An E-Learning Platform for Integrated Management of Documents Based on Automatic Digitization

Ana Belén Lago Vilariño and Iván Pretel García

***Abstract*— Despite the latest advances in computing, traditional paper is still widely used in learning and knowledge work. Most current learning technologies do not consider this paper-centric practice and focus on a complete digitization of learning contents, activities, and communication. This paper presents an e-learning platform that combines work with printed and digital documents. It integrates pen-and-paper-based interaction techniques that enable users to manage their digitized documents. In addition, this platform integrates different e-learning platforms providing a single intuitive interface to manage them. Finally, a case study of the use of the platform in university education is presented.**

***Index Terms*— Learning management system, digital pen, Moodle, Google.**

I. Introduction

IN THE last few years the Information and Communications Technologies (ICTs) have spectacularly grown enabling great changes inside daily life activities, in particular in the education world. ICTs enable new teaching and learning methods using a wide range of new functionalities.

The application of ICTs to the education sector causes huge transformations at all levels. Firstly, it is evident that the weight of teaching has decreased and the weight of learning is constantly growing. Secondly, the education area is moving from the classroom to virtual spaces. Thus, the teaching-learning process becomes more active than ever. The introduction of ICTs in the education sector has changed the focus of teaching and learning from a teacher-centred teaching to a learning where the key role is played by the student, who is supported by an advanced technology platform called e-learning system.

Note that these platforms have emerged as vital tools to support the teaching and learning process that can complement classroom learning with virtual activities. These platforms can be developed and deployed anywhere; they promote ubiquitous education and encourage the collaborative work because they decrease the barrier not only between teachers and students but also among the students.

The emergence of ICTs in the learning environment does not mean that all the traditional teaching-learning methodologies have become obsolete. In fact, we consider that combining traditional methodologies with new methodologies rising from the inclusion of ICTs can provide major benefits not only for the student but also for the teacher.

Focused on this idea, this work shows the result of combining traditional handwriting with e-learning platforms to improve the teaching and learning experience by bringing the benefits of the traditional paper to the digital documents [1]–[4]. It should be mentioned that taking handwritten notes has advantages for the learning process because this method enhances the capability of remembering information. It also includes very important features such as the documents'storage, coding and organization of data, the motivation of the associations and attention to important issues. Due to this, the most widely used learning technique is note taking using pen and paper rather than taking them directly through a computer.

In the developed platform, which is called PenLearning, the interface to interact with the e-learning platforms is going to be improved by using a digital pen. This kind of device works as a link between the virtual world and the traditional paper, thus improving the productivity of students and the sustainability of the learning environments.

Moreover, at the present time, the number of schools which use multiple platforms to provide teachers and students with a broader range of services is increasing more and more. The PenLearning platform offers, as innovative element, the integration with two other platforms (Moodle and Google) providing a single document management interface hiding the particularities of each platform.

The article is organized as follows. Section II describes the existing e-learning platforms. In Section III the digital pen technology is explained. Section IV shows some cases of use of the digital pen in the academic field. In Section V the functionality of the PenLearning system is detailed. Section VI presents the system architecture. Section VII presents the obtained results. Finally, conclusions about the use of the platform will be enumerated and also the future work will be exposed.

II. E-Learning Platforms

Several e-learning platforms are used in the academic environments. These platforms can be categorized into two main

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groups: commercial platforms and open source platforms. Initially, although the open source platform has not got any dependence on the provider and is easily expandable without restriction, institutions preferred commercial platforms. This is because they assumed that those platforms such as Web CT (now BlackBoard [5]) were more robust. In the present time, institutions try to use open source platforms to integrate the collaborative work of its members and enable the collaboration with communities; in this case, Moodle [6] is the most extended platform. Although the mentioned platforms are the most commonly used in academic environments, there are others that should be mentioned: Sakai CLE [7], Total LMS [8] and ATutor [9].

On the one hand, the main advantages of the commercial platforms offered are their great technical support, an extended documentation, the platform specialization and also their unification. Nevertheless, this group of platforms has a difficult management. On the other hand, the acquisition and maintenance of the open source platforms are cheaper; they involve less development time, and these systems are more sustainable and customizable. However, they require highly qualified administrators who have a very technical knowledge.

