and learning style. Typically, the content is structured into learning situations, which may include,

– Information
– Examples
– Counter-examples
– Benchmarks
– Redundant information
– Learning activity triggers (exercises)
– Laboratory and workshop activities
– Workshop activities
– Experiments
– Instructions for monitoring and evaluation
– Reinforcement (corrections based on required activities and possible comments)

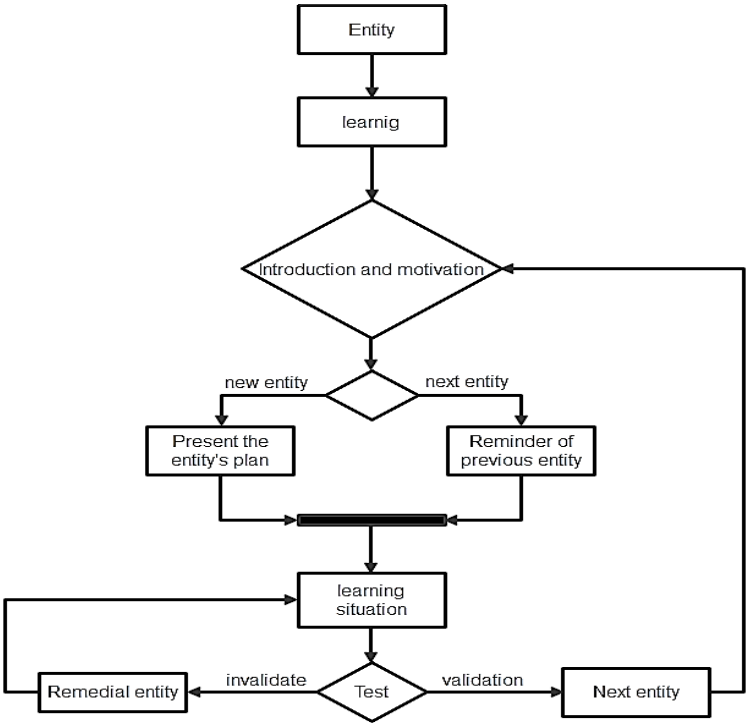

Figure 7. Learning entity of a personalised learning object

The learning entity may contain,

a. Instructional activities, including specific objectives for learning the modular entities, reminders, entry and exit tests (structured earlier); learning situations to build learning content; summaries, summaries, tables, diagrams, and illustrations.
b. A test to let the learner know if he/she has mastered the objectives of the entity, and also as an entry test to the next entity (if the first is a prerequisite for the second). This test can advantageously be located at the beginning of the next entity.
c. Remedial activities, depending on the results of the intermediate test: the learner is directed to the next modular entity in case of success, or a part of the entity in case of partial failure, or starts the modular entity again in case of overall failure.

– An output entity presented in Figure 8, which allows the learner to be directed to one or more subsequent or different modules or to remedial modules.

It usually includes,

a. Conclusion e.g. a general summary of the module, reviews and applications to complex situations.
b. A test that covers all the objectives of the module and is accompanied by a marking scheme and indications on the decisions to be taken according to the results obtained.
c. An exit remediation, for the learner who has partially failed the test.

At its core, an adaptive E-learning system is an interactive platform that adapts E-learning content, pedagogical model, and interactions to meet the specific needs and preferences of individual learners. This personalized approach serves to optimize the efficiency and effectiveness of the learning process. By analyzing data from the learner's interaction with the system, an adaptive E-learning system can modify the learning environment to suit the learner's strengths and weaknesses, ensuring that they achieve their learning objectives.

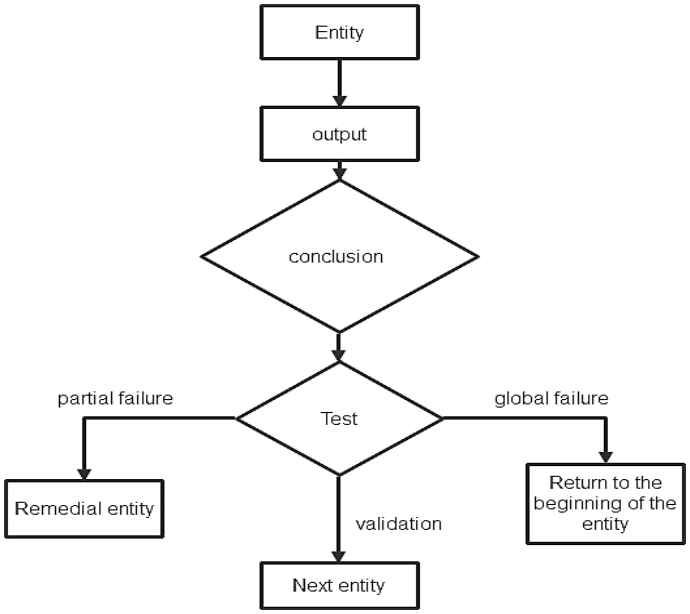

Figure 8. Output entity of a personalised learning object

Adaptive E-learning systems commonly utilize learner models, which are internal representations of a learner's characteristics. The system uses these models to tailor the learning experience to each individual's needs. However, constructing these models requires significant effort to gather and process the necessary information. As a result, adaptive E-learning systems embody the characteristics of adaptive systems by adapting to the unique requirements of each learner. To cater to the demands of the E-learning domain, these systems adjust the learning material using user models.

Adaptation in E-learning can be categorized into various types, including content, presentation, feedback, and navigation adaptation. The type of adaptation employed depends on the domain model and the learner model. For instance, content adaptation involves presenting learners with materials relevant to their knowledge level, while presentation adaptation involves modifying the way information is presented based on learners' preferences. The rules that govern these types of adaptation describe how pages are constructed and how they are presented to learners, providing a framework for designing effective E-learning experiences.

