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Evaluating the Effectiveness and Motivational Impact of Replacing a Human Instructor by Mobile Devices for Teaching Network Services Configuration to Telecommunication Engineering Students

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Abstract— The introduction of mobile technologies in class provide instructors with tools for contextualized, active, situated, any-time any-where learning. In fact, the role of the instructor can be partially delegated to the student by the use of a mobile device. This paper assesses if this delegation can be brought to the limit of eliminating the need of the physical presence of the instructor in the particular context of a situated learning environment consisting of a server room where third year Telecommunication Engineering students learn how to configure network services such as DNS, SMTP and HTTP. The paper presents the results of two experiments inside the “advanced telematic applications” course at the Carlos III University of Madrid. Two groups of students participated in the experiments, one following traditional instructor based classes and the other using NFC enabled mobile phones. The paper analyzes both learning increments and motivational aspects.

Keywords— educational technology; higher education; learning systems; student experiments

I. INTRODUCTION

The use of mobile devices in learning activities can enhance the shift from pure instructor centered classroom teaching to constructivist learner centered educational settings [1]. Several experiments during the last years have concentrated on studying how the use of mobile phones and PDAs in educational settings can enhance the learning process and learning outcomes. A context-aware language-learning support system using PDAs, GPS and RFID tags is described in [2]. The paper in [3] proposes a context-aware ubiquitous English learning system in a campus environment which can detect the learning location by wireless positioning techniques and retrieve specific learning content based on location information to individual learners through wireless networks. An environment for learning with educational resources based on RFID and ubiquitous computing technologies is described in [4]. A similar experiment which uses a context-aware ubiquitous learning environment which utilizes mobile devices, sensors and wireless networks to conduct situated learning is described in [5].

Among the main characteristics normally present in experiments using mobile devices in learning settings three of them are: their use for exploratory learning, in situated environments, for problem solving. In exploratory learning,

the students investigate a system on their own, often in pursuit of a goal. Exploratory learning [6] is a constructivist instructional approach, wherein the learners are encouraged to explore and to experiment on their own. Situated learning was defined by Brown et al. as “embedded within and inseparable from participating in a system of activity deeply determined by a particular physical and cultural setting” [7]. Problem based learning (PBL) originates from education in medicine [8] and consists of the manipulation of problematic situations, comprising the appraisal of the problem, creation of a problem space, the selection of goals and the deployment and monitoring of cognitive structures to reach those goals [9].

Among the main objectives targeted when using mobile devices in learning experiments two of them are of especial importance for the scope of this paper: improving the learning outcomes and enhancing the motivation of students. Liu et al. [4] evaluated the impact of using mobile devices in a situated learning environment on the grades of the students. Moura and Carvalho [10] studied if the use of mobile phones and podcasts encouraged the students to learn. The activity theory was used in [11] for designing ubiquitous learning scenarios showing that learners become motivated and engage in active pursuit and construction of knowledge when using ubiquitous technologies.

A common factor in the experiments such as [2]-[5], [10]-[11] is the use of mobile technologies as a support tool for the instructor, not reducing his or her role in the learning process but enhancing it with new space-time dimensions (any-time any-where learning). The research presented in this paper explores the limit situation in which the instructor disappears from the learning activity being replaced by a mobile device interacting with a situated learning environment. This paper analyzes both the learning increments and motivational impact when applying mobile devices in an exploratory, situated learning environment as a replacement for the human instructor. Two experiments were conducted with third year Telecommunication Engineering students learning how to configure network services such as DNS, NFS, NIS, SMTP and HTTP. In each of the experiments a control group of students attended a traditional instructor based learning environment while an experiment group did the activity on their own using NFC (Near Field Communications) enabled mobile phones interacting with NFC tagged learning objects. A pre-test was used to assess

the previous knowledge of the students. A post-test was used to assess the learning increment for both groups. The motivational impact was measured using a questionnaire with motivation related questions.