Focusing on the wide range of features offered by these platforms we can say that both groups of platforms offer the same functionalities: course management, group management, documents and questionnaires, communication tools…

Moreover, the number of academic centres which use tools focused on learning mixed with generic platforms such as Google is constantly growing. More and more academic centres sign agreements to access Google's services paying a minimal cost or for free. Google offers a collection of applications which can be correctly applied to the educational environment so as to provide an excellent communication platform (with applications such as GTalk, Gmail, Youtube and Google Groups), planning (Google Calendar) and document management (Google Docs).

The platform presented in this work is called PenLearning. One of the key features this platform has is the integration with the Moodle and Google platforms, concretely, with Google Docs [10]. Both platforms are used by students and lecturers at the University of Deusto. Although the design of the architecture of the platform enables an easy integration with other platforms, the platform evaluation took place at the University of Deusto.

In Fig. 1 a brief comparison of the main existing platforms is exposed. This comparison is focused on the functionality offered by these platforms including PenLearning.

The PenLearning platform provides all the features offered by these platforms and also adds a special feature: the digitization of the content generated by students with a digital pen. This feature allows the management of this digitized content through creating and modifying documents stored in different e-learning platforms (Moodle and Google). It also enables the collaborative edition of the digitized documents and the automatic evaluation of exercises. To provide the notes digitization using digital pens the system has been integrated with the Astutia platform and has been enhanced with Anoto, which will be described in the next section.

	Blackboard	Moodle	Sakai	Google Docs	PenLearning
Course Management	X	X	X		X
Self-assessment services	X	X	X		X
Real-time collaborative online edition				X	X
Automatic digitized notes uploading					X
External platforms integration					X

Fig. 1. Comparison between the main existing e-learning platforms.

III. The Digital Pen

In the last few years, digital pens have become popular, especially in sectors such as health, administration, business, education, transport and banking.

The digital pen technology consists of two components: a digital pen and paper. Currently, this technology allows digital capture, transmission and processing of not only handwritten text, but also drawings with just a piece of paper and a pen. Anoto [11] is the most used pen technology by the most well-known platforms [12].

At first glance the digital paper appears to be like a traditional preprinted paper: there is no difference in terms of the type or quality of the substrate. The only difference that can be present is a tiny dot pattern printed as a background. The human eye can only distinguish a light gray background.

This dot pattern has been developed and patented by the Anoto Technology group. Because the dot pattern is only visual, it can be applied to all kinds of paper, creating a digitally readable area.

The dot pattern consists of numerous small black dots distributed and following a pattern, which can be read by a digital pen. The position of the pattern specifies the exact location of the strokes of the pen, encoding the entire space of a form as coordinates with an extremely high level of accuracy.

Additionally, the pattern applied to each type of form has a unique identity so that each page is treated and processed separately from any other.

A digital pen is like a typical and daily life pen. It has the same use as the others. However, it is an intelligent device which contains inside, as is shown in Fig. 2 [13], a built-in infrared micro camera, an advanced microprocessor and a wireless communication device that captures, stores and then sends the handwriting through an encrypted format. This is how the digital pen ink is converted and transformed into digital data using a simple, immediate and secure way.

