Evaluating the practical application of the Siena social web based tool in Higher, Secondary, and Primary Education in Spain

Lorenzo Moreno Ruiz
Beatriz Beatrice Popescu Braileane
Carina S. González González
Claudia Lisete Oliveira Groenwald
Elisabeth Fumero Méndez
Dámaris González Pinto
Jamileth Lotero Nañez
Reymar Andrea Vargas Iniesta

ABSTRACT

The European Higher Education Area (EHEA) has invested efforts in an educational model that is based on student learning, and thus student focused learning needs. Under this framework, a tool called SIENA SOCIAL has been designed to help provide individuals with both autonomous learning and collaborative learning opportunities. In this paper, we analyse the possibility of extending the web tool beyond the higher education setting by testing it in primary and secondary educational settings. For this purpose, two experiments were designed: the first targets secondary education and uses the subject English as a Second Language, the second targets primary education and the topic The Human Body within the subject of Environmental Studies.

Keywords: SIENA. Teaching and Learning. European Higher Education Area.

Avaliando a aplicação prática da ferramenta social Siena baseada na *web* no Ensino Superior, Secundário e Fundamental na Espanha

RESUMO

O Espaço Europeu de Ensino Superior (EEES) investiu esforços em um modelo educacional que se baseia na aprendizagem dos alunos, focado nas necessidades de aprendizagem dos estudantes. Neste âmbito, uma ferramenta, denominada SIENA SOCIAL, foi desenvolvida para ajudar o desenvolvimento de uma aprendizagem autônoma e colaborativa. Neste artigo, analisamos a possibilidade de estender a ferramenta web para além do ambiente de ensino superior, testando-a

---

Lorenzo Moreno Ruiz – Universidade de La Launa, Tenerife, Espanha.
Beatriz Beatrice Popescu Braileane – Universidade de La Launa, Tenerife, Espanha.
Carina S. González González – Universidade de La Launa, Tenerife, Espanha.
Claudia Lisete Oliveira Groenwald – Universidade Luterana do Brasil (ULBRA), Canoas, RS, Brasil.
Elisabeth Fumero Méndez – Former students of masters programs offered by the University of La Laguna.
Dámaris González Pinto – Former students of masters programs offered by the University of La Laguna.
Jamileth Lotero Nañez – Former students of undergraduate programs offered by the University of La Laguna.
Reymar Andrea Vargas Iniesta – Former students of undergraduate programs offered by the University of La Laguna.

em ambientes educacionais do Ensino Fundamental e Ensino Médio. Para esta finalidade, foram realizados dois experimentos: o primeiro no Ensino Médio, utilizando o estudo de Inglês como segunda lingua, o segundo para o Ensino Fundamental, com o tópico corpo humano, na disciplina de Estudos Ambientais.

Palavras-chaves: SIENA. Ensino e Aprendizagem. Espaço Europeu de Educação superior.

1 INTRODUCTION

One consequence of joining the European Higher Education Area (EHEA) has been greater student participation in the teaching-learning process.

As evidenced in (HERNÁNDEZ et al., 2006), new didactic strategies have been implemented that are aimed at facilitating student learning. These strategies are designed to support students in becoming autonomous learners by encouraging them to take responsibility for developing their own knowledge.

Likewise, in recent years, we have seen the emergence of new evaluation systems that complement or substitute the traditional evaluation model that is based on students sitting written exams.

The emergence of new technologies has led to the advent of concepts such as blended learning, on-line education, collaborative work, and social networking, which is all possible thanks to the rise and use of tools such as Skype, Hangout, YouTube, Massive Open Online Courses (MOOC), video clips, Moodle, and so on. All of these new pieces of technology and concepts, in one way or another, have completely transformed the educational panorama.

Research into Education and ICT has flourished in the last decade, and a number of computer-based tools have come into being that facilitate self-study and self-assessment by students, while also allowing teaching staff to track student performance and perform their own assessment and evaluation of students' progress.

For several years now, we have been developing a tool that facilitates self-study by providing students with autonomous learning and collaborative learning opportunities and also a self-assessment component for the knowledge being acquired. Both the self-study aspect and the evaluation aspect have been approached using approximate reasoning: Bayesian inference is used for the multiple-choice questions in the computerized adaptive testing (CAT), and fuzzy logic is used to perform the evaluation.

This tool, called SIENA SOCIAL (an acronym of *Sistema Integrado de ENseñanza Aprendizaje*, which stands for Integrated System of Teaching & Learning) (MORENO et al., 2013), (MORENO et al., 2015), arose from a collaboration between the University of La Laguna (ULL) in Tenerife, Spain and the Lutheran University of Brazil (ULBRA) in Canoas, Brazil.

Up until this point in time, the tool had only been tested then successfully used in the higher education setting, and in a few instances, in the basic compulsory education

setting in Brazil (RUPPENTHAL, 2009). However, to date, no comparative study had been performed in the primary or secondary educational setting to contrast the results obtained using traditional teaching learning evaluation methodologies against the results obtained using the SIENA SOCIAL tool and CAT.

In this paper we present two examples of SIENA SOCIAL use outside of the university setting: in example 1, SIENA SOCIAL is used for teaching and evaluation in the subject *English as a Second Language* in the secondary education setting; and in example 2 SIENA SOCIAL is used in the teaching and evaluation the subject *The Human Body* in the primary education setting.

