

# Integration of Traditional and Emerging Technologies in the Education Sector

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## ABSTRACT

The constant evolution that the Internet and Communication Technologies (ICTs) have suffered in recent years, has allowed the creation and improvement of more productive sectors. Education sector has been one of the sectors which most increase has had due to ICTs. Unfortunately, ICTs have been designed and deployed to change drastically the learning methodologies. One of the reasons for this reality is the several technology plans promoted by the governments. The main objectives of this kind of plans are to provide ICT resources to students and schools, ensuring Internet connectivity within the classroom and to promote the access to digital educational materials. Moreover, the technological gap is the main problem to solve in this area. Lecturers, teachers and students have to learn a lot of tools to have better experience inside the educational environments. We show by this work a platform based on digital pens integrated with one Learning Management System to minimize the technological gap by using devices that are everyday used.

**Keywords:** learning management system; digital pen; technological gap, user experience

## 1. INTRODUCTION

The constant evolution that the Internet and Communication Technologies (ICTs) have suffered in recent years has allowed the creation and improvement of more productive sectors. Education sector has been one of the sectors which has had most increase due to ICTs.

One of the reasons for this reality is the technology plans promoted by public institutions and governments of the different countries. The most important plan in Spain, which promotes the use of ICTs in education, is called Escuela 2.0[1]. The main objectives of this plan are to provide ICT resources to students and schools, ensuring Internet connectivity and

interconnectivity within the classroom for all teams; to promote the training of teachers in the technological aspects, generating and facilitating access to digital educational materials; and to involve students and families in the acquisition, custody and use of these resources. One of the aims of these plans, which governments are trying to achieve, is the decrease of the technological gap.

Nowadays, we can find several number of education centres (from schools to universities) where a Learning Management System (LMS) is implanted. By those platforms resources like courses, subjects, teachers, students, or grades related to teaching are managed.

By this we show a platform based on digital pens integrated with one Learning Management System that can minimize the technological gap by using devices that are everyday used; in this case the subsequently exposed digital pen.

Firstly, existing LMSs are shown in Chapter II. In Chapter III we explain what a digital pen is. Chapter IV presents the Virtual Learning Environment (VLE) we have designed. In Chapter V we explain in great detail the system architecture of the VLE. Chapter VI presents the preliminary evaluation of the implemented system. Finally, the research is concluded and further work discussed in Chapter VII.

## 2. EXISTING LEARNING MANAGEMENT SYSTEMS

Moodle [2] is one of the LMS companies that has the highest market share. Moodle was one of the firsts LMS platforms. This fact, combined with the open source philosophy, is the principal reason why it has a great commercial success. The groups, courses, documents and questionnaires (inside a specific course) management are the most important functionalities that this LMS platform offers.

Due to the open source politic aforementioned, functionalities of Moodle grow steadily because of the facilities to create new components that developers have.

The other most used LMS in education centres is the BlackBoard Learning [3]. The biggest difference between this platform and Moodle is that BlackBoard Learning has a commercial use and so that, a license for its use has to be paid. Apart from this characteristic, the functionalities of both platforms are basically the same.

Sakai CLE [4] is a relatively new LMS that has deeply entered into the market. The main difference between this platform and the other two is that Sakai, apart from offering functionalities to manage different courses, adds more complete resources to manage different tests in order to evaluate the knowledge of the students.

These three platforms are the most commonly used in education but they are not the only ones. There are other fairly used platforms like In-houseDevelopment [5] and TotalLMS [6].

Moreover, there are many education centres where instead of using a system designed specifically for teaching, make use of generics ones. The most used platform in those centres is GoogleDocs [7]. Usually, schools that use this system have agreements with Google. This company offers the ability to access to various Google applications through an email from a domain which is different to the one Google offers (Gmail.com). GoogleDocs is typically used by companies for the sharing and collaborative editing of documents. The problem with this is that GoogleDocs, basically, focuses on records management across the board. At no time can be created courses, groups and so on, clearly representing concepts related to education.

	Moodle	Blackboard	Sakai	Google Docs	VLE
Course Management	✓	✓	✓		✓
Test management	✓	✓	✓		✓
Collaborative online edition				✓	✓
Automatic digitized texts uploading					✓

Figure 1. LMS comparison

Although the productivity of those 3 platforms is high, all of them have the same problem. When a student wants to share the notes that he takes in class with his classmates, he has to transform them to a digital document or take them directly by digital way.

