Polo del Conocimiento

Pol. Con. (Edición núm. 62) Vol. 6, No 9
Septiembre 2021, pp. 537-555
ISSN: 2550 - 682X
DOI: 10.23857/pc.v6i9.3064

Application of the SCRUMBAN methodology in the development of a system for recording school attendance with RFID devices in the ESPOCH

Aplicación de la metodología SCRUMBAN en el desarrollo de un sistema de registro de asistencia escolar con dispositivos RFID en el ESPOCH

Aplicação da metodologia SCRUMBAN no desenvolvimento de um sistema de registro de frequência escolar com dispositivos RFID no ESPOCH

Byron Ernesto Vaca-Barahona [I]
bvacab@espoch.edu.ec
https://orcid.org/0000-0002-3622-0668

Blanca Faustina Hidalgo-Ponce [II]
bhidalgo@espoch.edu.ec
https://orcid.org/0000-0002-9798-8240

Natalia Patricia Layedra-Larrea [III]
nlayedra@espoch.edu.ec
https://orcid.org/0000-0003-1017-1746

Steven Alejandro Salazar-Cazco [IV]
steven.salazar@espoch.edu.ec
https://orcid.org/0000-0002-9708-5885

Bryan Alexander Baldeón-Hermida [v]
bryan.baldeon@espoch.edu.ec
https://orcid.org/0000-0002-5642-3702

Correspondencia:

Ciencias Tecnológicas y empresarial
Artículos de investigación

*__Recibido:__ 16 de julio de 2021 *__Aceptado:__ 30 de agosto de 2021 __* Publicado:__ 06 de septiembre de 2021

I. Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador.
II. Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador.
III. Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador
IV. Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador
V. Escuela Superior Politécnica de Chimborazo, Riobamba, Ecuador

Abstract

This research aims to develop a computer application that allows the automation of the registration of attendance to classes of teachers and students of the Polytechnic School of Chimborazo (ESPOCH) using radio frequency identification devices (RFID), to optimize attendance registration times to class and generate reports up to the current date. Observation and interview techniques were used to identify requirements, which were applied at the ESPOCH School of Systems Engineering. The SCRUMBAN agile software development methodology was used for the project stages. In addition, the prototype of an RFID device was designed and implemented, with ARDUINO MEGA and an RFID reader. For the evaluation of software quality, the research focused on the productivity characteristic, establishing two metrics: time to complete a task and productive proportion; Based on the ISO / IEC 9126-4 usage quality standard. For this, the time capture method was applied and the data obtained were evaluated by means of the T-student statistical test. This process resulted in the acceptance of the alternative hypothesis that indicates: The computerized system to automate the registration of attendance to classes of teachers and students reduces the time of attendance registration, improving productivity in the institution. An improvement result of 66.46% was obtained with the use of the system.

Keywords: Software engineering; computer system; radio frequency identification (RFID); agile development methodology (SCRUMBAN); ISO / IEC 9126 standard.

Resumen

Esta investigación tiene como objetivo desarrollar una aplicación informática que permita la automatización del registro de asistencia a clases de profesores y alumnos de la Escuela Politécnica del Chimborazo (ESPOCH) utilizando dispositivos de identificación por radiofrecuencia (RFID), para optimizar los tiempos de registro de asistencia a clase y generar informes hasta la fecha actual. Para la identificación de requisitos se utilizaron técnicas de observación y entrevista, las cuales fueron aplicadas en la Escuela de Ingeniería de Sistemas de la ESPOCH. Para las etapas del proyecto se utilizó la metodología de desarrollo ágil de software SCRUMBAN. Además, se diseñó e implementó el prototipo de un dispositivo RFID, con ARDUINO MEGA y un lector RFID. Para la evaluación de la calidad del software, la investigación se centró en la característica de productividad, estableciendo dos métricas: tiempo para completar una tarea y proporción

productiva; basado en el estándar de calidad de uso ISO / IEC 9126-4. Para ello, se aplicó el método de captura de tiempo y los datos obtenidos se evaluaron mediante la prueba estadística T-student. Este proceso resultó en la aceptación de la hipótesis alternativa que indica: El sistema informático para automatizar el registro de asistencia a clases de profesores y estudiantes reduce el tiempo de registro de asistencia, mejorando la productividad en la institución. Se obtuvo un resultado de mejora del 66,46% con el uso del sistema.

