ABSTRACT
Due to the rapid development of innovative technologies, current digital society faces challenges for changing the environment. Constructing and applying Smart Learning Environments (SLEs) has emerged for supporting knowledge representation and learning content creation. In this paper, we focus on Smart Open Learning Environment (SOLE) that provide adaptive self-regulate learning based on Computational Thinking (CT). This contribution describes the progress of a pedagogical scenario promoted by Open Learner Model (OLM) to enhance CT through a SOLE that aims to support the learning process and to provide Adaptive Self-Regulated Learning.
In this paper, we present our work, which takes advantage of different technologies such as ontology, Learning Analytic for a SOLE in order to be better managed and to offer more flexibility and comfort. Subsequently, we describe a learning scenario through SOLE and we propose a model for it that describes the interaction of its components. Then we propose different ontological models for the semantic of SOLE and we detail OLM ontology. We aim to deliver open content, which is adapted to specific learner context, profile, progress and CT’s Level in the learning process.

KEYWORDS
Smart Open Learning Environment, Computational Thinking, Ontology, OLM, Open Education Resource, Adaptive Self-Regulated Learning

1. INTRODUCTION
The daily evolution of the world and our current digital society faces challenges for changing the environment and the rapid development of modern technologies. One of the major relevant fields is Learning Environment that has been advanced in many different ways. As mobile technology continues to evolve, learning environments are emerging that have the potential to revolutionize the approach and approach to the learning process. Designing and constructing Smart Learning Environments (SLEs) has emerged for supporting knowledge representation and learning content creation. Smart learning can be described as a technology-based learning model that dynamically recognizes and acts on learners’ individual circumstances, backgrounds, learning needs and styles, and the state of their learning process (Molina-Carmona, R. et al 2019). In this context, SOLE have surfaced. Our objective is to provide adaptive open learning based on Computational Thinking (CT). We need flexibility and interoperability to provide learners with different resources to suit their contexts, needs and preferences (Harchay, A. et al. 2012 ICCIT). The goal of the smart Open learning environment will be the development of Adaptive Self-Regulated Learning (ASRL) and CT’s skill. It aims to improve the quality of learning and the qualities of the learner and his CT’s competencies throughout the learning period and to enable a learner to learn more concretely, more efficiently, more flexibly and more comfortably at any time and any place.

We also propose to examine learning outcomes and skill level of learner toward open assessments. For that, we propose to promote SOLE with Open Learner Model (OLM), which will be an important tool to deploy Adaptive Self-Regulated Learning (ASRL). OLM will be used for helping learners visualize their current knowledge or their skill levels in various ways. Open Learner Models have proven their efficiency in facilitating the follow of learner's skill level and profile and then to produce an adaptive Self-Regulated Learning using Open Education Resources (OER). Learners differ in their skills, needs and profiles that should be considered in the design of the learning process (Harchay, A. et al. 2014). We need to track learners when learning and to gather more data from learning contexts and environments. These collected data are being
analyzed to give actionable insights for an adaptive self-regulated Learning. In order to meet the needs of learners, it is necessary to include an assessment process; to analyze and transfer distributed knowledge in a smart environment to share the same meaning, relate to different domains, and make decisions at the right time (Samia, Z. et al. 2018). Adaptive content engine provides learners with personalized learning paths and learning content based on their profile (Chen, W. 2019). To reflect the knowledge proposed by a SOLE, learning materials should be designed. For that, we propose to take advantage of innovative technological solutions such as ontologies and Learning Analytic (LA).

The objective of our research work is to propose ontological models for SOLE promoted by CT and that provide ASRL. In this paper, we introduce the use of ontologies and LA to promote the learning process. Further, we use the ontology to model the semantics of SOLE. It will be used for facilitating information integration and knowledge sharing. To do this, we will first detail our pedagogical scenario for a learning process in a SOLE based on Computational thinking and we propose a model for it. Thus, we propose different models to implement the semantics of our framework of SOLE based on Computational Thinking; hence, we propose an ontology for Open learner model. Finally, we give a conclusion, and outlook of future work.

2. ONTOLOGY AND SMART LEARNING ANALYTIC FOR SOLE

For our proposed SOLE, an interesting characteristic is to provide an ASRL that takes care of the learners’ preferences, CT’s skill level, learning style and needs. For that, we propose the use of learning analytics that has proven its importance in education since its inception (Rezgui, K. et al. 2014). It makes the learning process easier, comfortable, and more convenient by visualizing data about the learning process. LA involves the measure, the collect, the analyze and the report of contextual learner data to understand and optimize learning and learning environments (Siemens, G. (2012). To better visualize learners’ information such as knowledge, skill level motivation and performance, OLM is used. It can be considered as a specific type of LA. Learning analytics is considered as an important component in SLE. It contributes as a data-driven approach; it helps to provide complex data available to better help learners to understand, to optimize and to interpret aspects of their learning process. It provides OLM with information about learning traces for learners, the current state of the learner and learning process and activity data of the learners. Combining learning analytics with an open learner model helps to make learning analytics visualizations more meaningful for the learning process, and experiences with big data and visual analytics can advance OLM with today’s data-rich, evidence-based online learning opportunities (Bull, S et al. 2016). LA has the ability to contribute to smart learning and to improve learning experiences and outcomes.

