TOWARDS A RECOMMENDATION FRAMEWORK TO SUPPORT DESIGN OF LESSON PLANS IN THE ITEC PROJECT

Manuel Caeiro-Rodríguez, Rubén Míguez-Pérez, Juan-Manuel Santos-Gago, Luis Anido-Rifón, Manuel Fernández-Iglesias
University of Vigo
E.E. Telecomunicación, Spain
{mcaeiro; rmiguez; jsgago; lanido; manolo}@det.uvigo.es

ABSTRACT
This paper describes the approach taken by the European FP7 iTec project to support the design of lesson plans in a multi-cultural heterogeneous environment. This approach is based on the use of semantic technologies to provide teachers with recommendations on the best resources available at and from their schools to support the requirements imposed by higher-level educational designs, named Learning Stories in iTec terminology. The authors present the different data models proposed to describe the iTec educational ecosystem and discuss the algorithms that drive the recommendation engine to offer proposals on the best tools and resources to support a specific lesson plan in a concrete school.

KEY WORDS
Educational design, semantics, data models, teachers’ support and guidance.

1. Introduction

The iTec (Innovative Technologies for an Engaging Classroom) project is intended to provide answers to a common situation in European schools: in spite of having more and more sophisticated tools available (e.g., interactive blackboards, last generation learning management systems, collaborative tools, advanced mobile terminals), mainstream educational practice has not evolved yet to be able to take the most of these new resources. Thus, the question posed in this context is “how can we take the most of digital resources to better motivate students and improve pedagogical practice at the same time?”

iTec aims to provide solutions to this situation by developing engaging scenarios for learning that can be validated in a large-scale pilot, and be subsequently taken to scale. New scenarios proposed by iTec pose a relevant challenge to teachers, as they are the ones who will eventually implement them. A convenient technological support is needed to help teachers to more easily discover, assemble and fully exploit the new tools available. Nevertheless, this situation is not related to tools only, but engaging scenarios for learning need also to include other types of resources, like learning content, events and people. For this, the iTec project declares as one of its main commitments “to build a prototype assistant for advising users on how to find, select and combine resources to support learning plans”.

The iTec Composer and iTec Scenario Development Environment (SDE) are the two key elements to fulfill this objective. The former facilitates the selection and combination of resources, namely tools, events, people, and learning content. The later provides recommendations on them taking into account the specific context where educational activities are performed. Both applications are used as supporting tools by teachers when designing learning activities, and are fully included in the life cycle of an engaging scenario as defined by the iTec project.

This paper is focused on the description of the iTec SDE. First, we discuss the functionalities offered by the iTec Composer and iTec SDE, illustrating how they contribute to the design of lesson plans. The SDE is built upon semantic information models on the resources that may be included in these plans. Section 3 introduces these semantic models together with the strategy followed to define them. Next, we describe in Section 4 the SDE architecture and the main SDE components. Finally, we summarize the main results and conclusions of this work.

2. The Design Process

When deploying lesson plans within the iTec project, a complex process occurs that starts with an overall description of educational scenarios, and is completed with a final collection of Learning Activities (LAs) together with the resources needed to implement them in a specific school and educational context, in the form of a Learning Activity and Resource Guide (LARG). In other words, a LARG is a lesson plan enriched with the basic guidelines to develop the teaching/learning process in a specific context. iTec also defines a set of reference LAs, together with the requirements that specific resources (i.e., tools, people, events, content) must satisfy to implement them.

We describe below two artifacts developed within the iTec framework to facilitate the generation of LARGs from reference LAs. In the first case, the user is required to take all the relevant design decisions, while in the second case the user is provided with recommendations to facilitate decision-making.
2.1 The Composer

The Composer is iTEC’s proposal to provide support to the design of LARGs through the identification of resources relevant to the available LAs. Figure 1 illustrates the relation of the Composer with other subsystems developed within the project. Note that the SDE is a functional module within the iTEC Composer that provides additional recommendation features.