Our proposed system's architecture is based on Brusilovsky's standard dynamic adaptive hypermedia architecture [29]. We will enhance the domain model at this stage by incorporating pedagogical activities to enable the system to dynamically adapt the scenario (pedagogical and learning objects) based on the learner's profile (learning style and mode). Figure 9 presents our use case diagram, which outlines the various actors and their relation,

– The learner model guides the identification of the learner's profile through their learning style.
– The domain model assists in identifying the content that will be taught through pedagogical activities that align with the unique characteristics of each learner's profile.
– The system strives to incorporate the most suitable personalized learning object for each learning activity based on the learner's preferred learning style.

We have seen previously, the importance of our personalized learning object on motivation. To understand the logic and the functioning of the system, the class diagram allowed us to model our personalized learning object in the AHS as a class and our user case diagram allows us to better understand the way of thinking to model the relation between the different actors. The two diagrams allow us to realize our learning object proposal shown in the Figure 10.

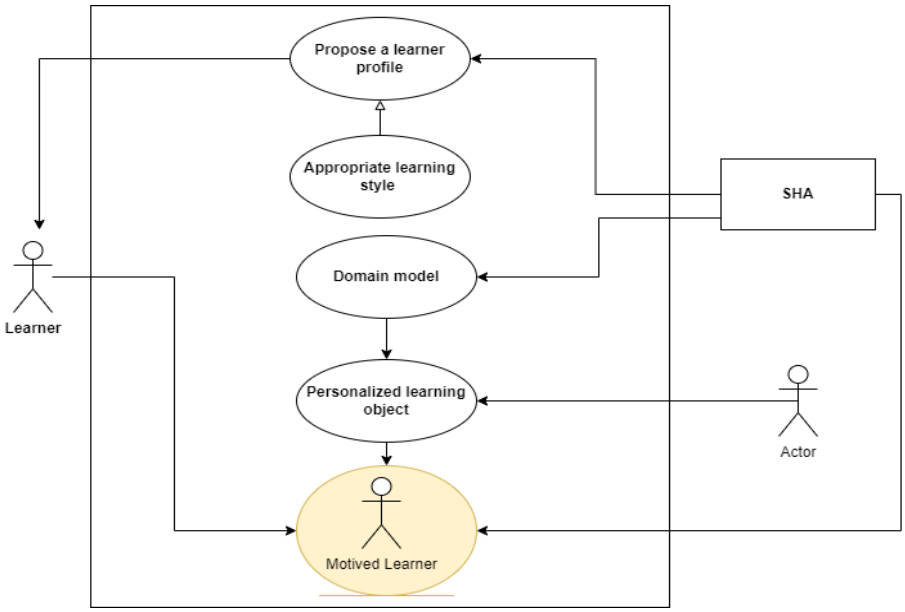

Figure 9. Use case diagram presents the interaction between AHS, the learner and the teacher

The integration and use of learning objects is recognized as one of the most interesting research questions in the field of E-learning. The use of personalized learning objects in this hypermedia system has allowed us to achieve the following objectives,

- To increase the motivation factor and the power to stimulate the development of intellectual skills such as the ability to reason, solve problems, learn to learn and create.
- Contribute in many ways to improve the acquisition of knowledge in various teaching subjects and the development of skills and attitudes that are related to this knowledge.
- Simulation, virtual manipulation, rapid connection between a wide variety of data, graphical representation and others that new technologies offer contribute to the linking of knowledge.

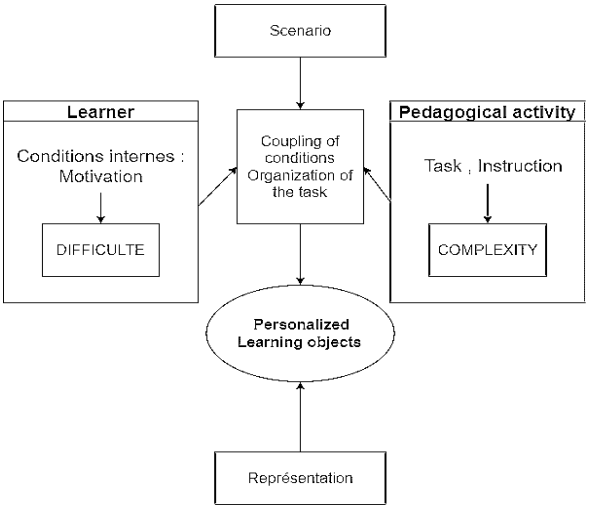

Figure 10. The use of personalized learning objects in this hypermedia system

5. CONCLUSION

The proposed pedagogical and technical approach in the paper involves the use of pedagogical objects within an AHS. This approach aims to enhance the learning experience by incorporating personalized learning objects that are tailored to the individual needs and preferences of learners. By utilizing this approach, learners can have greater control over their learning path, which can lead to increased motivation and engagement. The study demonstrates the effectiveness of this approach in improving the motivation factor and highlights the potential benefits of incorporating personalized learning objects into E-learning systems. We showed how and why our model can improve the motivation factor from the integration of personalized learning objects. We explained the relationship between the personalized learning object and learner motivation and discussed the important properties (definitions, characteristics) of personalized learning objects. Then we introduce our approach inspired by Barbeau's research. Specifically, this approach is based on two layers, a pedagogical layer and a technical layer, which briefly address theoretical and empirical implementations of factors that contribute to improving learner motivation. Our model is currently being implemented. By conducting an impact analysis of our instructional strategy on student motivation, cognitive engagement, and success. Future work will consist of measuring the effects of our personalized learning object integration model on motivation, cognitive engagement and student success in an AHS. This will allow us to verify the strengths of our system by testing it with students from the Higher Normal School of Tetouan, Morocco.

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