Along with this, the learning process should not be limited on time or location. The learner can learn when he wants. Whenever and wherever an opportunity is available, the learning process can take place. This opportunistic learning process needs ubiquitous learner support such as technical support and feedback (Rezgui, K. et al. 2014). For that, we propose the use of Smart learning analytics (SLA) which is considered as a variant of LA and it concerns data on how students learn. Smart LA is dedicated to improving learning by tracking learner competencies in as many learning activities as possible and providing tailored feedback to facilitate context-aware learning. It facilitates self-regulation, allowing learners to visualize their individual learning progress and design a study plan for themselves (Rezgui, K. et al. 2014).

Such as SOLE is built around OLM in order to deliver ASRL, we propose the use of Smart LA to improve learning experiences. This combination appears to be essential, aiming to enhance students’ self-reflection through easily perceptible visual representations, enable adaptive self-directed learning, increase user motivation, and even facilitate collaboration. Smart LA will promote OLM, and as a result, SOLE will be able to better sense, infer, anticipate and promote Adaptive Self-Regulated Learning.

Furthermore, semantic web tools such as ontology and knowledge representation, resource semantic annotation, knowledge argumentation, and services are also widely used by educators to improve the quality of education (Melesko, J. et al 2018).

The use of ontology in the area of Education has shown encouraging results. In a SLE, the use of SLA for the evaluation of the learner’s performance and the monitoring of learner’s state of knowledge can be enhanced by the use of Ontologies. The ability to conceptualize a taxonomy of learning goal motivate the use of ontology (Costa, L. et al. 2018). Besides, many elements such as competencies and competency-related groupings of competencies, e-portfolios, CT skill, learning style and preferences are essential elements of Open Learner
Model for adaptive learning and personalization in technology-based learning. However, in order to be handled by humans and software tools, OLM should be represented by an ontology (Paquette, G. et al. 2021). The use of ontologies provides the ability to infer learner knowledge from the information provided and allows for reuse and scalability in different learning contexts (Costa, L. et al. 2018). Ontologies enable the understanding of the structure of the presented information. Ontologies can not only be used as learning tools, but can also be used to assess learners’ abilities (Melesko, J. et al. 2018). For that, we propose the coordination between ontologies and SLA to evaluate learning process, learners’ outcomes and performances. The use of ontologies can enhance the semantic organization of learning content; also, it can provide an adaptive learning process.

3. LEARNING PROCESS SCENARIO

3.1 Scenario Description

In this section, we describe a scenario relevant to the learning process in higher education. It is related to our work to design and develop a conceptual framework for the Smart Open Learning Environment (SOLE), driven by Self-Regulated Learning to improve CT. The learning process happens when the learner is ready to learn in the ideal format and adaptable way. Our scenario describes the learning process in a SOLE promoted by OLM to deliver Adaptive Self-Regulated Learning considering the learner information and his CT skill level, OER and Open Assessment. The interaction between these elements will improve the quality of learning and the qualities of the learner, his competencies and his CT’s skills.

A prerequisite for the start of our learning process is the presence of learners with smart devices. In the first step, the learner accesses the platform, if he is not registered, he must register. Otherwise, our system will start following learner who will be closely tracked across all activities in the system. The learning process begin by the planning. The learner will choose SRL Tools, which refers to SRL Strategies, define his competencies goal and manage his information. Then he is free to choose between accessing his OLM or accessing the first suggested course selection which is CT.

Through OLM, the learner can visualize his skills and knowledge in different ways, participate in the reflection, decision-making, and design of his personal learning.

The second step is the preparation for the learning process. In order to access the first available course CT, it is necessary to assess his initial knowledge to determine his CT skill level. CT’s competency levels, combined with other feature such as learning style, preferences and competencies, is used for suggested CT’s content courses or other courses and related Assessment that are more appropriate to the learner's abilities.

The third step is to start the learning. The learner can choose and organize his Course and Assessment from the recommended Course and Assessment. In addition, he is able to choose Social Tools for his learning.

All information related to the learner such as initial knowledge, preferences, learning style, collected data from tracking, evaluation result, CT’s skill, level and feedback will be analyzed using Learning Analytics approaches, then appropriate Strategies which refers to a particular learner and the specificities of his learning can be defined.

The step number four, is to reflect about his learning Process. The learner access to his OLM to reflect about his learning, and the needed regulation of his goals and planning.