The first step when generating a LARG is to provide two key elements (c.f., figure 1), namely the collection of LAs that will be eventually included in the LARG; and the LARG Context, that is, the set of parameters characterizing the context where the learning experience will eventually take place (e.g., students’ age, language, learning subject). Then, the teacher may use the Composer to navigate across the collection of available resources to select the most suitable to the LARG. Additionally, the Composer may utilize the SDE to provide personalized recommendations according to the requirements included in each LA.

To support these functionalities, the Composer needs to access several data sources (see figure 1). Descriptions of learning content are available at the LRE, a service of European SchoolNet that provides over 230,000 learning resources in multiple languages [1]. The rest of the descriptions needed (i.e. technical settings, tools, people and events) are stored at the iTEC Back-end Registry.

Once a LARG has been produced, the next step will be to put it into practice in the real context of a target school. Generally speaking, we may understand the LARG as a shopping cart where the teacher has included, through the iTEC Composer, the elements (i.e., resources) that he/she wishes to use to be orchestrated in the final learning environment. Thus, the LARG is a list of LAs, each of them having a collection of specific tools, people, events and content needed to perform them. LAs also include descriptive information about its development (see section 3.1).

The LARG may be used as a reference document to configure all the tools and other resources needed for a specific lesson plan. The automatic configuration of these elements is also possible. For example, an iTEC shell may take as input an XML-coded LARG, and perform a self-configuration of the elements in it (e.g., widgets). The LARG may reference tools offered by the iTEC project through the iTEC Application Store (i.e. iTEC Technology), additional tools available to the school (i.e. Local Technology), and digital content stored in Learning Objects Repositories.

Figure 1. Relation of the iTEC Composer with the SDE and other sub-systems
2.2 The SDE

In spite of the support offered by the Composer, LARG generation may be a cumbersome process. Teachers should perfectly know the tools available in their schools (Technical Settings in iTEC terminology), the characteristics of other resources available, and the actual requirements of each LA. Determining which resources are the most convenient to perform LAs guaranteeing at the same time their feasibility in a specific LARG Context may not be a simple task. Therefore, while the Composer facilitates the production of a LARG, the SDE analyzes the actual requirements of LAs to offer recommendations on Resources satisfying these requirements according to the specific context where activities will be developed. More specifically, the iTEC SDE contributes to this objective by providing support to two processes:

- The “Technical Localization”. This refers to analyzing the feasibility of implementing the LAs taking into account the tools available in a specific school. The SDE includes functionalities to identify the LAs that better adapt to a specific school, or the relation of schools where a collection of LAs can be implemented.
- The Recommendation of Resources. These recommendations will be performed taking into account the specific requirements of LAs, together with any other information available on these LAs and resources, either explicit or implicit. Related to this, the SDE may also be used to check if an existing LARG satisfies all the requirements of a set of LAs, or to fetch resources satisfying specific requirements beyond those specified for an LA.

3. Data Models

The SDE functionality is built upon several data models. On the one side, we have models supporting the design of learning stories as units composed of one or several LAs. These models do not provide closed plans, but guidelines and recommendations to support and inspire lecturers to develop their educational plans in a given context. On the other side, we have semantic models on resources that may be included in lesson plans (i.e., tools, people, events and content). We describe in detail these two types of data models below.

3.1 Design Models

The iTEC approach to the modeling or design of lesson plans is intended to be open and inspiring. According to the principles of participatory design [2], the lecturers that will eventually implement a lesson plan should be the ones in charge of its design. iTEC includes several types of models reflecting this approach, namely Educational Scenarios, Learning Stories and Learning Activities, and LARGs.

The iTEC starting point for lesson plan designs are Educational Scenarios. A Scenario describes a specific educational practice where activities are developed using some resources and technological elements, with the participation of specific people. The most relevant component of a Scenario is its narrative part, where a real case is represented including real students and teachers, specific resources used, etc. A typical example may be as follows:

“Albert has organized a visit to the city zoo with his fourth-grade students for them to learn about the big African mammals. The kids have to take pictures from the animals and write down their most relevant features. Two students, Helena and Jakob, take pictures of lions and ask one of the caretakers at the zoo about their habits. Back at the school, all students upload their pictures to a shared folder in Dropbox. They also share their notes as text files. Helena uses some of the pictures and notes from other students to prepare a presentation on lions”.