However, in the following section, we begin by providing a brief analysis of SIENA SOCIAL's application in the higher education setting. Specific examples are provided from undergraduate degree programs in Computer Engineering and Industrial Electronics and Automation. Although it has also been applied as part of masters in Education and ICT, we have only focused on its applications in undergraduate degrees for the purpose of this paper.

In the next section, we then provide a detailed analysis of SIENA SOCIAL in the secondary education setting when applied to the subject English as a Second Language. The results obtained from SIENA SOCIAL are compared against the results obtained in traditional exams.

Lastly, we provide an analysis of SIENA SOCIAL in the primary education setting that compares the results obtained using SIENA SOCIAL against those obtained using traditional evaluation techniques in the subject The Human Body. However, this analysis is performed using a different methodology and set of results to those in the previous section.

2 THE SIENA SOCIAL TOOL IN THE UNIVERSITY SETTING

In the university setting, SIENA SOCIAL has been used in several Engineering undergraduate and master's degree programs, and in subjects delivered by the Education Faculty in different academic years.

In Moreno et al. (2013) the SIENA SOCIAL tool is presented as a web tool (http://sienasocial.ull.es) to assist students in learning content and in self-assessment, both individually and collaboratively. It is a tool that uses Bayesian networks for adaptive testing (MILLAN et al., 1998).

Currently, it includes fuzzy logic to aid the teacher in the assessment of collaborative work and uses the quality of messages, the test result, and the initiative shown by each student based on their participation during group activities to create marks. Following the Mamdani model, there are 4 variables with three fuzzy values each (81 fuzzy rules), with a defuzzification of the average of the maximums (MUÑOZ, 2007).

FIGURE 1 – Conceptual map showing student workflow within SIENA SOCIAL
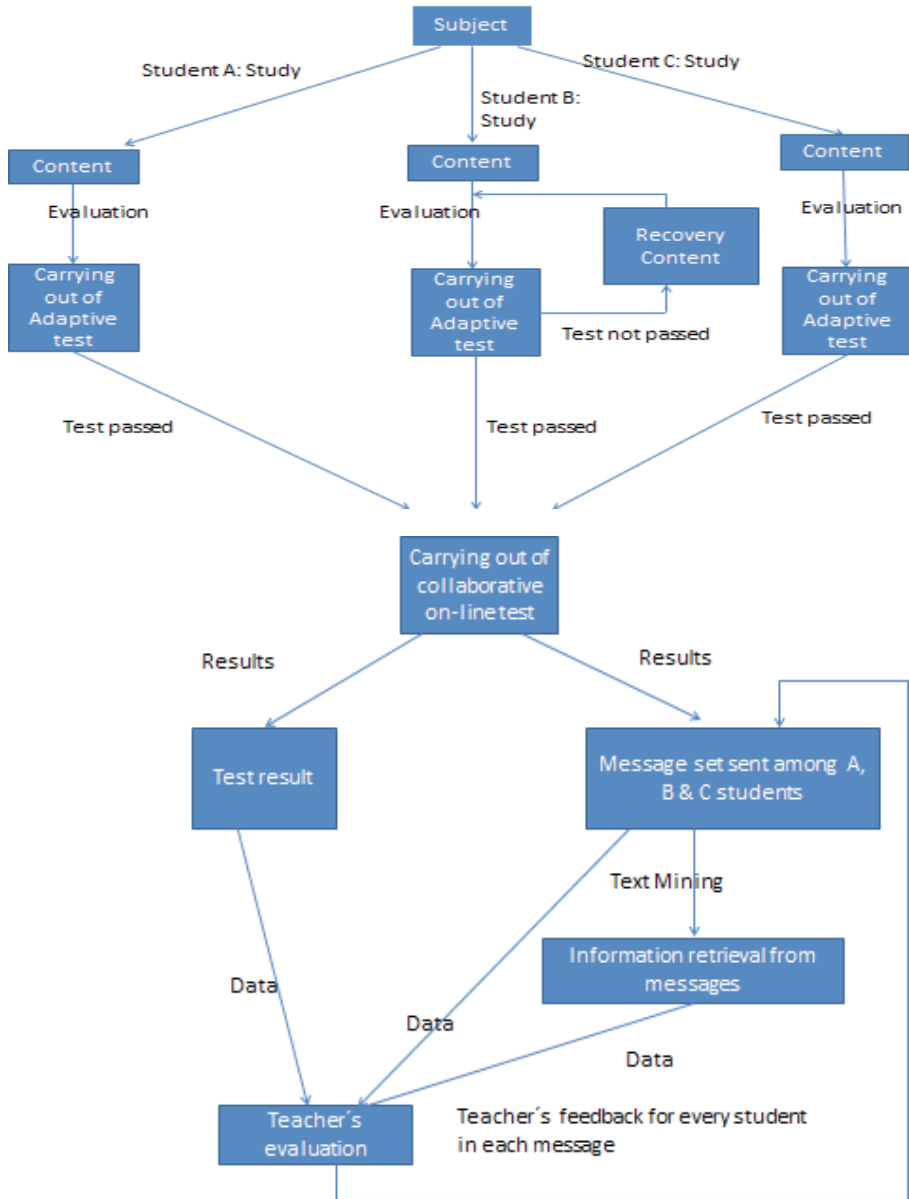
Source: made by the authors.