In the first case, the action of sharing notes has a low rate, because many people would not be willing to pass notes to digital format to share them later. The problem of the second case is that a low number of people would be able to take notes using a word processor as efficient as if they take them in a traditional way.

Another action that few LMS contemplate is the better and complete tests management. Even the tests are one of the most

common forms of assessment; none of the above described platforms enables the creation and automatically correction of tests.

### 3. THE DIGITAL PEN

A digital pen [8] looks and feels like a normal ballpoint pen. The person who uses this element does not realize that he is using a digital pen while he is writing; he does not sense the different between a digital and a traditional pen. Although the digital pen user does not realize of the difference, the digital pen contains an integrated digital camera, an advanced image microprocessor and a mobile communication device for wireless connection.

Thanks to the digital pen you can capture the handwriting, store it and finally send it in a safe way. By this manner you easily can convert the inked handwriting to digital data.

When a digital pen is used with a surface that has the Anoto dot pattern [9] printed on it, in the moment when the pen is put on the surface it starts to digitize handwritten text. Thanks to the Anoto dot pattern is easy to know in which place of the surface the digital pen is writing. The pen reads and records pen strokes in relation to the barely visible pattern. This digitizing content is sent to a server that saves all this data.

### 4. THE VIRTUAL LEARNING ENVIROMENT

Once we have analyzed the advantages and disadvantages of the existing LMS platforms, we have designed a new platform that takes into account the features that are already covered by existing platforms and adds very powerful new ones.

The new platform that has been designed and implemented along with the use of digital pen makes up what is called Virtual Learning Environment (VLE).

The main goal of this environment is to reduce the digital gap in the academic scope. To achieve it, the designed platform offers different functionality necessary to meet the 3 basic scenarios that have been established. The scenarios are attending classes, reviewing documents and conducting exercises.

Regarding the *attendance to class*, we have detected that the functionalities that has to satisfy the platform are the digitalization of the notes and the creation or edition of documents with the digitalized content. The system in order to meet these two features, allows students to take notes by traditional way (using a pen) and have them automatically available in digital format on the platform, with the advantages that entails.

Furthermore, the scenario in which students *review the scanned documents* has been contemplated. Once the student notes have been scanned and digitalized, the student not only can use this content to create new documents but also can merge the content with other documents stored in the platform. In order to make the documents more accessible to the VLE users, the platform is integrated with GoogleDocs, where all the documents are stored. Users can share all the documents they have created with several platform users. Through this sharing any student with

access to the document may take action on them such as correcting any information that is wrong or adding comments.

The functionalities that the platform develops to cover the scenario of *creation of exercises* are the creation of new tests and automatic correction of the digitized responses to them. The platform offers the possibility to create different tests, based on the questions, possible answers and the correct choice. When students complete the test in an answer sheet that has the Anoto pattern printed, automatically the items marked by the students are digitalized and the platform correct the test using the correct answers given by the teacher when the test was created.

Apart of the functionalities we can take out from the scenarios we have previously described (document digitalization, digitalized content management, test management, document sharing, etc.); there are another GoogleDocs functionalities that are offered by the VLE. The most interesting extra functionality is the collaborative online edition. Thanks to this functionality, more than one student can add information to a document or correct it at the same time.

### 5. SYSTEM ARCHITECTURE

The Virtual Learning Environment (VLE) is divided into the following 3 layers: Presentation, Logic and Integration. Each of these layers has its own distinct features. The *Presentation* layer is the responsible for exposing to the user all the functionality of the platform. The logic layer manages the system behaviour. Finally, the *Integration* layer is responsible for the communication with external services in order to obtain digital notes (Astutia) and management of documents (GoogleDocs).