The narrative part typically has a fairly short extension. In iTEC, Scenario descriptions are completed with short statements or item lists on aspects like aspirations (aspiration statement), objectives (aims of activity), nature of the activity (type of activity), technology and resources, tasks, physical spaces, roles and interactions. However, Scenarios are not conceived as rigid models, but just as a way to collect an innovative practice that could eventually serve as an inspiration to other teachers.

The next abstraction level will be Learning Stories (LSs) and their main building blocks, namely Learning Activities (LAs). An LS can be seen as the generalization of a Scenario. It shows how several generic LAs may be combined to construct a consistent lesson plan. In turn, LAs can be seen as building blocks to be included in several LSs. Each LA includes information on educational objectives, motivation for the involved actors (e.g., students and teachers), proposals on technology usage, and recommendations on resources to use, indicating when resources are required, desirable or just recommended. Resources may be described either as actual specific resources defining a closed set of requirements (e.g., ICCE 2012, Tim Berns Lee, a laptop), or as a collection of open requirements that may be satisfied by several resources (e.g., synchronous communication between Web users, a dinosaurs expert). They also include teacher guides detailing how the LA should be implemented in a specific classroom (e.g., time
needed, introduction, preparation, evaluation and assessment), and how to adapt the material to a specific course.

In the multi-national and multi-cultural context where iTEC is deployed, LSs and LAs need additional processing to be eventually used by teachers. LAs must be filtered taking into account the specific national educational context. They also have to be localized, which may involve their translation and their adaptation to the local uses, to locally available technologies and services, or to make them compatible with the specificities of local legislation.

LSs and LAs are the foundation of LARG specifications. Teachers may customize the proposed LAs and LSs introducing locally available resources to fulfill pending requirements. Hopefully, the final outcome (i.e., the LARG) will be detailed enough to be directly implemented, and open enough to be easily adapted to most classroom settings.

3.2 Models on Resources

The generation of recommendations in iTEC is supported by semantic technologies. The cornerstones of semantic modeling are the semantic models for tools, people, events and content:

- The tools that can be used in lesson plans are a fundamental resource. Tools are conceived as abstract entities that can be realized in several ways. We have physical tools, named Devices, and software tools, named Applications. In both cases tools are characterized by parameters like their description, tags, license, language, audience, supported standards, etc. Additionally, tools are also characterized by the relations established with other elements in the semantic model to express the functionalities provided in relation to other tools (e.g., compatibility). A particular type of tool is the iTEC Shell (c.f., Figure 1), an abstraction collecting tools that act as containers of other tools needing an execution environment. For example, the widget container in ROLE [3] is an iTEC Shell. Another relevant aspect is the way tools are grouped. The set of tools available in a school define its Technical Setting (TS). Typically, tools within a school are classified into two sets (cf., Figure 1): (1) the ones provided by the iTEC project (iTECTechnology) and (2) tools already available at the School (LocalTechnology). This classification enables recommendations on tools to be provided according both the applicable technical setting and the previous experience of teachers.
- Besides the teacher, pupils in future classrooms may have available a rich pool of experts in several areas to provide advice and support along learning activities. Furthermore, parents and other individuals in the local community may get involved in educational activities performed outside the classroom. Thus, people characterization goes beyond state-of-the-art people description, and must include all skills, expertise and context about an individual relevant to educational scenarios (e.g. fluency in a given language, degree of knowledge of a particular subject, communication tools at his/her disposal, affiliation, etc.).
- An event is any outside activity that may have educational relevance. Workshops, seminars, conferences, sport events, social gatherings, political meetings or even religious celebrations are examples of events that may support novel learning activities to improve the educational practice in European schools. Event conceptualization includes the most relevant features of events, like the type of participants, venue, relevant dates, audience, or specific tools needed to participate. The convenience or relevance of an event in the framework of a lesson plan is an important element to be considered in our recommendation models. The relation between events and tools (e.g. participation and communication tools) will also improve the impact and interest of recommendations.
- Learning content is any kind of information resource that can be used for teaching and learning. In iTEC, we consider LRE as being the main source of educational content.