Palabras clave: Ingeniería de software; sistema informático; identificación por radiofrecuencia (RFID); metodología de desarrollo ágil (SCRUMBAN); norma ISO / IEC 9126.

Resumo

O objetivo desta pesquisa é desenvolver um aplicativo informatizado que permita a automação do cadastro de atendimento às aulas de professores e alunos da Escola Politécnica de Chimborazo (ESPOCH) utilizando dispositivos de identificação por radiofrequência (RFID), para otimizar os horários de atendimento às aulas. e gerar relatórios até a data atual. Foram utilizadas técnicas de observação e entrevista para identificar os requisitos, os quais foram aplicados na Escola de Engenharia de Sistemas da ESPOCH. Para as etapas do projeto foi utilizada a metodologia ágil de desenvolvimento de software SCRUMBAN. Além disso, foi projetado e implementado o protótipo de um dispositivo RFID, com ARDUINO MEGA e um leitor RFID. Para a avaliação da qualidade do software, a pesquisa focou na característica de produtividade, estabelecendo duas métricas: tempo para completar uma tarefa e proporção produtiva; Com base no padrão de qualidade de uso ISO / IEC 9126-4. Para isso, foi aplicado o método de captura do tempo e os dados obtidos foram avaliados por meio do teste estatístico T-student. Esse processo resultou na aceitação da hipótese alternativa que indica: O sistema informatizado para automatizar o cadastro de presenças às aulas de professores e alunos reduz o tempo de cadastro, melhorando a produtividade da instituição. Foi obtido um resultado de melhoria de 66,46% com a utilização do sistema.

Palavras-chave: Engenharia de software; sistema de computador; identificação por radiofrequência (RFID); metodologia de desenvolvimento ágil (SCRUMBAN); Padrão ISO / IEC 9126.

Introducción

In the Polytechnic School of Chimborazo, attendance records for classes and laborato- ries, both for teachers and students, are kept manually. With this process some situa- tions are observed, for example: the person in charge of bringing the assistance of teachers, in certain occasions does not fulfill his task for various reasons, or in turn the teacher does not keep control with his daily attendance list; there are no statistics of students who regularly attend classes, etc.

The possibilities offered by the remote reading of the information contained in an RFID tag, without the need for physical contact, together with the ability to perform multiple readings simultaneously, opens the door to a very extensive set of applica- tions in a wide variety of areas, from traceability and inventory control, to the location and monitoring of people and goods, or security in access control. This allows radio frequency to be applied for identification, thus allowing us to identify objects using radio waves. This becomes a clear alternative to traditional systems of control and tracking of objects or people.

The research work: "ANALYSIS AND DESCRIPTION OF RADIO IDENTIFICATION FREQUENCY: TECHNOLOGY, APPLICATIONS,

SECURITY AND PRIVACY", focuses on an in-depth analysis of RFID Radio Fre- quency Identification technology, which is why it begins with an general overview of it, passing through its physical and technical aspects, frequencies, technology, regula- tions and legislation in the matter. Rodríguez, (2009)

According to David Chang and Alan Lozano, authors of the research project: “DEVELOPMENT AND IMPLEMENTATION OF A SYSTEM FOR CONTINUOUS CONTROL AND INVENTORY, USING RFID TECHNOLOGY, FOR THE LIBRARY AT THE UPS SEDE GUAYAQUIL LIBRARY”, this approach

is carried out with the aim of give the facility, saving time and unnecessary effort, avoiding losses of important teaching materials for students, in this case, applied in the library of the Universidad Politécnica Salesiana headquarters Guayaquil. Chang, Solís, (2013).

This research aims to register and control the attendance of teachers and students with the Radio Frequency Identification technology, Portillo García, Bernardos, (2008); differentiating itself from the aforementioned works due to its agile methodology and its added value in which it is intended

to avoid liability to the people in charge of taking the attendance of teachers to classes, ensure guaranteed data from the attendance record in real time and its availability when authorities and teachers require it.

State of the art

RFID (Radio Frequency Identification)

It is a technology that has a remote data storage and retrieval method that uses devices called RFID tags or labels. Portillo García, Bernardos, (2008).

Java EE (Java Platform, Enterprise Edition)

Java EE is portable and scalable, and supports integration with previous versions and components based on EJB architecture. Ordax, Díaz-Ufano, (2012).

Java EE simplifies business applications by defining and specifying a complex set of common standard services, such as naming, transaction management, concurrency, security, and database access. Mendoza, (2016).