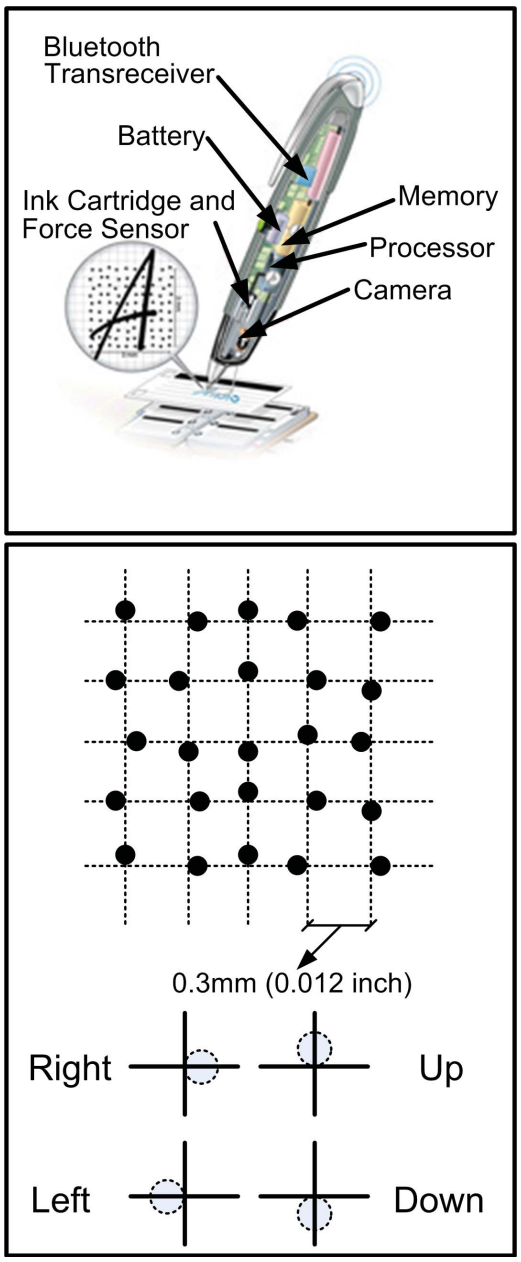

Fig. 2. Digital pen structure.

When a user writes using the digital pen, this device captures images of the microdot pattern paper (50 captures per second). Each capture contains enough data to calculate the accurate position of the pen, everything that is written or drawn, the exact times tamp when each stroke is made and also the unique identifier of the used paper.

IV. The Digital Pen in the Academic Environment

There are several projects that incorporate digital pens to the academic environment. A number of projects have focused on the collaborative learning during lessons based on annotations shared among the students. Inside this group of projects the Air Trans Note [14], [15] project has to be highlighted. In this project the studies are focused on the sharing of handwritten annotations with a group and getting real-time feedback. In CoScribe [16], the teacher begins the class providing notes with the Anoto pattern printed on them to the students in order to promote the sharing of the completed notes among the classmates. Pocket Pad [17] combines the Smartphone devices with the digital pens to capture, edit and manage information throughout a mobile application.

Another method which is used to encourage collaborative learning in class is to use the communication tools offered by e-learning platforms such as Wikis and Chats. Chang [18] and Iribe [19] integrate the digital pen with these tools.

The main aim of PenLearning is not only the capture of handwritten notes and then the sharing of digitized notes, but also the management of documents based on a digitized content manager which can be accessed inside class as well as outside. PenLearning has a friendly and intuitive interface that enables the production of new digital documents based on digitized content, the modification of existing documents with digitized content and a new platform to interact with the documents without paying attention to the location where the document is stored, in this case, Moodle or Google Docs. Consequently, the final user is not aware of the details of the integration of each platform.

Furthermore, it offers the functionality of the online collaborative document edition by several users at the same time.

V. System Functionalities

The main purpose of this platform is to demonstrate that traditional techniques such as handwriting can be combined with the new technologies in the academic environment to produce great tools and better benefits for students.

In order to do so, the platform exposes four services to students: a service to take notes during classes, a service to manage digitized documents, a self-evaluation service and an online collaborative edition service.

The platform allows students to *keep track of the class* taking notes through the traditional method (handwriting) while all the notes are simultaneously digitized and conveniently stored on the platform. In addition, students can work directly on the scanned document and they can add new content, comments and footnotes page.

Once the notes taken by the student have been digitized, the student can *manage* them. They can create new documents or include the new content in any existing documents. In order to simplify the management of the documents the student has, the platform is fully integrated with the two virtual environments offered by the University of Deusto (Google Docs and Moodle) showing to students the same structure of courses, directories and documents in both environments.

The platform provides students with a *self-evaluation service*. To offer this service, the platform allows the creation of different questionnaires and is able to make the automatic assessment of digitized responses. When students complete the answer sheet, which has the Anoto pattern printed, the responses are digitized and automatically evaluated by the platform. The assessment is based on the correct answers previously introduced by the teacher during the creation time. It allows students to be aware of their learning. Owing to this feature it is completely possible to use this service for setting