4. Knowledge based Recommender System

The SDE can be considered a smart assistant that can be accessed by teachers through the Composer. It supports the design of a LARG by facilitating the configuration of a specific learning experience with contextualized recommendations on resources satisfying the needs of a LA, and more specifically tools, persons, events, and learning objects. From a conceptual point of view, the SDE can be seen as a recommender constructed on top or a Knowledge Based System [4]. In other words, the SDE is a tool that computes recommendations according to the information available in the underlying Knowledge Base. The fundamental components in the SDE architecture are the Knowledge Base itself, and the Recommendation Engine. These elements are further discussed below.

4.1 Knowledge Base

The information managed by the software applications configuring the iTEC technological ecosystem is stored in several databases. Besides the LRE, the People & Event Directory manages descriptions of people, groups, and
events; the Widget Store is a centralized catalog of all iTEC widgets; and the Social Data Manager manages, on behalf of the Widget Store, user-contributed data - e.g., comments, ratings, bookmarks, tags - about widgets. The SDE collects metadata available in these repositories using the OAI-PMH [5] protocol, or interacting with a SPARQL Endpoint in the case of the LRE. Metadata gathered is registered at the SDE Knowledge Base to be further processed.

The SDE collects external data registers expressed in JSON and transforms them into equivalent RDF expressions according to the terms identified in the semantic models described in Sect. 3.2 above. Once this information has been included in the Knowledge Base, the system identifies the applicable rules in the semantic models and executes them on each individual record to extract new knowledge using the Pellet Reasoner and the Jena semantic engine.

The SDE Knowledge Base exposes information through a SPARQL Endpoint. This way, the SDE can be semantically queried using standard SPARQL queries. To facilitate the creation, processing and enriching of the information managed, OpenLink Virtuoso has been selected as the semantic storage system, as this server offers specific features to handle and expose RDF triplets.

### 4.2 Recommendation Engine

The SDE should respond to the requests submitted by the Composer in relation to the most appropriate resources available to implement a given LA. To be able to provide an ordered list of resources according to their suitability, the SDE must consider two types of criteria:

- **Requirements**: The definition of a LA may include a collection of conditions or requirements that must be satisfied by the resources to be used to implement it. For example, an activity may require “a specific tool to support asynchronous communication among participating users”.

- **Constraints**: LAs don’t take place in an abstract environment, but in an actual educational context (i.e., LARG Context). Requirements are independent of this context, but there are additional conditions (i.e., constraints) that stem from the concrete environment at the school where an LA will be carried out. Factors such as the subject (e.g., Maths, History), the target audience (e.g., children from 13 to 15), teaching language (e.g., French), educational competences of teachers, technical setting (i.e., tools available at the school) or the time interval when educational activities will take place, are examples of this second type of conditions.

Besides the requirements defined for the LA, the SDE must take into account both types of criteria above when providing recommendations. According to these criteria, the SDE constructs a set of SPARQL queries to be submitted to the Knowledge Base, which in turn returns a potentially large set of resources appropriate to implement the LA. The next step will be to assign to each resource in the list a value related to its usefulness or pertinence. This value is computed according to an aggregated function of the form:

\[
U = \sum w_i \cdot u(f_i)
\]

where \( u(f_i) \) represents an estimation of the partial utility of the resource according to factor \( f_i \), and \( w_i \) is a weighting constant to modify the weight of the marginal utility without modifying the computation of \( u(f_i) \). For each type of resource, a set of factors have been identified that determine its partial utility. For example, to compute the utility of a tool, the factors below have been identified:

- **Functionality**: Indicates a feature that the tool offers to a user. The iTEC project considers that a tool offers functionalities according to a given degree, that is, a given functionality may be more or less appropriate to complete a given task. For example, according to a 1/10 scale, the Skype tool may be considered to offer the “audio conferencing” functionality with a value of 10, and the “file sharing” functionality with a value of 3. Tools offering a higher functionality factor will rank higher. In case a requirement entails more than one functionality, 1) the tool must satisfy all the established functional requirements, and 2) ranking will be defined according to the degree of fulfillment of each individual requirement.