Web services

A web service performs a specific task or set of tasks and is described by a service description in a standard XML notation called WSDL (Web Services Description Language). The service description provides all the details necessary to interact with the service, including message formats (detailing operations), transport protocols, and location. Carvajal, (2016).

AJAX (Asynchronous JavaScript and XML)

Refers to a group of technologies that are used to develop web applications. By com- bining these technologies, web pages are more responsive since small data packets are exchanged with the server and web pages are not reloaded each time a user makes an input change. Ajax allows a user of the web application to interact with a web page without the interruption of reloading the web page. Website interaction happens quickly only with parts of the reload and refresh page. Bayona and Villagrán, (2017).

SCRUMBAN

The SCRUMBAN methodology is born from the combination of principles of the most important agile project management methods today: Scrum and Kanban. Alt- hough in principle they may seem the same, the two management strategies differ in the way the project is carried out. The

innovative SCRUMBAN plan is responsible for combining those elements that are complementary. For example, one of the most used combinations at the business level, is to manage the tasks planned with the Scrum method and plan the errors with the Kanban method. However, the mixing of the two implies a new way of management. Bayona and Villagrán, (2017).

JSON (JavaScript Object Notation)

JSON is a text format that is completely language independent but uses conventions that are widely known to programmers in the C family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal language for data exchange.

Methodology

SCRUMBAN was used for development to follow a continuous workflow while car- rying out small iterations to plan and review. In addition, thanks to the dashboard that contains the activities, you can have a continuous follow-up on the evolution of the tasks and thus help prioritize the pending tasks to be developed.

According to the author Sepúlveda Castaño, Sepúlveda, (2016); these are the 6 stages of the SCRUMBAN life cycle. These stages were used in the development of the system, and are described below:

Tasks to do

At this stage of the cycle, a meeting is held with the work team where the new tasks or activities to be carried out are defined. New tasks can arise at each meeting, which can be added over time. Table 1 specifies the activities of the first meeting.

Table 1. Technical project tasks to be done

N°	Tasks to do
1	As a developer, collect the functional and non-functional requirements
2	As a developer, define the programming standard
3	As a developer, define the system architecture
4	As a developer, define the user interface standard
5	As a developer, install the necessary frameworks and components in NetBeansIDE

Selected Tasks

The selected task is called: "User registration". This was developed in the Microsoft Planner tool. The task is moved from the to-do column to selected tasks and assigned a person in charge and responsible for the task, as shown in figure 1.

Figura 1. Assigning a task to a team member

Development

Once the task has been selected and assigned, we proceed to analyze whether the task is feasible to carry out. If it is not, small tasks must be created that can be controlled to finish, as shown in figure 2.

Figura 2. Example of SCRUMBAN subtasks

Testing

Tests are carried out on the system with the test mode of the NetBeans IDE, in which we place breakpoints in key instructions to verify that the system works as expected; as well as monitoring variables, sessions and files, as shown in figure 3.

Figura 3. Test mode

Deployment

The application was deployed on a Payara server where its operation is shown in fig- ure 4.

Figura 4. Test mode

Close

The tasks are marked as completed in the last column created in the Microsoft Planner dashboard and the tasks that continued were executed, as shown in figure 5.

Figura 5. SCRUMBAN dashboard with completed tasks

Discussion and results

Next, the results obtained with the development of the computer system to automate the registration of attendance to ESPOCH teachers and students with RFID devices are presented. These results were obtained by measuring response times of the com- puter system. With the data obtained in the measurement, the t-student distribution method was applied, in order to obtain the necessary information to evaluate produc- tivity. To measure the quality of the system, productivity was measured using metrics based on the ISO / IEC 9126-¬4 standard.

The characteristics and productivity metrics were chosen to be evaluated, which are shown in table 2.

Table 2. Characteristics and metrics to evaluate

Characteristics	Metric	Pregunta Central
Productivity	Time to complete a task.	How long does it take to complete a task?
	Productive pro- portion	In what proportion of time does the user carry out productive actions?

Through the interview process with secretaries of the different academic units, the total number of students and teachers could be known to determine the study popula- tion, and the sample for each of the processes was determined using probabilistic formulas as indicated in table 3.