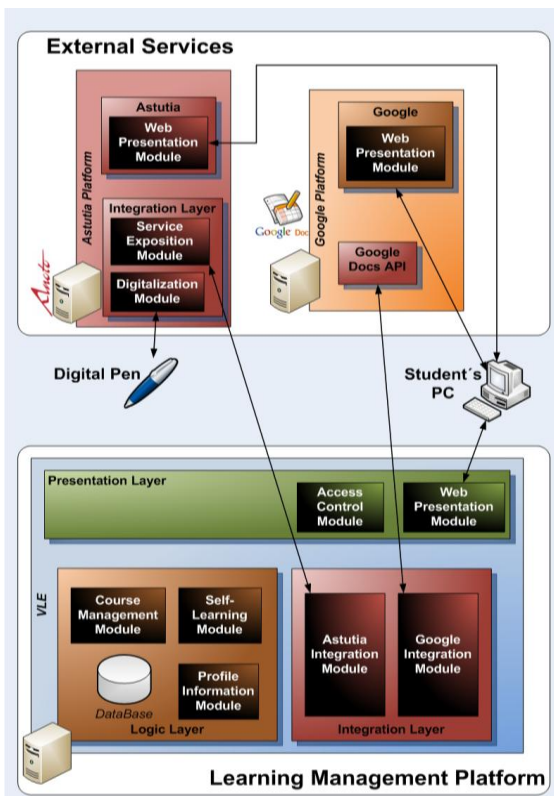


Figure 2. VLE Architecture

Within the *Presentation layer* of VLE two modules can be distinguished: Web Presentation and Access Control modules.

Web Presentation module enables users to access to all the services the VLE offers, such as to authenticate into the platform, manage their documents, manage the tests performed and so on. The access to this module by the user can only be made by using a web browser.

VLE platform provides the Access Control module in order to obtain a safe access to the contents of the platform through the Web Presentation module. This module controls that only authenticated users can enter to the private areas of the platform and they can only perform actions for which they have been authorized. For an efficient control an input filter has been implemented. This filter is consulted whenever a user makes a HTTP request on any resource located in the private area of the VLE platform

The *Logic layer* in turn, is divided into the following modules: Profile Information, Course Management and Self-Learning.

Effective management of information associated with a student profile is critical in any system and the mismanagement of it can cause a lot of security problems. For this reason the VLE platform provides the Profile Information module. This module provides functionality for user authentication, authorization and the registration of new user.

With authentication, the system always knows that the connected user to the platform is the user who claims be. As the VLE platform is all time in communication with Google and this company provides its own authentication systems [10], the Profile Information module will use the AuthSub authentication protocol that Google offers to authenticate to the platform. With this feature the user should not learn a new user name and password to access to VLE.

The authorization functionality that the platform offers effectively controls the access to all resources it manages. Like all documents that use VLE platform are hosted in GoogleDocs and it has its own policy on roles and permissions, VLE uses these access rules defined by Google. [11]

The last of the features provided by this module is the possibility of registration on the VLE platform. As discussed in the section of authentication, the credentials that are used in the platform are obtained from Google. Therefore, the first time a user accesses to the platform, this module checks that the credentials are correct and the only thing that all the users have to do is to provide the identifier of his digital pen in order to finish his registration.

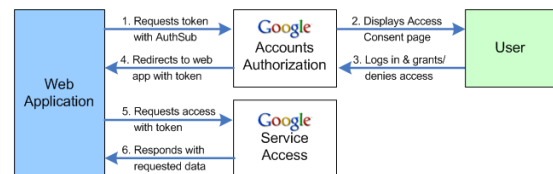


Figure 3. AuthSub protocol

One of the most important requirements of a virtual learning environment is the document management. To do this management VLE platform provides the Course Management

module. For the proper management of these documents, the module makes use of the integration layer described later. The most important features that this module offers are the following ones: Obtaining the courses in which the student is enrolled, obtaining documents to which a student can access within a course, uploading a new document to a course, deleting a document from a course, downloading a document of a course and creating a new document from a scanned document.

The last module in the logic layer is the Self-Learning module. This module is intended to facilitate the process of implementation and test evaluation. In this context the system offers two functions: Firstly, the creation of a new test and secondly, the completion and immediate correction of tests. In the first case, creation of a new test, this functionality is oriented to teachers who wish to assess their students through this system. The second feature in turn is directed to the student. The student, once performed the tests will know the results, because this module is responsible for obtaining the answers the student has written in the sheet and comparing them with the correct answers that the teacher has introduced when he/she created the test.

As for the system *Integration layer*, thanks to it, the VLE platform communicates with services offered by Google for document management and scanning services created within the project scope. This layer is of great importance because it is responsible for the platform to have all the information necessary to satisfy user needs.

The Google integration module communicates with the services offered by this company using REST (Representational State Transfer) calls [12]. The first call made from this module by each user is the authentication on the Google system. This call returns a token which is used by the following queries. These consultations will be made against the Google Documents List API [13]. Without the token the calls to this API will fail.