The rest of the paper is organized as follows. Section II describes the e-learning scenario in which the experiment was conducted. Section III is dedicated to studying the learning gains by applying both instructor and mobile device based environments to the learning process. Section IV evaluates the motivational impact of applying mobile devices to replace the human instructor for situated learning settings. Finally, conclusions are summarized in Section V.

II. THE E-LEARNING SCENARIO

This section presents the scenario in which the experiments were conducted.

The “advanced telematic applications” course at the Carlos III University of Madrid is dedicated to teach third year Telecommunication Engineering students how to configure network services such as DNS, NFS, NIS, SMTP and HTTP. The course is equally divided with theoretical lectures (30 hours) and applied labs (30 hours). The main competency targeted by the course is that students are capable of configuring and administering the Intranet and Internet services of a small company using Linux based servers and services. To motivate students, the configuration of the network inside the Telematic Engineering department at the Carlos III University of Madrid is used as a related, nearby working example. In fact, some of the theoretical lectures are based on describing slightly modified configuration files of the working services in that department’s network while some of the labs are just reduced versions of that services. Fig. 1 shows the servers’ room in which the network services run.



Figure 1. Photograph of the servers’ room

In order to replace the instructor in some of the classes two experiments were designed in which the contents of the class were embedded in an NFC based mobile phone. The objective of these classes was to explain some details about the configuration of some network services. Instead of the instructor explaining these details to students, a simulated servers’ room was tagged with NFC tags allowing the students to interact with its different servers and services. Each tag triggered the reproduction of a multimedia content in the mobile device when the student touched it. The student was able to reproduce the learning contents as many times as needed (due to the limitation of the screen size different

kinds of media should be applied instead of text [1]). The student was in control of the learning activity exploring the information provided by the learning objects (servers in the simulated room) constituting a situated learning environment. Since it was not practical to allow students to enter the real servers’ room, a simulated environment reproduced it using an NFC based panels. Fig. 2 shows the front and rear sides of one of the panels used in the experiments.

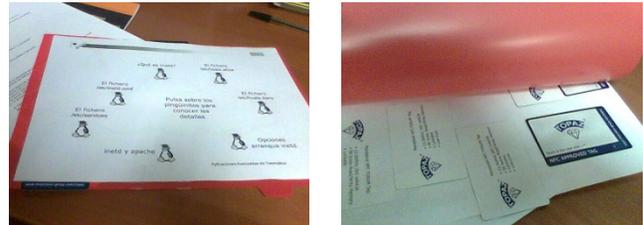


Figure 2. An NFC based panel. Front and rear views.

Each component of the front of the panel in Fig. 2 represents a Linux server. An NFC tag is attached to each component on the rear part of the panel. When the student touches each component on the front of the panel with the NFC mobile device (the Nokia 6131 NFC was used for both of the experiments) a video or audio associated to this component is reproduced.

In order to have enough data for statistical analysis, two different experiments were carried out. The first experiment consisted of an introductory class briefly describing the basis of each service later covered during the course. The second experiment was dedicated to learn the details of the “inetd” service, its configuration files in a Linux system and its component architecture. The first experiment was designed to study the learning outcomes for generic issues when using mobile devices while the second experiment complemented the first one with a learning experience providing more specific details. In both experiments, the class was randomly divided into two groups (the experiment and the control groups). The experiment group consisted of 10 students per experiment while the rest of the class (around 15 students) was assigned to the control group. A pre-test was done before the experiment. A post-test was carried out at the end of each experiment to measure the learning gains. The motivational impact of the use of mobile devices in the experiments was also evaluated by using a motivation questionnaire.

The pre and post tests consisted of 7 multiple choice questions in both experiments. The motivation questionnaire used a Likert-type scale [12] (1. Strongly disagree, 2. Disagree, 3 Neither agree or disagree, 4. Agree, 5. Strongly Agree) in all the questions. No extrinsic motivation related questions [13] were introduced in the experiments (there was no reward in terms of the final grade associated to the participation in the experiments). These questions were:

- How would you define your intrinsic motivation towards the use of mobile devices in class?

