Personalizing the connection between formal and informal learning in Smart Learning Environments

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Abstract. Smart Learning Environments aim at automatically adapting the learning experience based on learner's context. When this context is not restricted to formal settings, SLEs are a promising solution for automatically connecting formal education with informal learning opportunities that emerge in different physical and virtual spaces. To achieve this, SLEs can benefit from both the information from the formal learning design as well as the capability of sensing and analyzing the progress of each learner. In previous research, we have devised an architecture to interconnect the different technologies that form an SLE capable of connecting formal and informal learning across-spaces. This paper goes a step forward by exploring the information flow needed to model the current context and state of the learner to eventually trigger informal learning interventions.

Keywords: formal education, informal learning, personalization, Smart Learning Environments

1 Introduction

Smart Learning Environments (SLEs) seek to automatically provide personalized support to the students considering their individual needs and context [5, 7, 11] across physical and virtual spaces. By means of technologies and systems such as Virtual Learning Environments (VLEs) [1], mobile devices [13], wearables and Internet of Things (IoT) devices [14], SLEs can interact and present students with appropriate resources and activities, but also they can gather information that help to construct their educational context. The prior knowledge of the students, their learning style, the available resources and activities, their social relations with other students or their location are some variables that help to model their learning context [12].

When the learning context is not restricted to formal settings, SLEs are a promising solution for connecting formal education with informal learning [3].

Prior attempts to bridge both types of learning were related to self-regulated learning, where learners could establish communities of learning related with their concerns [2, 4]. However, the provided support do not consider the context of the learners to propose more meaningful experiences [9]. In this sense, SLEs can benefit from information about how students learn in their daily life and provide them with informal learning opportunities that emerge in different physical and virtual spaces, related with the formal learning.

In [10], the authors proposed an architecture to interconnect different technologies that form an SLE capable of connecting formal and informal learning across-spaces. However, to achieve such connection, SLEs have to align the aggregated data from the different learning spaces with the learning objectives to provide the appropriate support. This paper focuses on how SLEs can benefit from the learning design to overcome this issue.

The rest of the paper is structured as follows. Section 2 exemplifies the support of SLEs in a sample scenario- Section 3 describes the information flow happening in an SLE to support that scenario and how the learning design influences the different stages. Finally, section 4 present the main conclusions and future work.

2 Illustrative scenario

For the sake of illustration, we present a scenario that reflects how an SLE can achieve such connect. Stella teaches a Natural Science course in a high school. She is devoting the following three weeks to teach about the fauna, flora and landscape in the local region, focusing on one of these topics each week. With this purpose, the teacher prepares different activities for her students. First, she gives a short presentation *in class* of relevant aspects in one of the aforementioned domains. Then, she proposes the learners to do a reading or watch a video on the subject *available in the VLE at home*. The following day, *in class* she organizes a debate among the students discussing about the revised material. Finally, she asks her students to fill out a progress quiz *through the VLE* by the end of the week. This sequence of formal learning activities is described in the learning design.

In previous years, Stella observed that her students have some issues to reflect the theoretical concepts in the real world, so she decides to support her lessons with an SLE. As the SLE needs to notify students about possible activities, she suggests her students to install a companion app in their personal mobile devices, and eventually provide an informed consent regarding the use of the data it collects for academic purposes.

After the first week, Pedro has attended all in-class activities (as reported by Stella in the assistance report), watched the mandatory video but he did not checked any of the available readings (as reported by the VLE). As well, he did not score very high in the progress quiz (as reported again by the VLE). The SLE consults the learning design to seek the data sources linked to the different activities and gather the information about the performance of the students. As a result, from the information above, the SLE detected that Pedro's knowledge in local fauna is low. Pedro decided to install the companion app and, one day, he happens to walk in his town near a natural park, as reported by the app. The SLE, with the information coming from the app, detects that it is a suitable context to support Pedro, so it proposes Pedro an informal activity to identify the different tree species in the park, considering the topic of the learning situation.

3 Information flow during the enactment

In order to support the scenario described above, the SLE has to manage different information related with the actions of the students during the learning situation. The information flow that takes places in SLEs can adhere to the sense-analyze-react model [10]:

- **Sense**: the SLE gather data about the students' actions and interactions during the enactment of the learning situation, along with information about the learning space where students' are participating.
- **Analyze**: with the above information, the SLE models the students' context and their progression through the learning situation. These models evolve as the learning situation continues.
- **React**: with an understanding of the learning status of the students, the SLE can intervene and interact with them by providing appropriate resources and activities. These reactions are not defined beforehand by the teacher, due to the multiple conditions that should be considered to trigger them. Instead, the teacher can define guidelines that control the reaction of the SLE.

