# AN ADAPTIVE ASSESSMENT TOOL INTEGRABLE INTO INTERNET-BASED LEARNING SYSTEMS

E. GUZMÁN AND R. CONEJO
*Department of Languages and Computer Science. University of Málaga,*
*Bulevar Louis Pasteur, 35. Campus de Teatinos, 29071 Málaga, SPAIN.*
*E-mail: guzman, conejo@lcc.uma.es*

SIETTE is an adaptive web-based assessment system. It implements *Computerized Adaptive Tests*. In this system, the finalization decision, the item selection criteria and the estimation of the student's knowledge level are accomplished following a psychometric theory called *Item Response Theory*. In this paper, SIETTE is presented as an open tool that can be easily integrated into web-based learning systems. It can be also integrated into Intelligent Tutoring Systems by a more sophisticated mechanism. The main goal of the integration is that the student does not notice that he is making a test in a different tool. This system save time to the developers of learning system, since they do not have to implement specific tools for evaluation inside their systems.

## 1 Introduction

Currently there are a lot of Internet-based learning systems. These systems either do not have evaluation mechanisms, or the mechanisms used to evaluate the students do not take into account the differences, from the knowledge level's point of view, between the students. In the second case, questions posed to students are common to all of them. They are not fitted to the student knowledge level.

SIETTE [6] is a web-based assessment system. It implements an efficient *Computerized Adaptive Test* (CAT) [10]. In CATs, the finalization decision, the item selection criterion and the estimation of the knowledge level, are dynamically accomplished following probability-based criteria. More precisely, SIETTE uses a psychometric theory called *Item Response Theory* (IRT) [9].

In this paper, SIETTE is presented as an open assessment tool. The feature emphasized is that it can be easily integrated into web-based learning system, providing the students a way to self assess their knowledge about the topics studied. Also, this integration supposes an advantages for learning systems developers, since they do not have to implement in their own evaluation applications.

In the first section, the SIETTE system will be introduced. Its architecture as well as its operation mode are treated. Next, the integration process will be approached. This integration can be done in two ways. In a first simple approach, the learning system only has to call SIETTE with some parameters and wait until the test finishes. There is also a more sophisticated integration mechanism that can be useful for Intelligent Tutoring Systems (ITS). At last, some conclusion and the future work are presented.

## 2 SIETTE

SIETTE (It stands for *System of Intelligent Evaluation using Tests for Teleeducation* in Spanish) has been designed to be used through World Wide Web (http://www.lcc.uma.es/SIETTE ). By means of a navigation application, teachers can create and modify tests [4], and examinees can evaluate their knowledge about different subject.

Contents are structured in subjects. Each teacher can at least add one subject to the knowledge base of the system. Each subject is hierarchically structured in topics. SIETTE is able to give one qualification for each topic defined in the hierarchy. To make a correct assessment of a topic, a set of questions (items) are defined to evaluate this topic. This structure is called *curriculum.*

If an item is defined to evaluate one topic, it can be also used to evaluate the knowledge of the student in all the preceding topics in the hierarchy, as well as in the whole subject [5]. As a result, a test of the whole subject, a test of a topic or a test of a set of topics can be defined. In this last case, a restriction must be imposed: all the topics involved in a test must be sibling.

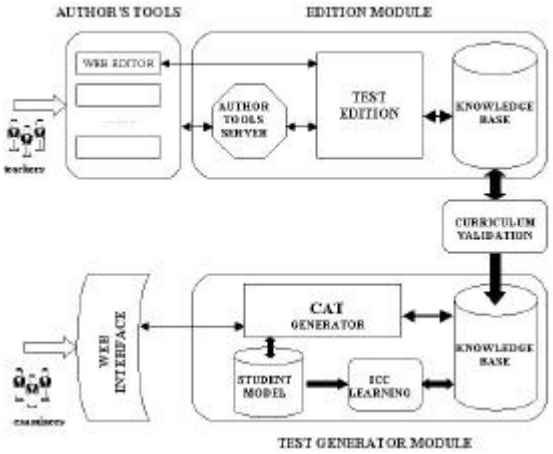


**Figure. 1.** The architecture of SIETTE

Its architecture, Figure 1, comprehends the main components of an adaptive test. These parts are organized in six main modules:

?? *Knowledge base*. It is composed by the concept domain (*curriculum*), the specifications of the tests and the items pool.
?? *CATs generator*. It poses the most suitable items every time in each test session.
?? *Tests editors*. They allow teachers to accomplish insertions and modifications on the knowledge base.
?? *The student model*. It collects all the information about the student needed by the test generator.
?? *Validation module*. It ensures that all the teacher's specifications of tests are coherent and their data are consistence, and therefore can be used by examinees.
?? *Learning module*. When teachers add new items to the knowledge base, they must estimate some configuration parameters. These parameters are only an initial approximation, so a calibration process is required. This module uses the information obtained from the student model.

### *2.1 The operation mode*

CAT systems follow an iterative algorithm. It begins with an initial estimation of the examinees' knowledge level and it has the following steps:

1. All the questions in the knowledge base (that have not been administered yet) are examined to determine which is the best item to ask next according to the current estimation of the examinee's knowledge level.
2. The question is asked, and the examinee answers.
3. According to the response, a new estimation of the knowledge level is computed.
4. Steps 1 to 3 are repeated until the stopping criterion defined is met.

The finalization criterion is configured in each test. First, in the edition phase, the teacher must indicate a minimum and a maximum number of items. These values set bounds to the number of items that may be posed to the students. If a student has taken the maximum value of items, the final estimation process of his knowledge is forced. Additionally, SIETTE offers the following adaptive finalization criteria: The most likely value of the estimated knowledge distribution of the examinee, upper to a certain threshold; or the variance of the estimated knowledge distribution is lower than a certain value.

## 3 Integration into educational systems

The main goal of the integration is that it should be as much as transparent as possible. That is, the student should not notice that he is making a test in other different system, and once the tests finishes, the control must be transparently given back to the learning system.
This integration can be summarized in the following steps:

1. First of all, the teacher must be provided with a login/password to access to one of the author tools of SIETTE. This login/password are given by the administrators of SIETTE.
2. The teacher must create a subject with a *curriculum* composed by topics and items.
3. Some definitions of test may be also provided by the teacher.
4. In the learning system, links to the SIETTE system are included, every time the evaluation is required.
5. Once, the assessment finishes, the control is be given back to the system in terms of the parameters provided to SIETTE in the initial call.

Next, we will focus in steps 4 and 5, that is in the communication between SIETTE and the learning system.

### *3.1 A simple mechanism of integration*

A first approach to the integration, supposes the maintenance of the hypothesis that each item only assesses one topic of the *curriculum* in each test session. As a result, the estimation of the knowledge level for each topic can be done by accomplishing a test for each topic.
From a procedural point of view, this mechanism does not require any especial commitment from the learning system side. The system will perform a call to SIETTE giving some parameters that settle the test session options. Therefore, the integration is too easy, since SIETTE only needs to know either the test that is going to be made, or directly the topic assessed. Additionally, other parameters can be given to SIETTE like the way of visualization of the responses, show or not the correction of the item after the student's response, etc. Also, SIETTE should receive a set of URLs. It will interpret the number of these URL parameters as the number of knowledge level in which it must classify the student. When the test finishes, a call to the URL corresponding to the knowledge level of the student about the topic of the test, will be generated. These URLs are used to give back the control to the learning system, as well as to show the students their qualification in the test.