- Comparing learning with mobile devices and traditional instructor based classes, what do you enjoy most?
- Would you be willing to do a second experiment like this in the future?

Section III is dedicated to present the results of the experiments related to the learning gains of the students. Section IV presents the results related to the motivational impact because of the use of mobile devices.

III. EVALUATING THE LEARNING GAINS

By substituting a human instructor by a mobile device in situated learning environments the learning process is able to become open at any time. Moreover, the use of learning devices can motivate the participation of students. However, these benefits could not be pursued by themselves if they implied paying the price of reducing the learning outcome of the process. Previous experiments like [4] have shown that augmenting a situated instructor-led learning process with mobile devices increases the learning outcome of the process. This section is dedicated to study the learning outcome when the presence of the instructor is fully replaced by a mobile device. Two experiments have been carried out as described in section II.

In the first experiment, the 31 students attending the class were divided into two groups, one of 10 students (the group of the experiment) and the other of 21 students (the control group). The group of the experiment was that size because of the number of mobile phones simultaneously available. The selection of students for the group of the experiment was random and did not correspond to any prior classification. The control group received a normal lecture about the main characteristics of some services in a TCP/IP network. The session took place in a classroom with slides showing a diagram containing multiple servers as a simulated servers' room and was explained by the professor of the course. Students could ask the professor to repeat any part of the class if needed but within the time frame limits of the class.

The group of the experiment was moved to another room with NFC mobile phones. Students interacted with NFC panels as presented in Fig. 2 simulating the interaction with the physical servers in the servers' room. The learning objects used were based on video and audio and contained the same information that the professor gave to the control group in class. The students were able to control the learning experience by exploring the panels at their own pace, replaying the contents if needed. No synchronous communication channel was provided to allow students to ask questions to an online instructor.

At the beginning of the session, each student of both groups answered a pre-test with questions about the contents of the experiment. The objective of this pre-test was to measure any prior knowledge that students may have had so that the learning gain could be measured at the end of the experiment. The test consisted of 7 questions that were rated on a scale between 0 and 7.

Once the session finished, both groups were asked to answer a post-test containing again 7 questions to assess the

learning gain of the process in both groups. The average results are presented in Table I.

TABLE I. AVERAGE OF TEST RESULTS IN FIRST EXPERIENCE

Group of	Pre-Test	Post-test
Experiment	1.7	3.6
Control	2.14	4.57

In the second experiment, the 24 students attending the class were again divided into two groups, one of 10 students (the group of the experiment) and the other of 14 students (the control group). The methodology was the same but the students participating in the group of the experiment were different from the first one. The learning content described the details of the "inetd" service, its configuration files in a Linux system and its component architecture. Table II shows the average results of the tests used for this experiment.

TABLE II. AVERAGE OF TEST RESULTS IN SECOND EXPERIENCE

Group of	Pre-Test	Post-test
Experiment	2.33	5.56
Control	3	5.93

Table III presents the average values for the difference in the learning gains in both experiments for both groups (represented by the difference between pre-test and post-test). The learning gains for the group of the experiment were slightly worse in the first experiment but slightly better in the second one. An Anova test is presented later in this section to assess if there is an influence of a non random factor with an impact in the learning gains of both groups.

TABLE III. AVERAGE OF INCREASE RESULTS BY EXPERIENCE AND TOTAL AVERAGE

Group of	First experiment	Second experiment
Experiment	1.9	3.22
Control	2.43	2.93

The sample space generated by the two groups regarding the learning gains (the difference between the post-test and the pre-test values for each student) is presented in Fig. 3.