- **Rating**: Indicates the degree of popularity of a tool. Tools receiving a better appreciation from the community will rank higher.

- **Underlying technology (Local vs. iTEC technology)**: Discriminates if a school already has a given tool, i.e., if the tool belongs to its Local Technology, or if the school has access to the tool through the iTEC project, i.e., if it belongs to iTEC Technology. Tools belonging to the Local Technology will rank higher than tools belonging to iTEC Technology, as the former are supposed to be better known by teachers at that school.

- **Shell integration**: This factor ranks tools according to their running environment. As far as SDE is concerned, this factor determines if a tool can or cannot be run on a Shell. Tools that can run on a shell (e.g. Widgets) will rank higher than tools that cannot be integrated in a Shell (e.g. Microsoft Word).

- **Type of Tool (Application vs. Device)**: This factor determines the type of tool (Application or Device) that provides the required functionality.
For the same functionality, Applications will rank higher than Devices, as access to Devices is more limited than access to Applications. Besides, Applications can be more easily integrated into a Shell.

- Cost: Indicates if a tool has an associated usage cost. For tools offering the same functionality, free tools will rank higher than non-free tools.
- Language: This factor references the languages supported by the tool’s user interface. In case a LARG Context specifies a single language (most common situation), tools whose user interface supports language will rank higher.
- Competence: This factor references the technical expertise of a teacher defining a LARG. Tools that the involved user already have experience with will rank higher.
- Age Range: Indicates the age range for which a tool has been explicitly designed. Tools whose age range matches the age range defined in the corresponding LARG Context (i.e., the age range of the students participating in the LA from a LS) will rank higher. In case an exact match cannot be found, the tools with a closer age range to the one in the LARG Context will rank higher.

To assign a weighting factor to each partial utility, a survey was performed among domain experts participating in the iTEC project. A total of 23 responses were collected and subsequently used to estimate these factors.

5. Conclusion

iTEC is a four year project funded by the European Commission under the 7th Framework Program. It has been selected in a very competitive call and, as such, it has very ambitious objectives. Overall, it aims to envisage how European schools should face the next decades in terms of new, revolutionary and engaging learning activities supported by the latest technologies at hand. One of its most demanding technological endeavors is the design and development of the SDE, a semantic-based recommendation engine managing a set of ontologies specifically designed to model the iTEC educational ecosystem. The eventual outcome from this task will be a smart agent that will provide teachers with (1) identification of which Learning Stories can be developed into Lesson Plans (LARGs in iTEC terminology) in a specific school, and (2) the automatic identification of those resources available at the school that meet the requirements imposed by the activities included within that Learning Story.

The benefits of the SDE should be analyzed in the context of a large global educational system where hundreds, maybe thousands of Learning Stories are available for teachers to implement at their schools and with their students. In this situation, regular teachers need help to identify which Learning Stories can be actually implemented using the resources available both at and from their schools. Secondly, once a Learning Story is selected, there may be many, perhaps too many, tools and resources that could be used or put them into practice. Once again, teachers may feel lost when selecting the best resources. The SDE helps teachers in this process, supporting them in the automatic identification of Learning Stories whose implementation is feasible at their schools, and recommending the best resources available to actually support them, taking into account both the Learning Story’s intrinsic requirements and the context where the Learning Story is to be implemented (e.g., student’s age range, language, subject).

iTEC is currently at its second year. The SDE is already available to be used as an add-on to the Composer. So far, it has been tested by internationally recognized pedagogical experts within the consortium with a very positive feedback, making it clear the potential value of such a tool. Next steps are focused on widening the spectrum of resources available for recommendation, mainly parsing resources from external sources, including Linked Data and the optimization of the recommendation algorithm using the feedback from the first expert evaluation process. Implementation at large scale, in the 1,000 schools participating in the iTEC project is expected for 2013 and 2014, when the actual value of this artifact will be assessed, and potential shortcomings identified for further improvement.

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