Fig. 1 represents the collaborative work performed by three students – A, B and C – who first work individually and then collaboratively. The messages the students send,

the test result, the number of times each student intervenes in the test, and the number of times the student starts a conversation in each question of the test are all variables that are selected by the fuzzy logic in order to evaluate the students and assign a grade to each individual.

Fig. 2 shows the Bayesian network for a subject belonging to Computer Architecture. This network consists of 9 nodes that contain a total of 736 questions. The number of questions varies from 39 in the node *Fundamentals of Design* to 143 in the node *Virtual Memory*. The questions are designed to present students with three levels of difficulty.

FIGURE 2 – Bayesian network of a subject from the course Computer Architecture
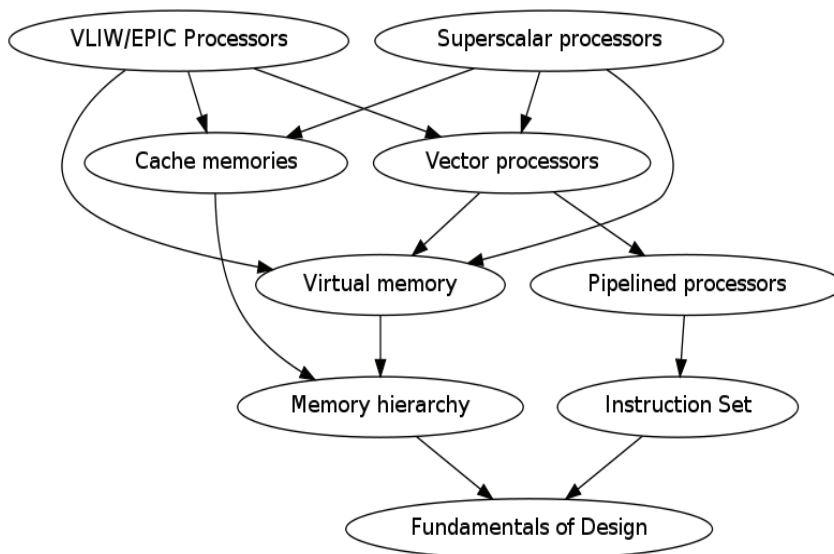
Source: made by the authors.

Fig. 3 below shows the conceptual map for a module in the subject Advanced Architectures and Specific Purpose. This course, and the abovementioned course, both belong to the degree program Computer Engineering. There are 7 nodes with a total of 264 questions, also designed to provide three levels of difficulty.

FIGURE 3 – Bayesian network of a module from the subject Advanced Architectures and Specific Purpose.
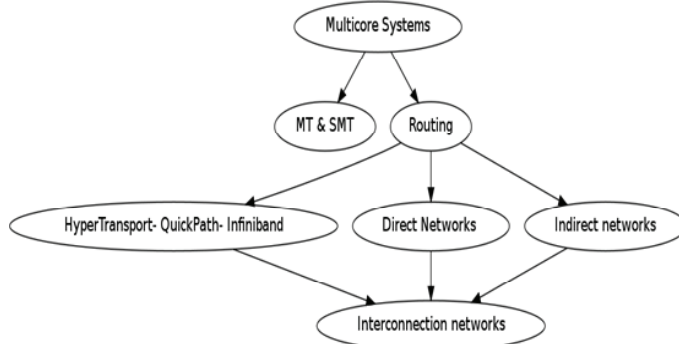
Source: made by the authors.

In these subjects, the students perform tests both individually and collaboratively.

Fig. 4 below shows the results of one such collaborative test for the aforesaid subject and some of the messages sent in the *MT & SMT* node (Multithreading and Simultaneous Multithreading).

FIGURE 4A – Results of a collaborative test.

Source: made by the authors.

FIGURE 4B – Set of messages shared between students who sat the test in Fig. 4A.

Name	Message		Time	
San Miguel Simik	diferentes hilos de ejecucion compartan las unidades funcionales de procesaor	2	17:48:14 (Change)	Borrar
Andres Cidoncha Carballo	El primero es superescalar porque no aprovecha tan bien los slots y el ultimo es SMT porque lo aprovecha el mejor, se puede ver con los desperdicios horizontal/vertical. El del centro parece que es el de grano fino.	3	17:50:23 (Change)	Borrar
Maria Fernanda San Miguel Simik	si, el del centro es de grano fino, ya que cambia de hilo en cada instruccion que este ejecuta	3	17:51:25 (Change)	Borrar
Maria Fernanda San Miguel Simik	por tanto se ve una ejecucion intercalada	3	17:51:45 (Change)	Borrar
Adrián Abreu González	Cierto, el primero es superescalar por lque la ejecución del hilo es la misma todo el rato, la del centro es grano fino porque cambia a pesar de estar usando muchas unidades	3	17:53:09 (Change)	Borrar
Adrián Abreu González	Y el ultimo es smt por todo el aprovechamiento que tiene	3	17:53:19 (Change)	Borrar
Adrián Abreu González	HTT es tecnologia propietaria de intel, con lo cual descartamos la respuesta de AMD, es su estrategia de implementación de multiples hilos, pero utiliza dos procesadores virtuales	4	17:56:20 (Change)	Borrar
Andres Cidoncha Carballo	Esta tecnologia de intel consiste en simular dos procesadores lógicos dentro de un único procesador físico.	4	17:56:58 (Change)	Borrar
Maria Fernanda San Miguel Simik	la primera no es porq la tecnologia de intel no consiste en la comunicacion entre los cpus y los hilos, sino que incluye dos procesadores virtuales	4	17:58:48 (Change)	Borrar
Maria Fernanda San Miguel Simik	claramente se pueden compartir recursos	5	18:01:45 (Change)	Borrar
Adrián Abreu González	Yo creo que tiene sentido la forma competitiva donde tienen que luchar por los recursos y quizás la equitativa donde se les dan de forma igualada, pero de esta ultima no lo tengo muy	5	18:02:30 (Change)	Borrar

Source: made by the authors.