At this level, the learner return to the first step and can changes his planning, the selected SRL Tools and his goals according to the reflection made in the latest step.

3.2 Learning Scenario Analysis

The goal of this study is to enhance learner Computational Thinking by providing a new Smart Open Learning Environment through the adaptation of Self-Regulated Learning based on Open Learner Model, CT and OER. Since our scenario is proposed for SOLE, we need to study and define the principal characteristics of smart open environment. Also, we focus on the objectives for the application of Open Learner Models in higher education to enhance CT in the context of self-regulated learning, the characteristics of Open Learner Models and how these have been associated to different phases and areas of self-regulated learning and how Open Learner Models promote self-regulated learning in different areas and phases in order to reach Adaptation self-regulated learning. In order to acquire and enhance CT competencies our Self-regulated learning approach
will deliver the most appropriate content and resource depending on the context. So, it is necessary to study the concept of context and its different features. Similarly, we propose to regulate our learning process through our OLM, than to deliver resource and content adapted to the context, and in conformity with the OLM (CT skill level, preference, style...) and the SRL strategies. For that we need the use of a set of technologies, such as semantic web and web services, for the development of a framework relative to our scenario.

3.3 Learning Scenario Model

In this section, we detail the scenario model, as shown in Figure 1, representing a learning activity in a SOLE. In order to manage appropriately learning scenario, different entity and dispositive need to coordinate to deliver Adaptive SRL. Scenario model is useful to describe learning process in SOLE in diverse context and for different domain. Our Scenario model define the entities that are needed for the success of the learning process and describe interaction between them. It aims to promote learner to be an active learner who is able to decide and to take decision about his learning process. The proposed scenario model aims to provide SRL tools to assist learner in conducting Adaptive SRL through the four phases of SRL when considering OLM. Self-assessing, CT’s skill level, learning performance, learning preference, competencies are considered for defining SRL strategies.

The scenario model consider the four phases of SRL such as defined by Zimmerman (Panadero, E. 2017), which are the “self-evaluation and monitoring”, the “setting of goal” and the “planning of strategies”, the “implementation of strategy” and the “monitoring of planning “and finally “the monitoring of outcome”.

Our scenario model for Adaptive SRL process is based on principal module. The learner, as an active learner in the learning process, is in the heart of our scenario model and interact with the other module “OLM”, “SRL Tools”, “Domain”, “Context”, “Course”, “Assessment”, “SRL Strategy”, and “Social Tools”.

In a “Context”, a learner manages “OLM” which is related to a “Domain”. Through OLM learner can visualize and manage many features such as ‘profile’, ‘Preference’, ‘CT skill’, ‘Competencies’, ‘Assessment Portfolio’ and ‘Feedback’.

In addition, Learner applies “SRL Tools” that refers to “SRL Strategy”. For “SRL Strategy” we propose cognitive, Metacognitive, Resource management and Assessment Management. Learning activity recommendation is an interesting feature in the learning process, for that Resource management and Assessment Management are used for recommending appropriated OER and Open Assessment. In our scenario model we suggest that the definition and the planning of SRL strategies depends on the analyze of information delivered by OLM such as CT skill level, learning Style, preferences...Similarly, the goals related to CT and competencies are managed and regulated considering the defined SRL Strategies and its associate phase.

Furthermore, a learner have the opportunity to choose his course and assessment related to it. Course and Assessment are delivered from recommended OER and Open Assessment that are proposed according to SRL strategy.

The learner have the ability to use a set Social Tools during his learning Process. Our Learning scenario model for self-regulated learning enhances learner CT’s skill level, competencies, performance and promote the learner in thinking about his Learning process. The learner interact actively with the SOLE and focus on the acquisition of knowledge and competencies as well as the planning, the reflection and the monitoring of his learning process. The learner is involved into the learning process, make important decision and became self-directed.
4. ONTOLOGICAL MODELS FOR SOLE FRAMEWORK

4.1 Proposed Models for SOLE

For the development of framework for SOLE, we need to use a set of technologies such as Semantic Web to ensure greater flexibility and interoperability in providing learners with different resources tailored to their context, needs and preferences (Harchay, A. et al. 2012 ICCIT).

Our objective is to propose an ontological model for our framework for SOLE in order to deliver ASRL. For the design of model related to proposed pedagogical scenario, we need to consider the formal models and criteria involved in adaptive hypermedia systems that form the basis of most adaptive learning systems (Aroyo, L. et al. 2006).

In our work, we suggest different models that will be described by ontologies in order to implement the semantics of our framework. Ontology is one of the most practical that enable the representation of data and enable to represent and interchange semantic (Harchay, A. et al. (2012).