Table 3. Population and sample

	Process	Population	Sample
Time to complete a task	Attendance record of 10 students by the teacher	27 teachers from the School of Systems Engineering	25 teachers
	Student registration	92 students of the first semester of the School of Systems Engineering	77 students
Productive proportion	Student registration by the teacher in 30s	27 teachers from the School of Systems Engineering	25 teachers

Metric: Time to complete a task Process 1

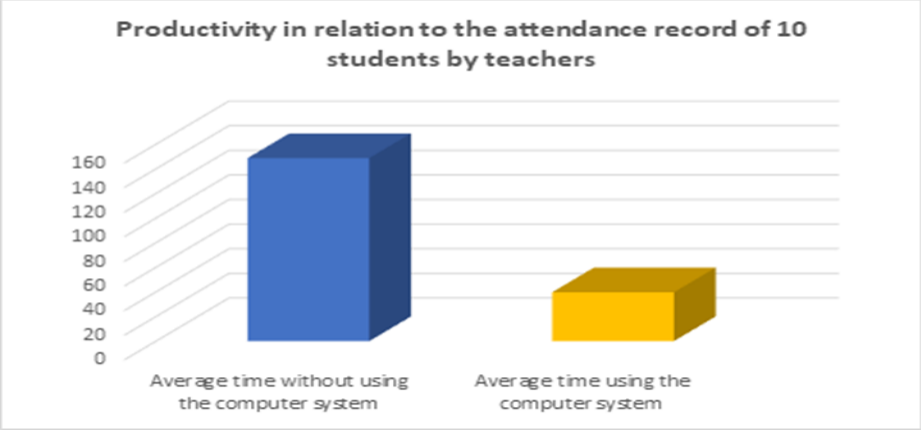
The time it took for a teacher to complete the attendance record manually with 10 students was measured, and the average time was calculated. Then the time was measured, carrying out the same process, but using the computer system. Time is expressed in seconds and tenths of a second (ss, d). Measurements are shown in table 4.

Table 4. Times involved in registering attendance of 10 students for each teacher

Attendance registration task for 10 students by teachers in the normal way and using the system		
Teacher	Time without using the comput- er system	Time with the use of the com- puter system
Teacher 1	154,52	42,64
Teacher 2	153,64	34,23
Teacher 3	147,67	43,12
Teacher 4	150,99	47,76
Teacher 5	147,29	42,26

Teacher 6	153,41	45,02
Teacher 7	159,43	43,16
Teacher 8	159,3	38,1
Teacher 9	141,31	40,33
Teacher 10	151,11	46,74
Teacher 11	142,62	36,29
Teacher 12	145,72	30,52
Teacher 13	147,38	43,49
Teacher 14	140,9	33,29
Teacher 15	147,25	29,61
Teacher 16	146,44	43,14
Teacher 17	144,63	44
Teacher 18	140,56	33,64
Teacher 19	141,81	33,11
Teacher 20	154,74	38,17
Teacher 21	141,26	32,4
Teacher 22	143,6	48,3
Teacher 23	149,33	47,9
Teacher 24	159,83	43,34
Teacher 25	152,47	30,62
Average	148,68	39,65

Figure 6. shows the summary of the results



Fuente: Productivity in relation to the attendance record of 10 students by teachers

To determine the time savings in the attendance record of 10 students by the teacher, using the computer system, the following aspects are proposed:

Object of experimentation. The computer system to automate the registration of at- tendance to classes of teachers and students of the ESPOCH with RFID devices.

Experimentation subjects. Teachers from the Polytechnic School of Chimborazo. To design the experiment and measure the productivity of the system, data is col-lected using the observation technique, considering the population and study sample.

We proceed to analyze if there is a time difference between the normal process and the process using the RFID web system, for which the T-student parametric distribu- tion is applied.

Null hypothesis. "The computer system does not optimize the attendance registra- tion time of 10 students per teacher"Alternative hypothesis.

"The computer system optimizes the attendance registration time of 10 students per teacher" Statistical hypothesis approach.