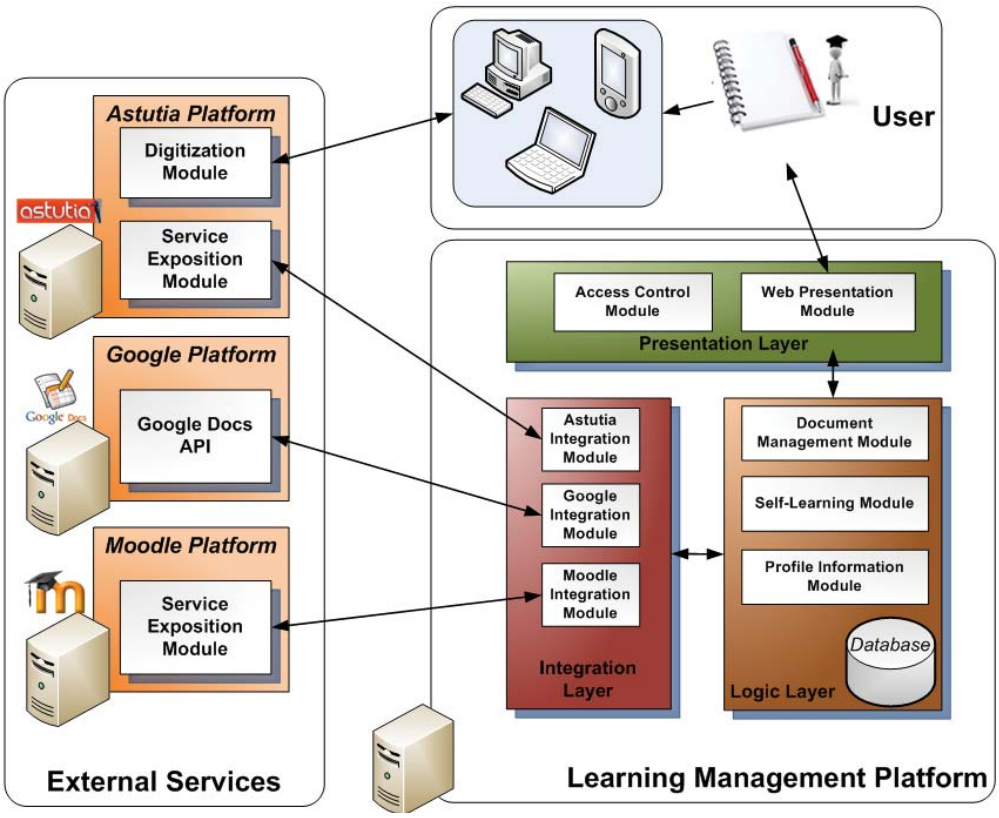

Fig. 3. System architecture.

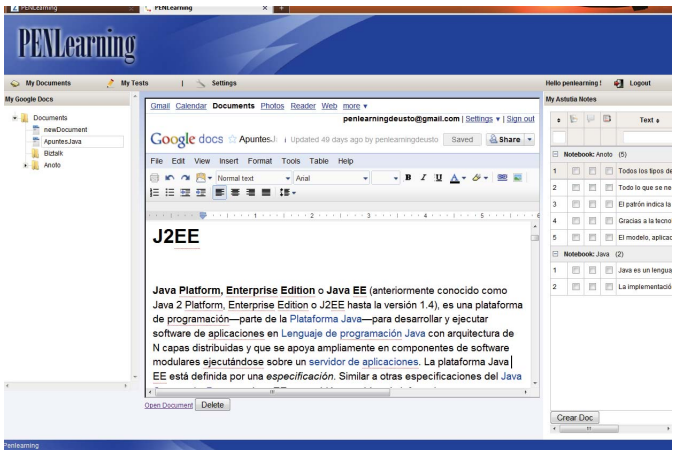

Fig. 4. Main screen of the platform.

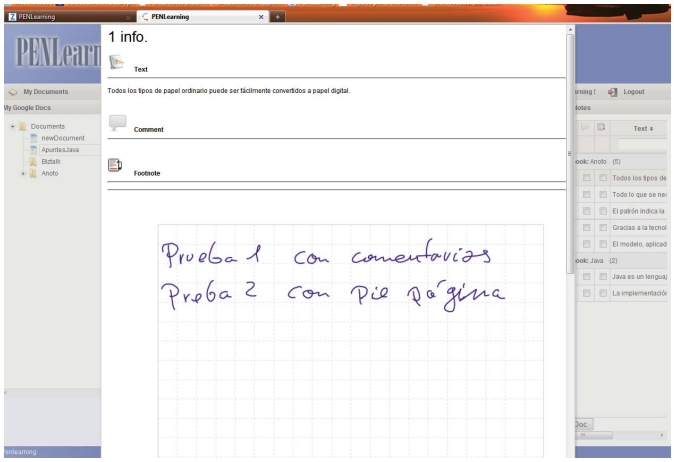

Fig. 5. Digitized notes visualization screen.

exams without the drawback of the possible access to non-related web content because the need of a computer during the exam is suppressed.