Indeed, we consider a SOLE as an open system that needs to coordinate different model in order to provide ASRL. Thus, to implement the semantic of SOLE we suggest using the design of a set of ontological models for delivering adaptive and personalized resources to each learner. For that, we refer to adaptive hypermedia systems that consider five models to present the knowledge driving the adaptation process (Aroyo, L. et al. 2006). The set of proposed models in (Kravčík, M. et al. 2006) are the domain model, the user model, the context model, the activity model and the adaptation models.
In our work, we propose a set of models for SOLE framework as shown in figure 2 open learner model, Context model, Domain model, SRL model, Resources model, Scenario model and CT model.

- **Open learner model**: the adaptation and self-regulation of content through the learning process should be done according to the learner profile, needs, competencies and CT skill level. Thus, open learner model identify the learner and represents his characteristics such as his profile, competencies, CT skill level, performances, preferences, and goal.
- **Context model**: it refers to the context in which the learning take place, it describe the circumstances and “the environment characteristics” in which the learning process occurs (Kravčík, M. et al. 2006) such as spatial and temporal dimensions. Complementing the user model
- **Domain model**: it aims to conceptualize the design of adaptive and self-regulated hypermedia application and to specify what to provide, adapt and regulate (Kravčík, M. et al. 2006). It defines a set of concepts and their relationship in order to create the knowledge base for learning domain.
- **SRL model**: it describes the semantics of self-regulation. It consider four dimensions: processes, materials, adaptation strategies and self-regulation strategies.
- **Resources model**: it enables the identification of different resources needed for the learning process and provides a common scheme for describing the indexing structure of the resources delivered from OER.
- **Scenario model**: it describe the progress of self-regulated learning process through SOLE in order to deliver adaptive content and resources from OER.
- **CT model**: it provides CT information for a learner and describe the progress of acquired CT’s skill level.

![SOLE models](image)

**Figure 2. SOLE models**

### 4.2 Open Learner Model Ontology

Ontology becomes a key technology for representing conceptual knowledge and performing semantic search in documents (Samia, Z. et al. 2018). In SOLE, the learning process uses information that is really large and complex as an information for the everyday work to receive and retrieve it. SOLE that uses advanced technologies needs to coordinate different tools and features.

Adaptive Self-Regulated Learning in a SOLE should be based on the learner profile, CT’s skill level, preferences, competencies and needs. In order to deliver ASRL, SOLE considers a collection of a set of concepts from different models such as the OLM model, the SRL model, context model, the domain model, etc. These concepts interact and collaborate to provide the most appropriate learning process. The combination and coordination of the different models enables Adaptive Self-Regulated Learning.

In this section, we propose an OLM ontology as shown in Figure 3 that details the information about the learner, his knowledge and his learning process details.

For our OLM ontology, we have used other ontologies such as:

- SIOC ontology for specifying social communities and their relationships Blogs, and wikis.
- FOAF ontology focuses on the relationship between users and their communities.
• PAPI Learner specification (Rezgui, K. et al. 2014). Designed to support the storage, retrieval, search and exchange of learner data between different systems.

Figure 3. OLM Ontology

Our OLM Ontology includes the following elements:
• CT-skill: it refers to the learner’s CT skill level.
• Competencies: it refers to the competencies goal and to the acquired competencies.
• Performance: it describes the measured performance such as certification and experience.
• Profile: it defines the learner’s profile such his knowledge and discipline.
• Agent: it refers to FOAF ontology, we suggest the use of its sub class ‘Group’ and Organization.
• Identification: it refers to (IMS LIP) and it enables to identify a learner using identifier, name, email address, diploma.
• Portfolio: it represents a collection of learners’ works, or references to them for verification of his achievements and abilities.
• Feedback: it describes learner responses to their learning experiences, interactions with groups, and the complexity and usefulness of learning materials.
• Preferences: it describes the learner’s preferences, language, his preferred learning style and his interest.

5. CONCLUSION

In this paper, we are interested in developing a framework for SOLE based on Ct. we proposed the use of technologies for supporting the Learning Process. Technologies such as Learning Analytics and ontology are used to promote our SOLE. We have first presented the proposed technologies and the benefits of their use for our proposed SOLE. Then, we have proposed a Learning process scenario through SOLE. We have proposed a description for our scenario and for the different features involved in this scenario. Subsequently we suggest a Learning Scenario Model that show the interaction and collaboration between the proposed fields in order to deliver Adaptive Self-Regulated Learning.
Thereafter, we proposed different ontological models to promote the OLM. The Smart Open Learning Environment (SOLE) has as goal the improvement of the quality of learners' learning and their CT skill level throughout the learning period. It aims to enable learners to learn in a more specific, efficient, flexible and comfortable way.

Regarding our further work, we will develop the necessary ontologies for the proposed models for SOLE. We also envision implementing and collaborating on proposed technologies in a framework. In fact, this framework will allow us to provide adaptive self-regulated learning to promote learner on his learning process and to enhance his CT skill level.

REFERENCES


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