The inclusion of the learning design in the information flow can benefit SLEs to better orchestrate the aforementioned actions. Through specifications such as IMS-LD [6], learning designs can be structured and computationally understood by systems and applications, allowing, for example, their deployment in multiple learning spaces [8]. In a similar approach, SLEs can considered the information provided in the learning design through the information flow, presented in 1.

This flow begins with the **deployment** of the teacher's learning design among the learning spaces where the specified activities and resources take place. The information contained in the learning design (such as activity timing, topics, goals and related learning spaces) will be used during the next phases of the information flow.

Once the learning design has been deployed, the SLE can proceed with the **collection of data** related with the student participation in the learning situation. Each learning space offers measuring tools to track how students are participating in the different activities or how they interact with the available resource (*e.g.*, timestamped actions in the VLE such as retrieving a document or answering a quiz, or presence and location in the physical space). The SLE gathers all the appropriate information from the pertaining learning spaces, according to the learning design, and prepares it for its analysis.

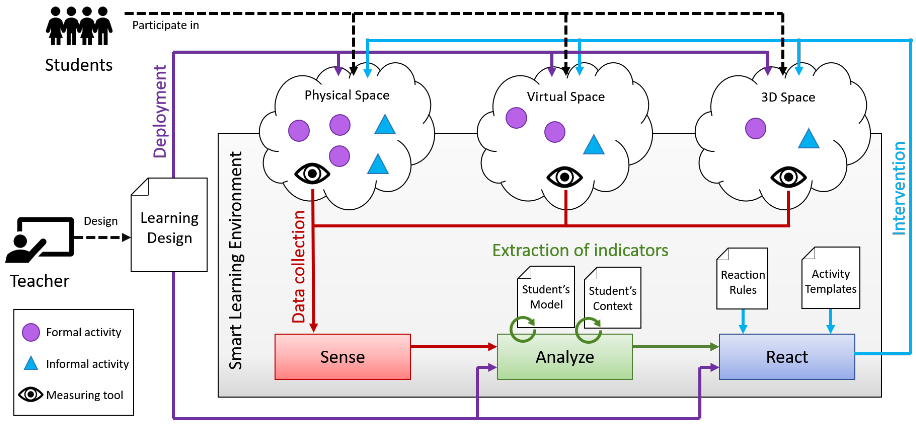

Fig. 1. Information flow in the Smart Learning Environment during the enactment of learning situations

In the analysis phase, the SLE **extracts the indicators** that complete the actionable information the SLE has about the student. This information can be classified in two sets: (1) the student's model, that contains information derived from the progress and performance through the different activities (*e.g. degree of knowledge of a certain topic*); and (2) the student's context, more related to the current conditions of the learner (*e.g.* his location and whether he is currently connected to the SLE). Both of these sets are constantly evolving as the learning situation takes place. During this phase, the SLE relies on the learning design to determine the appropriate analysis to perform, as well as to match the student's model with the goals and topics considered in the design.

With the student's model in continuous evolution, the SLE can automatically react and **intervene** and provide the personalized support to the students. To do so, the SLE evaluates previously configured reaction rules and activity templates, leading to a personalized, informal support. The reaction rules trigger by evaluating information from the student model that concerns the topics and goals of the situation. On the other hand, the activity templates contain a variety of possible reactions, from simply informing the teacher (so that she can decide how to react) to suggesting simple or more complex activities (*e.g.* a personalized reading or quiz, to take pictures and comment a physical resource, or to identify the tree species as in the scenario). It should be noted that rules and templates are defined before in a general fashion, but are tailored on the fly to the corresponding topics, goals and context. All this reaction process takes place automatically without the teacher's intervention.

4 Conclusions and future work

SLEs present potential opportunities to enhance students' learning experiences by connecting formal and informal learning. To this end, these environments should properly align their understanding of the students with the learning goals of the formal education. This paper presents how the inclusion of the learning design in the information flow of an SLE can help in the construction of the model of the student and in the provision of appropriate resources. Nevertheless, there is pending work in the automatic provision by SLEs of appropriate resources according to the learning design. In future work, the authors will collaborate with stakeholder for the definition of the reaction templates and the provision of resources to present to the students in different learning spaces and context.

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