In addition, the platform offers a *collaborative online document editing service*. Thanks to this service students can share documents with other students, who can make changes in real time. Therefore, this platform provides the teamwork support where the students have a great access management system, which gives access to classmates to the real-time edition of the document through the Google platform.

VI. System Architecture

The platform (see Fig. 3) consists of four layers: Presentation, Logic, Integration and User, each layer with specific functions.

A. Presentation Layer

The Presentation layer is responsible for providing platform services to the user in a simple and friendly way (see Figs. 4 and 5). The Logic layer manages the system behavior. This layer contains two main modules: web presentation and access control module.

The *web presentation module* enables students to access the services offered by the platform such as the platform authentication, the documents management, the user profile management, and the self-learning exercises among others.

The platform provides secure access to the contents of the platform through the *access control module*. This module controls that only authenticated users can use the private areas of the platform and that students can only perform actions that have been authorized. In order to have an efficient access control an input filter has been implemented, which is activated whenever a user makes an HTTP request to resources located in the private area of the platform.

B. Logic Layer

The logic layer is divided into the following modules: document management module, self-learning module and the profile information module.

The core element of the platform is the *document management module*. Its main innovation is the integration with three external services to support more advanced services: Astutia Platform, Moodle Platform and Google Apps, concretely, Google Docs.

First, this module gets the fully-digitized notes previously taken by the student with the digital pen through the Astutia integration module. Second, it interacts with the e-learning platform, which is used by the student (Google and Moodle), to show the users all the documents they can modify, including both platforms. It is important to mention that the documents are shown with the same structure of courses and directories that these platforms have, thus facilitating interaction with the system.

Among the functionalities this service provides we can include: edition of existing documents, insertion of new digital content in existing documents, document creation using digitized content, elimination of existing documents, and the collaborative document edition by multiple users of the same document, thus allowing the users to make changes to a document in real time.

The *self-learning module* aims to provide a tool for automatic completion and evaluation of exercises. This module is developed not only for students, but also for teachers. Inside this context, the system provides two functions: first, the creation of new exercises and second, the completion and the self-correction of the exercise.

The first one is developed mainly for teachers, to evaluate students in a simple way eliminating the time invested in their evaluation. The second is used by students, allowing them to obtain the results instantaneously. To do so, this module gets the students' answers using the Astutia platform and compares them to the correct responses provided by the teacher.

The *profile information module* is responsible for the efficient management of the information associated with the profile of the user. This kind of information is very critical in the majority of systems, so it can lead to serious security problems. This module provides services for user authentication, authorization and registration.

C. Integration Layer

Thanks to this layer, the platform is able to communicate with the services offered by Google and Moodle for managing documents, and also with Astutia for digitizing the information captured by the digital pen.

The integration with Google and Moodle is possible through the mentioned services offered by these platforms using representational state transfer (REST) calls [20]. Focusing on the integration with Google, the first call made by its corresponding module for each user is the authentication in the Google system. This call returns a ciphered token that is used in subsequent requests. These following requests are related to the management of the documents of the user; they will be sent to the Google Documents List API [21], where it is required to include the obtained token in each of the requests.

Furthermore, the communication services offered by the digitization platform called Astutia are exposed by the simple object access protocol (SOAP) technology [22]. The method used to implement communication with Astutia differs from Google and Moodle. In this case the Astutia platform starts the communication by periodically sending digitized data directly to the platform. In order to do so, it has been essential to develop and deploy several services in the PenLearning platform. Those services are invoked by the Astutia platform. The implemented services are the reception of digitized content and the processing of written answers during the exercises.

D. The User

The user takes notes on a piece of paper with the printed dot pattern. We have designed a specific format for taking notes and for performing evaluation exercises. This format enables Astutia (Fig. 6) to interpret the content. The information captured by the pen is sent to the Astutia platform through a computer with a USB port or with a Bluetooth interface. It is also possible through a mobile device with a Bluetooth interface.