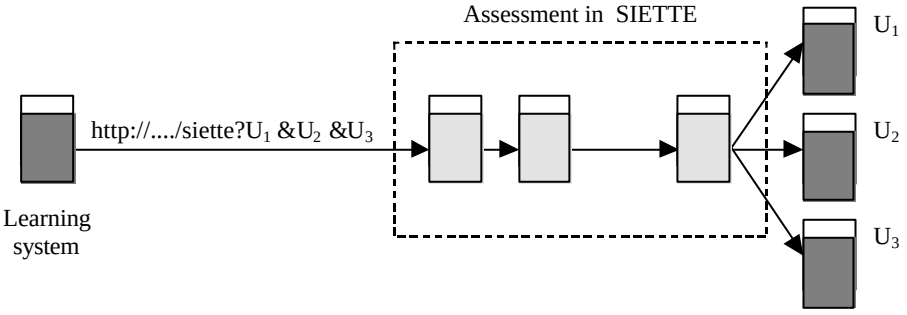


**Figure 2 :** The simplest way of integration of SIETTE

An example of this kind of integration is a tutorial of Linear Programming. This tutorial is currently under development. It is composed by a set of HTML pages and Java applets. They are used to teach the students the notions about this domain. The contents of the tutorial are organized into topics (or lessons). Also, each topic has a link to a test. Through this test, the student is evaluated about the topic. Each test has about fifteen questions. The student is evaluated in three knowledge levels: 0, it indicates that he must review the contents of the topic; 1: if the student has enough knowledge to go on with the following topic, although he

may review the previous topic; and; 2: if the student has plenty of knowledge about the topic. Anyway the final decision of continue or review is freely taken by the student.

### *3.2 Integration into ITS*

SIETTE was initially conceived as the diagnosis module of an ITS. The main feature of these systems in comparison to other computer aided learning systems is that they are adapted to the students. They offer to the students a personalized instruction [7]. Traditionally, these systems have a student model with the subject taught, and an instructional planner, that decides which is the following instruction. Thanks to the planner, the system does not recommend concepts studied, or concepts very difficult. To take these decisions, the planner uses the student model. It will choose the most adequate concept to study, and the best way in which it can be accomplished. The student model will be mainly update thanks to the assessment accomplished in the diagnosis module.

If it was desirable to make a test of several topics, according to the former integration, a different test for each topic should be done. This does not seem to be the best way from the student's point of view. The best alternative is to accomplish only one test, where several topics can be assessed simultaneously. In ITS, this kind of tests can be useful in the first step of the instruction to infer the initial knowledge level of the student. Through this pre test, a best adaptation from the start point of the instruction can be achieved.

From a procedural point of view, the integration with an ITS is more complex, since it requires a more detailed parameters from the tutorial system to SIETTE and vice versa. In addition to the tests or topics to be accomplished, the parameters of the call from the tutorial system to SIETTE, can be the a priori estimations of the knowledge level of the student in each topic. These data can be obtained from the student model of the ITS. This information will improve the reliability of the assessment, but it is not completely necessary, since SIETTE can use by-default distributions. Once the assessment has been done, SIETTE gives as a result, the a posteriori estimations of the knowledge levels to the tutorial system through the URLs provided in the initial call. Data given back to the ITS are coarse. They must be processed and will be used to update the student model.

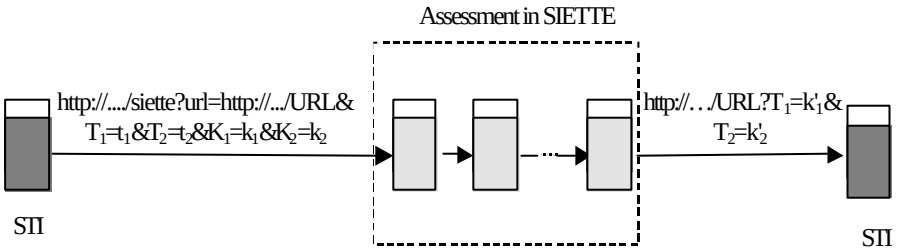


**Figure 3.** Integration into an ITS

## 4 Conclusions and future work

SIETTE has been implemented as an open assessment tool. As a result, any web based learning system can easily use the services provided by this system. This implies that developers of learning systems do not have to spend time in the creation of assessment modules.

In addition, SIETTE implement CATs. This means that well-found assessment mechanisms are ensured, where tests are adapted to the estimated knowledge level. These kind of adaptive tests offers a lot of advantages: the difficulty of the items is adapted to the knowledge level of the student, usually the number of items of each test session is lower than in classical tests where this number is also fixed, etc.