Recently, the SIENA SOCIAL tools have been incorporated in the degree Industrial Electronic Engineering in the subject Advanced Industrial Automation. It acts as a complement to the models and simulations that have been developed to assist taught classes in this subject, in particular, a model and simulation of a FESTO manufacturing plant for parts transportation that has been created using 3D modelling software (LOTERO; VARGAS, 2015).

The Bayesian network is as follows (Fig. 5):

FIGURE 5 – Bayesian network of the subject Advanced Industrial Automation.
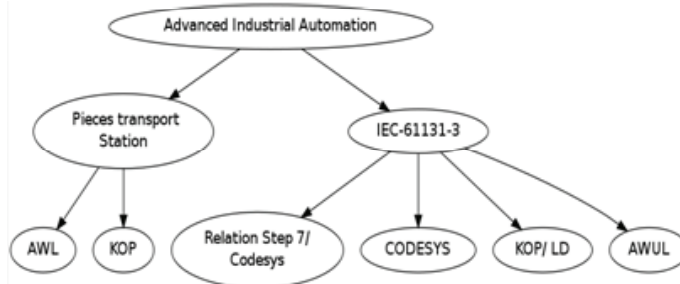
Source: made by the authors.

In order to be more innovative when it came to creating the questions, we included multimedia files such as images and videos. The following questions include a link to a YouTube channel used to host content. Users can upload and share simulation videos created in the software *Inventor.*

At this time, efforts are being made to add more questions to each node. There are currently 88 questions in total.

FIGURE 6A – A test question hosted on the YouTube channel.

Source: made by the authors.

FIGURE 6B – YouTube channel used to host different videos.

Source: made by the authors.

3 EXAMPLE 1: SIENA SOCIAL IN SECONDARY EDUCATION

Using SIENA SOCIAL to detect the level of students' English grammar

Objective of study: The aim of this study was to develop computerized adaptive tests (CATs) on the SIENA SOCIAL platform and test the reliability of results obtained from said tests (FUMERO, 2015). During this process the goal was to identify the answers to the following questions:

• Is it possible to use the SIENA SOCIAL tool to create an adaptive test for English as a second language that can be used by secondary school students?

• Does the tool offer a quick, reliable and easy way to evaluate their level of English grammar?

• How reliable are the adaptive test results in comparison to results obtained from traditional testing, in other words, are the adaptive test results an accurate reflection of students' grammar level?

To answer these questions, two groups were studied. The subjects of each group remain the same, but the variable that changes is the source of their results. Thus, the object of our study, the SIENA SOCIAL tool, shall provide the experimental results while the traditional written exams that are delivered over the academic year shall provide the control results.

The subjects chosen to participate in our study were 34 students from a secondary school Santa Cruz de Tenerife (Canary Islands, Spain), with heterogeneous English language skills.

These 34 students consisted of two groups: students from the second year of Compulsory Secondary Education (E.S.O) and students from the fourth year of Compulsory Secondary Education. All of the students took the adaptive test in the last month of the academic course.

To ensure consistency, the following decisions were taken: firstly, to choose students who were completing the end of an evaluation cycle. The reason for this was that there are clearly defined official objects and evaluation criteria for these cycles (2nd and 4th of E.S.O); secondly, to compare and contrast the official objectives and evaluation criteria against the Common European Framework of Reference for Languages. Based on this comparison, it was concluded that the language level A1-A2 should correspond to students completing the second year of E.S.O, and level A2-B1 should correspond to students completing the fourth year of E.S.O.

The results obtained for each of the participants of the experimental groups were compared against a control group, whose level of English grammar was calculated based on their average mark obtained from 4 to 6 written exams sat over the course of the academic year that covered exactly the same content as the SIENA SOCIAL computerized adaptive tests.

In the case of second year E.S.O students, the main group was divided into subgroups based on their marks: those students who scored less than 5 were deemed to have a level inferior to A1 (<A1); those students who scored between 5 and 7 were deemed to have level A1; and those students who scored between 7.1 and 10 were deemed to have level A2.

In the case of fourth year E.S.O students, the same process was followed, but in this instance those students who scored less than 5 were deemed to have a level inferior to A2 (<A2), those students who scored between 5 and 7 were deemed to have level A2, and those students who scored between 7.1 and 10 were deemed to have level B1.