E. Implementation

Java Enterprise Edition (JEE) has been used to implement the platform. The logic layer and the integration layer have been implemented using Enterprise Java Beans (EJB). Furthermore, to develop the presentation layer two frameworks have been used: Java Server Faces (JSF) and Rich Faces. Finally, to implement the communication services inside the Astutia platform, the web services were developed using the Windows Communication Foundation (WCF) of the Microsoft.NET framework.

The JBOSS application server has been used to deploy the Learning Management Platform and the Internet Information Services (IIS) server to deploy web services for the integration with the Astutia platform.

VII. Evaluation

Once the learning management platform was completely developed the evaluation of the system was performed to test

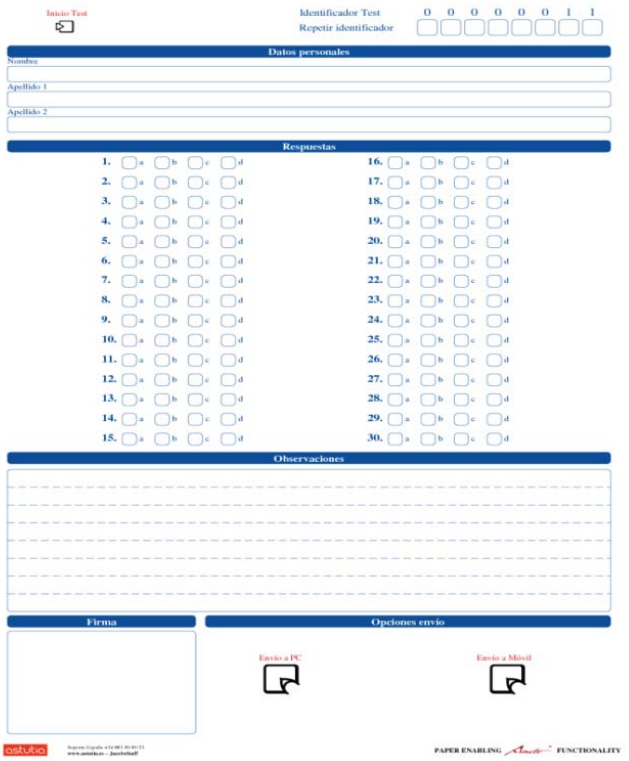

Fig. 6. Answers form.

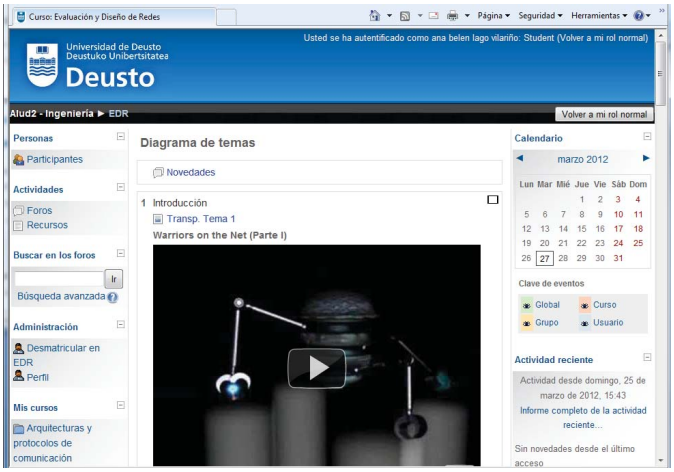

Fig. 7. Moodle course of the Evaluation and Design of Networks course.

the benefits of it. The evaluation was made up of a group of students of the subject of Evaluation and Design of Networks, which is taught in the fifth year of the Computer Engineering degree from the University of Deusto. The evaluation took a week and the course hosted in Moodle is shown in Fig. 7.

Participating students were provided with the necessary equipment to carry out the evaluation: a digital pen and a notepad with the Anoto pattern printed on its pages.