On the other hand, the management of the communication with the services of digitization is performed by SOAP calls (Simple Object Access Protocol) [14]. These services have been implemented within the project scope.

We have used the Java Enterprise Edition (JEE) for the implementation of the VLE platform. To implement the layers of Logic and Integration, Enterprise JavaBeans (EJB) API has been used. On the other hand, in the case of the presentation layer, we used the JavaServer Faces (JSF) and RichFaces frameworks. Finally, the Web Services for the digitalization have been implemented using the Windows Communication Foundation (WCF) tool of Microsoft .NET framework.

As for the servers where applications are deployed, we decided to use JBOSS as application server for the VLE platform deployment and Internet Information Services (IIS) for the deployment of the digitalization management Web Services.

## 6. PRELIMINARY EVALUATION

Finally, we decide to carry out the evaluation in a learning environment where the sharing of notes is a typical action on the students' lives. For this reason, we have considered the university as the most suitable place for conducting the tests. The selected users are students of the Network Design and

Evaluation subject that is taught in the fifth year of the degree of Computer Engineering at the Faculty of Engineering at University of Deusto. Students who have done the tests have had at their disposal all the necessary equipment: a digital pen, a notebook with the Anoto pattern printed on its pages, an answer sheet and a computer to access to the platform.

In order to validate the implemented platform we have studied the ISO/IEC 9126 [15] standard. ISO 9126 defines a quality framework by three aspects: Internal Quality, External Quality and Quality in Use. Internal Quality is the totality of characteristics of the software product from an internal view (i.e. cyclomatic complexity, code maintainability). This kind of quality can be improved during code implementation, reviewing and testing. External Quality is the quality when software is executed, which is measured and evaluated focusing on the software application behavior (i.e. number of wrong expected reactions of software). Finally, Quality in Use is defined within ISO/IEC 9126-4. It is the quality of the software system that the user can perceive when it is used in an explicit context of use.

It measures the extent to which users can complete their tasks in a particular environment. It is measured by four main capabilities of the software product in a specified context of use:

- 1) Effectiveness: The capability to enable users to achieve specified goals with accuracy and completeness.
- 2) Productivity: The capability to enable users to expend appropriate amounts of resources in relation to the effectiveness achieved.
- 3) Safety: The capability to achieve acceptable levels of risk of harm to people, business, software, property or the surrounding environment.
- 4) Satisfaction: The capability to satisfy users.

These capabilities have to be measured in order to calculate how the quality in use of evaluated software is. Focusing on this kind of platforms, we have measured the satisfaction and the effectiveness of the platform.

The formulas used to calculate the shown characteristics are based on the adaptation of the formulas set of ISO 9126-4 standard for the system evaluated.

To make the experiment we lent five pens to a group of university students, these students could share notes by the exposed platform. Moreover, other five students collaborated in the experiment sharing between them the notes, but using traditional techniques. In these tests, several concepts have been explained and the students have had to aim by their respective methods of capturing notes. They have assisted three classes of 50 minutes in which students generated notes. These notes have been studied and several metrics have been captured for the subsequent calculation of results. At the end of the course, a test of satisfaction has also carried out to measure the satisfaction level.

In order to capture the metrics that make up the features to be measured, all the generated drafts have been read and several data have been completed. These data were the concepts explained at class, the concepts captured by the students, the number of sheets used and the number of discarded sheets. As

we have already mentioned, the effectiveness measures the proportion of the goals achieved with completeness. In this case, the goals have been to capture the largest number of concepts presented and to minimize the number of sheets needed for the preparation of the final notes. Thanks to this, we had noticed the differences between taking notes by an ordinary way (Pen and paper) and taking notes by the described platform (VLE).

Another feature to be measured is the level of student satisfaction using the Digital Pen in class. A satisfaction form created by Google Docs has been sent and answered by mail using the accounts created by the studied students.