FIGURE 7 – Subject conceptual map.
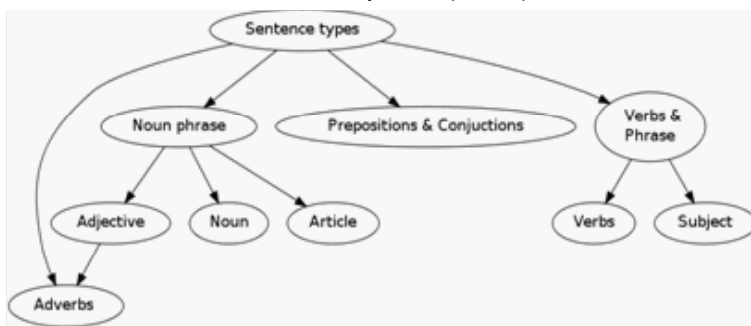
Source: made by the authors.

However, it was important to correlate our questions to the levels established by the Common European Framework of Reference for Languages, but the arbitrary nature of this process due to a lack of precise descriptions for each of the stated levels led the authors to perform a literature review in order to establish precise descriptions. Relevant websites were selected that explicitly stated how the official objectives and evaluations of the academic course correspond to each language level mentioned above.

The criteria used to search for and select said websites are detailed below:

- The websites must contain content that corresponds to the levels set forth by the Common European Framework of Reference for Languages,

- Trusted authors must manage the websites and their content,

- Reliable sources must be used to create content,

- Content should be targeted towards secondary school students.

As part of this search more than forty websites were consulted, and those not complying with the abovementioned criteria were discarded.

The resulting conceptual map (Fig. 7) contained 10 nodes divided into different difficulty levels, as shown in Table 1 below. In order to progress to the more advanced nodes, students would first have to pass the simpler nodes.

TABLE 1 – Organization of the nodes.

Nodes	Level 1	Level 2	Level 3	Level 4
Adverbs	√			
Noun phrase			√	
Prepositions	√			
Adjectives		√		
Noun	√			
Article	√			
Verb phrase		√		
Verb	√			
Sentence type				√
Subject	√			

Source: made by the authors.

The bank of questions contains a total of 259 multiple-choice items. Each item has 4 possible answers, of which only one is correct.

TABLE 2 – Results obtained in the different nodes.

Users	Adverbs	Noun phrase	Prepositions	Adjectives	Noun	Article	Verb phrase	Verb	Sentence type	Subject	Resultado medio use of english
EM2B01	0.013		0.168		0.878	0.888	0.03	0.599		0.949	0.50
EM2B100	0.032		0.35		0.977	0.627		0.053		0.169	0.37
EM2B60	0.096		0.925		0.458	0.892		0.015		0.823	0.53
EM2B7	0.993	0.998	0.984	0.989	0.991	0.995	0.996	0.993	0.989	0.989	0.99
EM2B8	0.35		0.006		0.262	0.941		0.065		0.017	0.27
EM2B09	0.046		0.805		0.922	0.914		0.865		0.432	0.66
EM2B10	0.95		0.041	0.978	0.262	0.071	0.033	0.503		0.996	0.48
EM2B15	0.626		0.52	0.995	0.886	0.952		0.299		0.909	0.74
EM2B17	0.026		0.159		0.744	0.096		0.125		0.012	0.19
EM2B18	0.008		0.026		0.032	0.992		0.067		0.163	0.21
EM2B19	0.564		0.169	0.861	0.009	0.345	0.022	0.995		0.994	0.49
EM4B70	0.113		0.013		0.587	0.855		0.137		0.958	0.44
EM4B20	0.013		0.096		0.177	0.925		0.536		0.487	0.37
EM4B5	0.994	0.653	0.945	0.995	0.996	0.991	0.994	0.994	0.929	0.977	0.95
EM4B6	0.049		0.059		0.962	0.944		0.991		0.487	0.58
EM4B49	0.262		0.847		0.596	0.97	0.013	0.76		0.972	0.63
EM4B10	0.215		0.992		0.971	0.99	0.197	0.99		0.823	0.74
EM4B11	0.995		0.003	0.35	0.093	0.991	0.003	0.576		0.972	0.50
EM4B200	0.033		0.033		0.143	0.069		0.327		0.35	0.16
EM4B1300	0.049		0.35		0.878	0.98		0.014		0.455	0.45
EM4B150	0.026		0.15		0.951	0.619	0.596	0.982		0.989	0.62
EM4B160	0.35		0.012		0.994	0.657	0.159	0.98		0.972	0.59
EM4B170	0.859		0.026	0.375	0.12	0.934		0.599		0.455	0.48
EM4A1	0.922	0.007	0.989	0.639	0.959	0.809	0.993	0.994		0.949	0.81
EM4A02	0.918	0.426	0.991	0.978	0.992	0.979	0.96	0.991		0.958	0.91
EM4A5	0.03		0.013		0.426	0.835		0.064		0.487	0.31
EM4A05	0.992	0.94	0.457	0.991	0.977	0.99	0.994	0.996		0.99	0.93
EM4A10	0.596		0.984	0.025	0.12	0.147	0.013	0.994		0.909	0.47
EM4A120	0.333		0.059		0.35	0.523		0.133		0.977	0.40
EM4A16	0.991	0.993	0.847	0.994	0.984	0.994	0.963	0.978	0.994	0.989	0.97
EM4A30	0.635		0.047	0.558	0.39	0.951	0.929	0.995		0.652	0.64

Source: made by the authors.

Table 2 shows the results obtained by each student in the different nodes. The first column, highlighted in three colours, contains students' user names. The colours are to identify whether the students are in 2nd year of E.S.O, or in form 4A or 4B of the fourth year of E.S.O.