The experiment was conducted with a group of fifteen students who performed different tasks, such as collecting and sharing notes. Those tasks were performed inside and outside the classroom. Students were divided into three groups of five members each group. The first group should use the PenLearning platform to perform the tasks; the second group

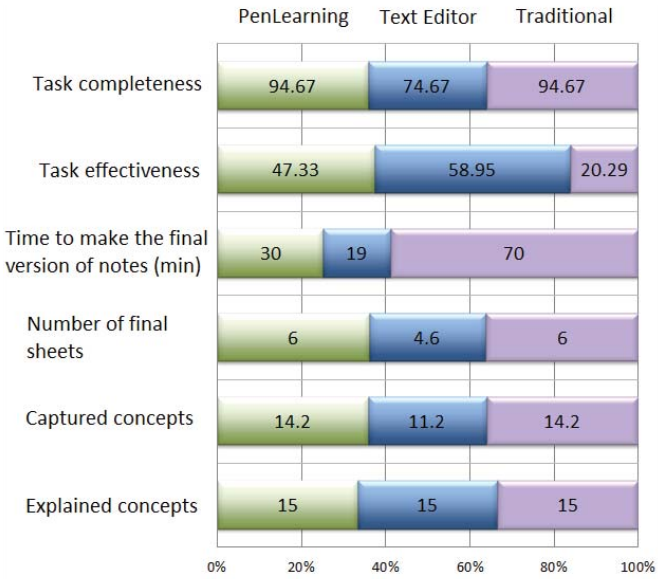

Fig. 8. Results of the evaluation.

should use a text editor; and the last group a normal pen with typical paper sheets.

During the evaluation we have studied all the digitized content and we have captured several metrics that have allowed the measurement of the students' satisfaction with the platform.

As an example, one of the evaluation sessions and its results are shown. The target of this session was to measure the efficiency of the platform and the satisfaction of the user but not the required time to learn to use the platform, which was measured in other sessions. Therefore, they asked the students, who had previously learned to use the platform, to take notes about the concepts explained in class.

One of the analyzed aspects was the number of concepts explained in class against the number of concepts captured by the different groups (this relationship has been called *Completeness of the task*). As is shown in Fig. 8, the group using the editor text for taking notes collected fewer concepts than the other groups, predominantly because the collection of drawings and diagrams directly on the computer in a short period of time is too difficult.

Another aspect to be evaluated is the *effectiveness of the task*. It is defined as the required time to make a final version of digitized notes, considering the captured concepts. In this case, the required time to make the notes using a text editor is low because the student should insert only the images and concepts that are not captured during the class. But its main problem is the small number of captured concepts. PenLearning, compared to the other groups, can automatically scan not only the notes but also the images and tables. It allows a final version of the notes investing a very short time. Consequently, its effectiveness is proved.

The final aspect that was evaluated was the satisfaction of the PenLearning users. To so, a questionnaire was sent to complete the evaluation sessions. Examining the results shown in Fig. 9, we can see that students are satisfied with the system. In fact, today, students have continued using the platform in other subjects.

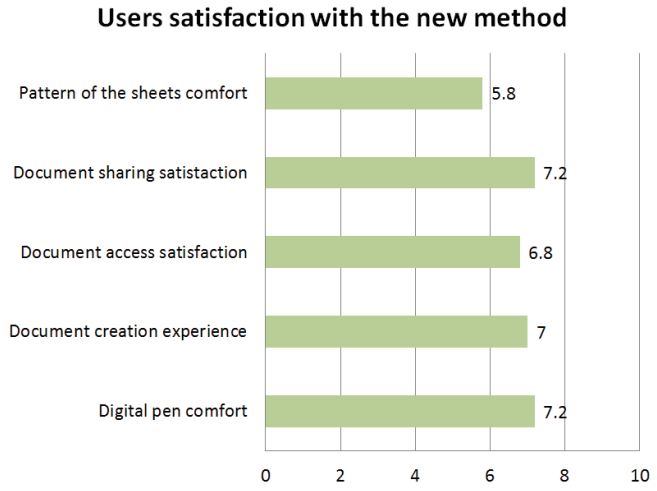

Fig. 9. Results of the satisfaction questionnaire completed by users.

Through this evaluation, the system has proved to be a great tool for document management and as collaborative editing tool, providing an added value and a great progress in the development of ICTs focused on the education sector through the support of multiple learning platforms and the use of the digital pen.

VIII. Conclusion

Through this platform it is demonstrated that the application of ICTs in education does not need to change all that exists in this sector.

Combining the traditional methods with the new tools can obtain additional benefits. It was demonstrated by the interest shown by the students who took part in the evaluation. Our future work will focus on the integration of digital pens with other services offered by the educational platforms. It will also be focused on the improvement of the digitization tools to extract information using Artificial Intelligence techniques such as Natural Language Processing and Machine Vision.

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