- **Bilateral contrast H0:**

$\mu a = \mu d$ or also $\mu a - \mu d = 0$ H1: $\mu a \neq \mu d$ or also $\mu a - \mu d \neq 0$

- **Bilateral contrast**

H0: $\mu a \leq \mu d$ or also $\mu a - \mu d \leq 0$ H1: $\mu a > \mu d$ or also $\mu a - \mu d > 0$

Considering the variances and knowing that two times with different conditions were measured, the following expression was used:

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Were

$$S^2 = \frac{\sum^{n1}(x_i - \bar{x}_1)^2 + \sum^{n2}(x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

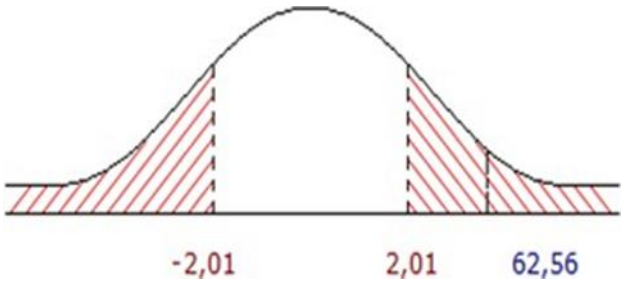
When replacing variables, the calculation is as follows:

Sample size (n) = 25 α/2= 0.025

Degrees of freedom (v) = 25 - 1 = 24 tα/2 = t0.025 = 2.01

The degree of significance or rejection is α = 0.05. The region of acceptance of the null hypothesis is between the scores t = [-2.01; 2.02]. The value t = 62.56, is located outside the acceptance region of the null hypothesis, therefore the alternative hypoth- esis is accepted as observed in Figure 7.

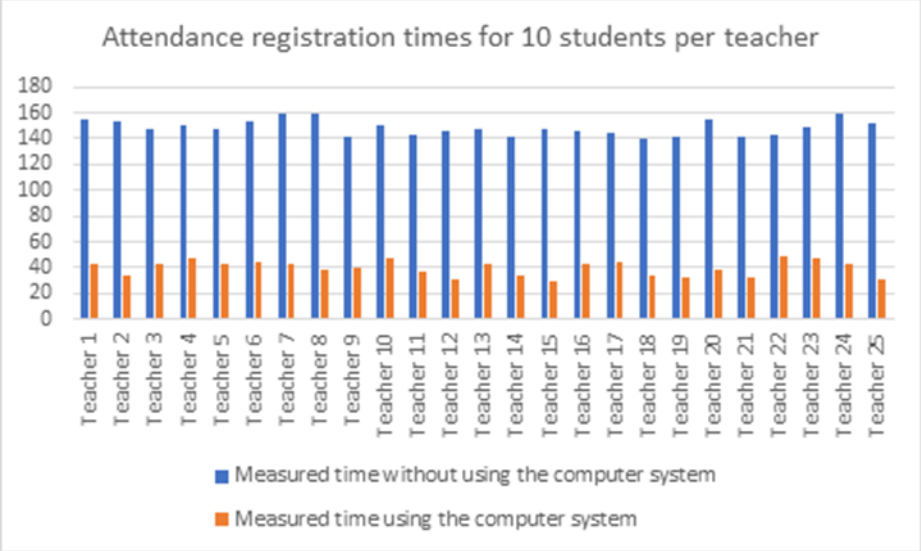
Figura7. T-student graph of the attendance record of 10 students by the teacher



This indicates that there was indeed a decrease in the time it takes to record the at- tendance of 10 students, using the system, compared to the manual process.

Figure 8 shows the improvement of times in the attendance record compared to the manual process. The orange column indicates the times in seconds to register with the system prototype, while the blue column indicates the times measured to carry out the same process manually.

Figura 8. Manual time vs. system time: Attendance record of 10 students per teacher



The average time using the system was 39.64s, and the average time with the man- ual process was 148.68s. This indicates a decrease in time of approximately 109.04s, equivalent to a 73.34% improvement compared to the manual process.

Process 2

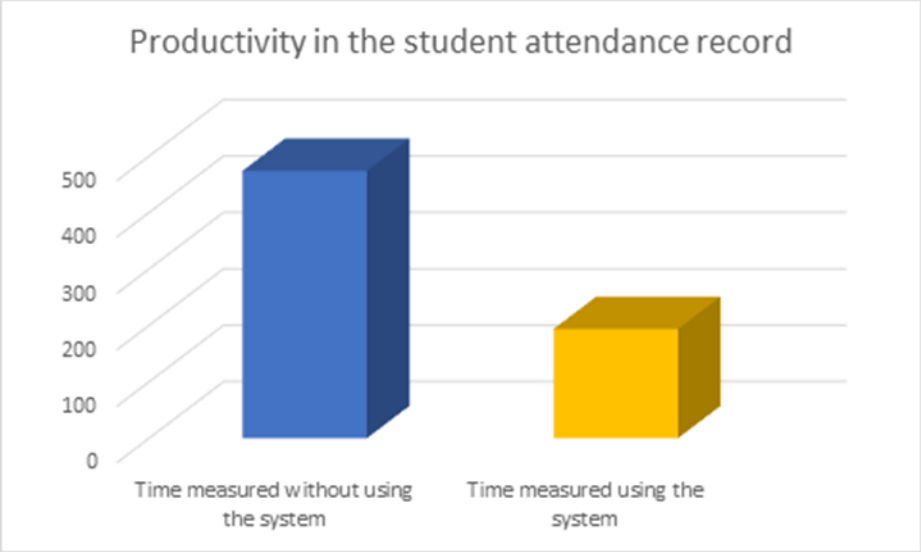
The time it took for students to complete their attendance record manually in 2 sub- jects was measured. The time of the same process was measured using the computer system. The time is expressed in seconds and tenths of a second (ss, d). These meas- urements are shown in Table 5.