The columns marked in yellow are those in which nodes are open from the start. These nodes are the simplest nodes of the conceptual map. All users have access to these starter nodes. These serve as the initial tests that students can take regardless of the mark achieved. The columns marked in purple correspond to the nodes that are unblocked as and when the previous level is successfully passed. The green column contains the average mark once all tests are completed. To calculate a student's average mark, the grades obtained in each test are tallied up and then divided by the number of tests taken. In this table, we have included the data needed to obtain an accuracy percentage when the averages of the SIENA SOCIAL adaptive tests are compared against the averages of the Use of English sections of traditional written exams. These results are shown in Table 3.

As in Table 2, the first column in Table 3 is highlighted in three colours and contains students' user names. The colours are to identify whether the students are in 2nd year of E.S.O, or in form 4A or 4B of the fourth year of E.S.O.

Columns 2 to 6 reflect the different marks obtained in the traditional written tests sat during the course. In general, students sat between 4 and 5 tests. Cells filled in in red in column 2 indicate that students did not take the test. In column 7 the colour yellow is used to highlight the average score obtained by students during the academic year. In order to calculate the average we have only used the section of the tests designed to measure students' knowledge of English grammar. This weighted average was reached by tallying together the marks for said sections and dividing the value by the number of tests taken.

TABLE 3 – Comparative results.

Medium level 2nd of ESO: A1 (5-7)/A2 (7,1-10) Medium Level 4th of ESO: A2 (5-7)/B1 (7,1-10)	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	Average in Grammar	Results obtained in the siena social test from the tests Carried out use of English	Absolute value between both results use of English
EM2B01	0.64	0.54	0.714	0.4	0.65	0.589	0.5	0.0888
EM2B100	0.24	0.52	0.252	0.5	0.21	0.344	0.368	0.0236
EM2B60	0.51	0.45	0.374	0.52	0.62	0.495	0.53	0.0352
EM2B7	0.84	0.98	0.952	0.97	0.86	0.920	0.99	0.0696
EM2B8	0.40	0.19	0.28	0.52	0.31	0.340	0.27	0.07
EM2B09	0.68	0.57	0.64	0.7	0.8	0.678	0.660	0.018
EM2B10	0.48	0.645	0.56	0.67	0.51	0.573	0.48	0.093
EM2B15	0.60	0.82	0.69	0.94	0.84	0.778	0.74	0.038
EM2B17	0.04	0.03	0.2	0.41	0.17	0.170	0.19	0.02
EM2B18	0.35		0.21	0.43	0.385	0.344	0.21	0.13375
EM2B19	0.26	0.51	0.5	0.58	0.55	0.480	0.49	0.01
EM4A1	0.78	0.86	0.84	0.84	0.92	0.848	0.810	0.038
EM4A02	0.92	0.82	0.65	0.84	0.86	0.818	0.910	0.092
EM4A5	0.43	0.41	0.46	0.323	0.40575	0.406	0.310	0.09575
EM4A05	0.825	90.6	0.87	90.22	0.89425	0.894	0.930	0.03575
EM4A10	0.31		0.53	0.43	0.47	0.435	0.470	0.035
EM4A120	0.085	0.73	0.48	0.623	0.4795	0.480	0.400	0.0795
EM4A16	0.82	0.99	0.9	0.779	0.87475	0.875	0.890	0.01525
EM4A30	0.38	0.79	0.55	0.723	0.61075	0.611	0.640	0.02925
EM4B70	0.44		0.53	0.65	0.52	0.535	0.44	0.09
EM4B20	0.39	0.315	0.75	0.48	0.36	0.459	0.37	0.09
EM4B5	0.95	9	0.99	0.84	0.76	0.890	0.95	0.06
EM4B6	0.53	4,5	0.58	0.46	0.5	0.504	0.58	0.08
EM4B49	0.95	5,2	0.95	0.77	0.76	0.790	0.73	0.06
EM4B10	0.925	6,8	0.95	0.8	0.54	0.779	0.74	0.04
EM4B11	0.6	2,3	0.55	0.55	0.15	0.416	0.5	0.08
EM4B200	0.4		0.28	0.19	0.19	0.265	0.16	0.11
EM4B1300	0.58	1,65	0.7	0.29	0.51	0.449	0.45	0.00
EM4B150	0.7	2,2	0.85	0.48	0.39	0.528	0.62	0.09
EM4B160	0.725	5,3	0.7	0.48	0.52	0.591	0.59	0.00
EM4B170	0.75	3,7	0.53	0.39	0.32	0.472	0.48	0.01

		Diagnostic approximate	0.29
		Less Diagnostic approximates	0.2
		Correct Average	9.3548

Source: made by the authors.

Column 8 contains the averages obtained from the tests taken in SIENA SOCIAL. The last column contains the absolute value of both marks. This absolute value expresses

the difference between both set of results. It has been established that the difference should be less than one if the results are to have significant value.

In the bottom right of the table we have presented the approximate diagnosis and less approximate diagnosis value of the same. We also provide the success rate as a percentage, which at a glance shows us that SIENA SOCIAL is a reliable tool for detecting students' level of English grammar.

In this initial analysis that used a total of 31 participants, 29 have a success rate approximate diagnosis of less than one. Only two participants had a value greater than one. In these cases, the values stood at 1.3 and 1.1. The total success rate percentage was 93.54 %.