### Student satisfaction

\*Obligatorio

**Is the pen comfortable? \***

1 2 3 4 5

Really uncomfortable      Very comfortable

**How is your experience in creating documents on the platform? \***

1 2 3 4 5

Very poor      Excelent

**Is the access to digitized documents efficient? \***

1 2 3 4 5

Very inefficient      Very efficient

**How is your experience in sharing documents on the platform? \***

1 2 3 4 5

Very poor      Excelent

**How much does the Anoto pattern disturb you while you are writing? \***

1 2 3 4 5

Very little      Very much

**How much would you pay for a digital pen? \***

Less than 50€

50€ to 100€

100€ to 200€

200€ to 300€

More than 300€

Figure 4. User satisfaction form

This form could capture the metrics used to the calculation of the satisfaction feature. In other words, by this form the students

could give us their feedback about their satisfaction and the discretionary use of the platform. In the following image we can see the asked questions and the answers given by students.

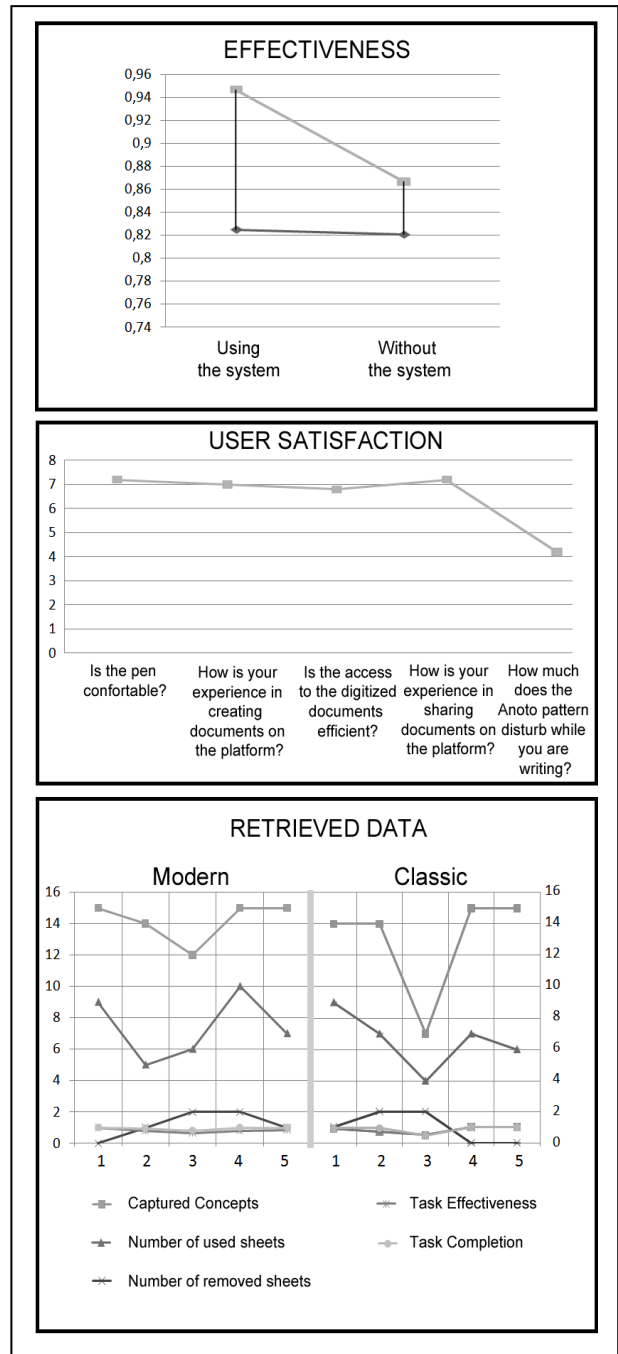


Figure 5. Graphs of retrieved results

## 7. CONCLUSIONS

As we can see in the previous graph that shows the averages of effectiveness of the platform, there is no improvement in the effectiveness of note taking because it shows a little reduce of the use of real paper sheets. However, an improvement is seen in the completeness of the note-taking because it increases by 8%. It surprisingly means users will not be affected by the new device use.

Focusing on the results corresponding to the satisfaction of students using the system we can see not only the digital pen does not affect the use, but also the printed pattern has a good acceptance. In an overall view we can say students were satisfied sharing and using the system, in fact, the discretionary use calculated is very good (more than 60% would pay more than 50€ for the digital pen).

Summing up, we have implemented a system to share notes by a digital platform with digital pens. By this way, we can improve competencies and we can provide a better method to digitize the notes without new devices. As we have shown, this system can help to write more complete notes with the same efficiency and completeness and also satisfying the students.

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