Table 5. Student Attendance Record Times

N°	Subject	Time measured without using the system	Time measured using the system
1	Statistics I "A"	451.8	189.6
2	Statistics I "B"	495.8	197.4
Total time		947.4	387
Average per student		12.31	5.03

Fuente: The results are shown graphically in figure 9.

Figura 9. Productivity in the student attendance record



To determine the time savings in the registration of student attendance by teacher, using the computer system, the following aspects are considered:

Object of experimentation. The computer system to automate the registration of at- tendance to classes of teachers and students of the ESPOCH with RFID devices.

Experimentation subjects. Students from the Polytechnic School of Chimborazo.

It is analyzed if there is a time difference between the manual process and the pro- cess using the RFID web system, for which the T-student parametric distribution is applied.

Null hypothesis. "The computer system does not optimize the registration time of student attendance"

Alternative hypothesis. "The computer system optimizes the registration time of student attendance."

Considering the variances, knowing that two times with different conditions were measured and considering that the sample is 77 students, the following expression was used:

$$T = \frac{\bar{x}_1 - \bar{x}}{\sqrt{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Where:

$$S^2 = \frac{\sum_{i=1}^{n1} (x_i - \bar{x}_1)^2 + \sum_{j=1}^{n2} (x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

When replacing variables, the calculation is as follows:

$$t = \frac{12.31 - 5.03}{\sqrt{(0.88\,(\frac{1}{77} + \frac{1}{77}))}}$$

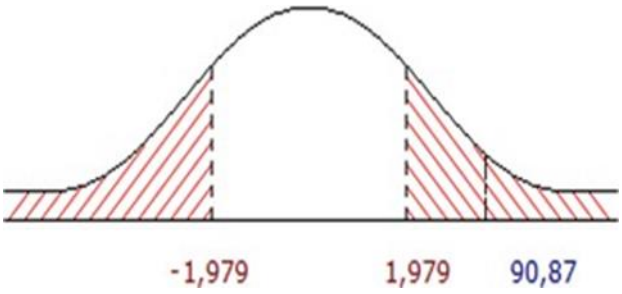
$$t = 90.87$$

Sample size (n) = 77 α/2= 0,025

Degrees of freedom (v) = 77 - 1 = 76 tα/2 = t0.025 = 1,979

The degree of significance or rejection is α = 0.05. The region of acceptance of the null hypothesis is between the scores t = [[-1,79; 1,79]. The value t = 90.87, is located outside the acceptance region of the null hypothesis, therefore the alternative hypoth- esis is accepted as observed in Figure 10.

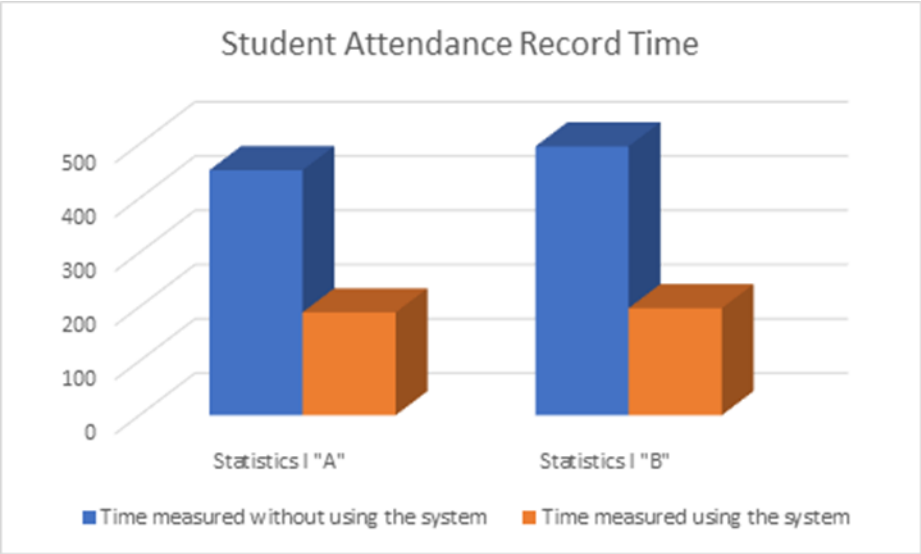
Figura 10. T-student graph of the student attendance record