4 EXAMPLE 2: SIENA SOCIAL IN PRIMARY EDUCATION

Objectives of study: The aim of this study was to test whether the SIENA SOCIAL tool was a reliable and useful education tool that could help primary students in Year 6 with self-study and self-assessment. The subject covered was Environmental Studies (GONZÁLEZ, 2015).

This subject contains 10 nodes. Each node contains 30 multiple-choice questions (students have to choose the correct answer from amongst several possible answers). There are three difficulty levels: easy, medium, and difficult.

FIGURE 8 – Subject Conceptual Map.
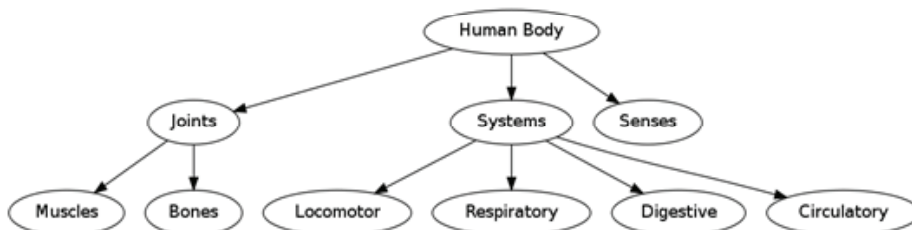
Source: made by the authors.

The questions used in the 10 nodes were created using course textbooks and teaching materials prepared by the teacher. The questions covered 'Unit 3: The locomotor system', 'Unit 4: Our senses', and 'Unit 5: Nutrition'.

Unlike in the secondary school setting, students in this part of the study were asked to actively participate in the creation of questions for the SIENA SOCIAL platform. This required students to take an active role in their own learning process in order to prepare the questions found in each node of the conceptual map. In order to facilitate this learning process the teaching staff would sit down with the groups to discuss the

questions being proposed by students, the difficulties they were having with the unit, and the difficulties they were encountering as a result of working in collaboration with other students. The teaching staff provided feedback that included suggestions for new questions, feedback regarding the difficulty of proposed questions, new strategies to improve teamwork, etc.

The experiment group consisted of 22 students aged between 11 and 13 years old. The students understanding of the subject is fairly heterogeneous, as such students were categorised into three groups: those who were capable of assimilating the material and passing tests, those who had to repeat tests in order to pass, and those who had learning difficulties. In this last category, two students required the assistance of a Special Educational Needs teacher, and another two students who were repeating the course and frequently showed disinterest.

A control group was established using the results obtained from the tests, exams and projects that were completed by students during the academic year (see Table 4). These results were compared against the experimental results obtained from the computerized adaptive tests in SIENA SOCIAL in the subject The Human Body.

TABLE 4 – Comparative results.

Students	Average Mark Unit 3: Locomotor System	Average Mark Unit 4: Our senses	Average Mark Unit 5: Nutrition	Average Mark	Average mark SIENA SOCIAL	Assimilation of the basic concepts
CH1	0.55	0.7	0.4	0.55	0.94	SI
CH2	**0.4**	**0.79**	**0.6**	**0.6**	**0.95**	**SI**
CH3	0.765	0.66	0.7	0.71	0.90	SI
CH4	0.85	0.91	0.6	0.79	0.93	SI
CH5	0.14	0.29	0.0	0.14	0.87	NO
CH6	0.61	0.69	0.6	0.63	0.92	SI
CH7	0.575	0.78	0.7	0.69	0.95	SI
CH8	0.71	0.58	0.5	0.6	0.92	SI
CH9	0.77	0.77	0.6	0.71	0.96	SI
CH10	0.79	0.8	0.7	0.76	0.93	SI
CH11	0.94	0.9	0.9	0.91	0.96	SI
CH13	0.7	0.63	0.6	0.64	0.96	SI
CH14	0.53	0.43	0.3	0.42	0.90	SI
CH15	0.63	0.62	0.6	0.62	0.96	SI
CH16	0.66	0.67	0.5	0.61	0.94	SI
CH17	0.69	0.61	0.5	0.6	0.92	SI
CH18	0.57	0.58	0.5	0.5	0.91	SI
CH19	0.94	0.89	0.9	0.91	0.96	SI
CH20	0.64	0.8	0.6	0.68	0.92	SI
CH21	0.88	0.87	0.8	0.85	0.93	SI
CH22	0.56	0.6	0.3	0.48	0.92	SI

Source: made by the authors.

In the first column of the table, we have presented the student user names. The green columns contain the marks obtained for the following units 'Unit 3: The locomotor system', 'Unit 4: Our senses', and 'Unit 5: Nutrition', which contain the same content as that covered in SIENA SOCIAL. Steps have been taken to simplify the table, because in each unit, students received separate marks for their written exam, oral presentation, activities, and PowerPoint presentation. The red column contains the average mark given for the three units. We have highlighted in yellow those students who failed to pass, as they did not get the necessary minimum grade of 5.

The orange column contains the average mark from the results obtained in SIENA SOCIAL. The last column addresses whether students assimilated the basic concepts of the subject The Human Body that were presented in SIENA SOCIAL by completing the cells with a simple 'Yes' or 'No'. Yes was used if the average mark for the tests was greater than 0.9, as this would indicate that the basic concepts were acquired. Out of a total of 21 students, 20 were able to obtain and average equal to or greater than 0.9 using SIENA SOCIAL. Only student CH5 did not meet this target, with a score of 0.87. The success rate was 95.23%.