From the integration point of view, firstly, a simple mechanism of integration has been presented. Following the rules of this integration technique, SIETTE has been integrated into several web-based learning systems

[1]. For instance, it has been integrated into an adaptive tutorial of Agrarian Economy [3]. In this system, an adaptive tutorial tool, SIGUE [2], assists the students through their navigation in the pages of the tutorial. The tutorial is divided into topics, and each topic has associated a test provided by SIETTE. Once, the test session has finished, depending on the knowledge level of the student, the system will show him a page with his qualification. This page contains the adequate links to new topics or to the previous one, in the case that the qualification of the student is too low.

A second stage in the integration is the use of SIETTE inside an ITS. An example of this, is the integration into MEDEA [8]. MEDEA is a web-based architecture of ITS, structured in components. In this way, the learning of certain subject will be accomplished by the use of some components. All these components are coordinated by the instructional planner and can be even external to the system. They can be classified in different classes depending on its character. In MEDEA, the following components can be found: *instructional components*, that allow to teach different topics; and *evaluation components*, that allow to assess the knowledge of the students in the subject. As a result, SIETTE is an evaluation component. Every time the instructional planner decides that the student must be evaluated, SIETTE will be called with some properly parameters.

One of the main lacks of these last integration mechanism is that both systems must have a common *curriculum*, or at least, a correspondence may be established between the *curriculum* used in the tutorial system, and the *curriculum* settled in SIETTE. Therefore some automatic mechanisms is required to establish the correspondence between the *curricula* in both system, although it will probably mean a lack of autonomy in both systems.

**References**


1. Arroyo, I., Conejo, R., Guzmán, E., Woolf, B.P. (2001). An Adaptive Web-based Component for Cognitive Ability Estimation. In: J.D. Moore, C. Luckhardt-Redfield, W. Lewis Johnson (Eds.), *Artificial Intelligent in Education: AI-ED in the Wired and Wireless Future*. 456-466.
2. Carmona, C., Bueno, D., Guzmán, E. & Conejo, R. (2002). SIGUE: Making web courses adaptive. In Brusilowsy, P., De Bra, P. & Conejo, R. (ed.) Proceedings of the II International Conference on Adaptive Hypermedia and Adaptive Web Based Systems. Lecture Notes in Computer Science. Springer-Verlag.
3. Carmona, C., Guzmán, E., Bueno, D. & Conejo, R. (2002). An adaptive web-based Tutorial of Agrarian Economy. In: *Adaptive Systems for web based education*, Málaga. 57-63.
4. Guzmán, E., Conejo, R. & Domínguez, F. J. (2002). Una herramienta de autor autónoma para un sistema de tests adaptativos a través de Internet. *III Congreso Internacional de Interacción Persona-Ordenador*, Madrid. 90-96.
5. Guzmán, E. & Conejo, R. (2002). Simultaneous evaluation of multiple topics in SIETTE. *Proceedings of Intelligent Tutoring Systems Conference 2002*. Lecture Notes in Computer Science. Springer-Verlag.
6. Ríos, A., Millán, E., Trella, M., Pérez-de-la-Cruz, J. L. & Conejo, R. (1999). Internet Based Evaluation System. In *Proceedings of the 9th AIED*. Amsterdam: IOS Press.
7. Self, J. (1990) Theoretical foundation for Intelligent Tutoring Systems. *AAAI/AI-ED* 1990; 45.
8. Trella, M., Conejo, R., Bueno, D. & Guzmán, E. (2002). An autonomous component architecture to develop WWW-ITS. In *Adaptive Systems for web based education*, Malaga. 69-80.
9. Van der Linden, W. & Hambleton, R. (eds). (1997). *Handbook of Modern Item Response Theory*. New York: Springer Verlag.
10. Wainer, H. (ed.). (1990). *Computerized Adaptive Testing: a Primer*. Hillsdale, NJ: Lawrence Erlbaum Associates.