This indicates that there was indeed a decrease in the time it takes to record the at- tendance of students, using the system, compared to the manual process.

Figure 11 shows the improvement of times in the attendance record compared to the manual process. The orange column indicates the times in seconds to register with the system prototype, while the blue column indicates the times measured to carry out the same process manually.

Figura 11. Manual time vs. time with the system: Student attendance record



The average time using the system was 193.5s, and the average time with the manual process was 473.8s. This indicates a decrease in time of approximately 280.3s, equiv- alent to a 59,17% improvement compared to the manual process.

Conclusiones

- The study of RFID technology allowed to obtain and apply key concepts for the development of the registration system attendance of teachers and students. The system allowed for a significant decrease in the time taken to register attendance. In addition, this technology offers faster data reading, compared for example with Bluetooth, for which both the sender and the transmitter must be linked previously.
- The technical project was developed under the agile SCRUMBAN methodology. This methodology divides tasks into subtasks to decrease their difficulty. In case of complications with a task, it can be registered in the section "pending" to resolve it later. This fulfills the purpose of agile methodology which is to prioritize work- flow.
- The developed system works with three components: the RFID device, the web system and web services provided by ESPOCH. The web system consumes the da- ta directly from the university's web services, which allows real and reliable data to be obtained from the institution's students and teachers.

- To measure the productivity of the computer system, the ISO / IEC 2196-4 standard was used. With measurements performed was determined that using the system has a 73.34% improvement in the time it takes a teacher to record the attendance of their students, and 59.1% improvement in the time it takes students to record their attendance. This is due to the approach system of RFID technology and its ability to quickly read data. This improvement in time allows teachers and students to optimize their time in the development of their other academic activities.

Referencias

1. Rodríguez Hernández, "ANÁLISIS Y DESCRIPCIÓN DE IDENTIFICACIÓN POR RADIO FRECUENCIA: TECNOLOGÍA, APLICACIONES, SEGURIDAD Y PRIVACIDAD," Instituto Politécnico Nacional, 2009.
2. D. Chang Falconí and A. Solís Lozano, "Desarrollo e implementación de un sistema para el control e inventario continuo, utilizando tecnología RFID, para la biblioteca de la UPS sede Guayaquil," Universidad Politécnica Salesiana- Ecuador, 2013.
3. J. I. Portillo García, A. Belén, B. Nieto, and A. M. Bernardos Barbolla, tecnología de identificación por radiofrecuencia (RFID): aplicaciones en el ámbito de la salud. 2008.
4. J. M. Ordax Cassá and P. A. Ocaña Díaz-Ufano, Programación web en java, no. January. 2012.
5. G. Mendoza Gonzalez, "Desarrollo de Aplicaciones en Java | Configuración Payara Server," 2016. [Online]. Available: http://geovanny0401.blogspot.com/2016/08/configuracion-payara-server.html. [Accessed: 17-Dec-2018].
6. F. Carvajal Palomares, ADMINISTRACIÓN Y AUDITORÍA DE LOS SERVICIOS WEB, no. December. 2016.
7. J. Villar Cueli and F. Huércano Ruiz, Implementación e integración de elementos software con tecnologías basadas en componentes, no. December. 2014.
8. A. C. Bayona Guáqueta, A. C. Tao Romero, and J. C. Villagrán Gutiérrez, "Documento Scrumban," 2017.

9. D. Crockford, "JSON," 2016. [Online]. Available: https://www.json.org/json- es.html. [Accessed: 14-Jun-2019].
10. J. M. Sepúlveda Castaño, "Propuesta de aplicación de Scrumban para gestionar el proceso de generación de proyectos de I+D+i con el modelo Canvas: estudio preliminar," p. 82, 2016.