Following an analysis of the results, it was observed that the student who did not achieve the set score of 0.9 was a student whose average mark for traditional assessment was under 5, which would have meant a fail. Even so, this student's SIENA score is very close to being a 0.9, which demonstrates that the tool encouraged greater motivation, which in turn led to an improvement in the student's marks.

The other two students who failed the course based on their average marks (CH14 and CH22) achieved scores of 0.9 or slightly higher, demonstrating that they were capable of completing the basic concepts of the subject using the SIENA SOCIAL tool.

The conclusions that can be made from using SIENA SOCIAL computerized adaptive tests is that SIENA SOCIAL is an appropriate tool for assisting students with self-assessment in the primary education setting for the subject Environmental Studies, in particular to help consolidate their learning.

The results obtained show that 95.23% of students were able to consolidate the basic concepts of the subject using the SIENA SOCIAL tool and CATs. Using the tests students performed self-assessment and showed great interest in the creation process behind the tool and its use in the classroom. At the start of the study, despite knowing the transformative potential of CATs, there were concerns that students would view the use of this tool as merely one more obligation that they were expected to complete in order to pass the course or that they would find the exercise and associated tests tedious. However, these fears were unfounded. From the get go the majority of students were keen to participate, and the tool possessed the 'novelty factor'. They also enjoyed being key agents in the creation process rather than merely the targets of the tests.

According to students, the tests were relatively easy to complete once they understood how the application worked. They were also keen on keeping tabs on how

many questions they were asked by the tool once they realized that fewer questions equated to more right answers and thus a higher mark in the test.

5 CONCLUSIONS

The SIENA SOCIAL web tool, which has been widely used in undergraduate and master degree programs in the higher education setting, has been successfully employed in both primary and secondary educational settings. Based on the results obtained in this study, it is possible to conclude the following:

For the subject English as a second language in the secondary education setting, and through the selection of suitable questions, it was possible to obtain the same results as those obtained via traditional periodic testing having first established the criteria for selecting the experimental groups. These criteria consisted of forming experimental groups using students from the second year and fourth year of E.S.O, which correspond to the final stages of the first and second cycle respectively as these academic years correspond to the levels set by the Common European Framework of Reference for Languages – level A1-A2 corresponding to students who complete the second year of E.S.O, and level A2-B1 corresponding to students who complete the fourth year of E.S.O.

In the primary education setting, a different strategy was taken as a means to encourage greater student participation and to motivate them to engage in the learning process. This strategy involved getting students to create the questions that would form part of the SIENA SOCIAL tests rather than leaving this task solely to teaching staff. Our results showed that the use of SIENA SOCIAL assisted students in assimilating the fundamental concepts of the subject The Human Body, although it is recognised that the SIENA SOCIAL tests were perceived to be easier than the traditional periodic evaluations, which in large part was credited to how the tests and questions were created.

In both cases, in primary and secondary educational settings, students have provided us with evidence that the SIENA SOCIAL tool is useful for assimilating concepts and increases motivation.

REFERENCES

FUMERO, E. *Siena Social y la detección de nivel de gramática en lengua inglesa*, 2015. Universidad de La Laguna.
GONZÁLEZ, D. *Siena Social como herramienta de ayuda a la autoevaluación en conocimiento del medio*, 2015. Universidad de La Laguna.
HERNÁNDEZ, F.; ROSARIO, P.; CUESTA, J; MARTÍNEZ, P.; RUIZ, E. Promoción del aprendizaje estratégico y competencias de aprendizaje en estudiantes de primero de universidad: evaluación de la intervención. *RIE Revista de Investigación Educativa*, v.24, n.2, p.615-632, 2006.

LOTERO, J.; VARGAS, R. A. *Herramienta de apoyo a la enseñanza del estándar IEC 61131 basada en la automatización y simulación de la tercera estación de la planta Festo y Siena*, 2015. Universidad de La Laguna.

MILLAN, E.; CRUZ, J. L. P. DE LA; TRIGUERO, F. *Using Bayesian networks to build and handle the student model in exercise base domain in science*. Berlin: Springer Verlag, 1998.

MORENO, L.; GONZÁLEZ, C. S.; GONZÁLEZ, E. J.; POPESCU, B.; GROENWALD, C. L. O. Teaching Computer Architecture using a Collaborative Approach: The SIENA Tool, Tutorial Sessions and Problem Solving. *International Journal of Engineering Education*, v. 29, n. 2, p. 510–519, 2013.

MORENO, L.; GONZÁLEZ, C. S.; POPESCU, B.; GROENWALD, C. L. O. Evaluación del aprendizaje en la Educación Superior: Una Propuesta metodológica. CISTI 2015. *Anais...* , 2015. Aveiro (Portugal).

MUÑOZ, V. *Diseño e Implementación de Planificadores Instruccionales en Sistemas Tutoriales Inteligentes mediante el Uso Combinado de Metodologías Borrosa y Multiagente*, 2007. Universidad de La Laguna.

RUPPENTHAL, V. *Sistema Integrado de Ensino e Aprendizagem*: Uma Experiência com Números Naturais, 2009. Universidade Luterana do Brasil.