In order to statistically analyze the data in Fig. 3, the normality of the samples is first assessed. To consider normality in the distribution of the samples in Fig. 3 both the index of asymmetry and the kurtosis should be close to zero. In addition, the p-values for the Kolmogorov-Smirnov and Shapiro-Wilk tests should be greater than 0.05. The summary of the values of the kurtosis and index of asymmetry for the two groups in the two experiments is captured in table IV.

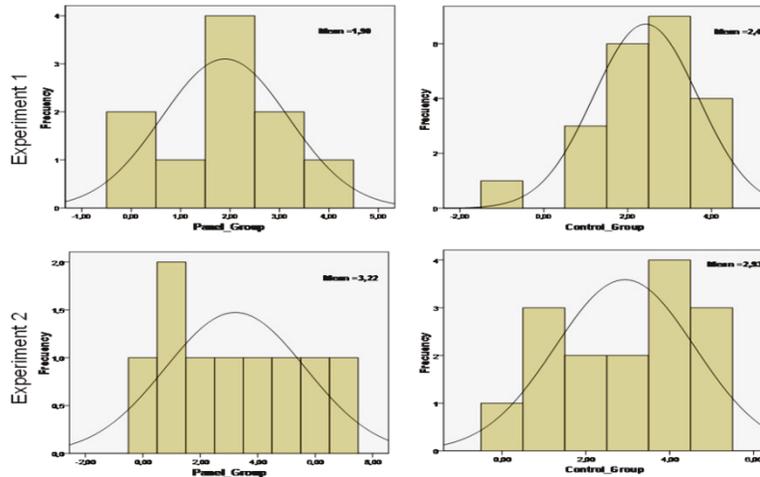


Figure 3. Learning gains for the group of the experiment

TABLE IV. KURTOSIS AND INDEX OF ASYMMETRY FOR THE 2 GROUPS IN THE 2 EXPERIMENTS

Experiments	Groups	Kurtosis	Index of asymmetry
1	Experiment	-0.43	-0.16
	Control	1.39	-0,92
2	Experiment	-1.29	0.27
	Control	-1.25	-0.31

The values for the Kolmogorov-Smirnov and the Shapiro-Wilk tests are captured in table V.

TABLE V. KOLMOGOROV-SMIRNOV AND THE SHAPIRO-WILK TESTS FOR THE 2 GROUPS IN THE 2 EXPERIMENTS

Experiments	Groups	Kolmogorov-Smirnov	Shapiro-Wilk
1	Experiment	0.139	0.392
	Control	0.027	0.024
2	Experiment	0,200	0,701
	Control	0,088	0,130

The Kolmogorov-Smirnov and Shapiro-Wilk tests show values greater than 0.05 for nearly all the cases except for the control group in the first experiment.

In order to assess if the learning gains of the group of control are greater than those of the group of the experiment due to non-random factors, or on the contrary, the differences in learning gains for both groups can be assumed to be related to random factors, an Anova test is performed to the learning gains for the 4 samples of students (including the two groups in the two experiments). The F value obtained is 1.37 which is smaller than the critical value 2.79 and the p-value obtained is 0.26 which is bigger than the critical value of

0.05. Therefore it can be assumed that the differences in the learning gains are due to random factors, and therefore, the learning gains obtained using mobile devices as a replacement of the instructor are similar to those obtained in the presence of instructor.

Assuming that the control group in the first experiment presents a non normal distribution and calculating the non-parametric Kruskal-Wallis test (for the same set of data values) a p-value of 0.37 (greater than 0.05) is obtained, showing, therefore, similar results as those obtained by the Anova test.

Having validated the learning gains, the next section is dedicated to study the motivational impact of using mobile devices as a replacement of the human instructor in class.

IV. EVALUATING MOTIVATIONAL ISSUES

Educational researchers distinguish between intrinsic and extrinsic motivations [13]. Intrinsic motivation is related to the interest, curiosity and enjoyment that a task causes in the student, while extrinsic motivation measures the engagement of a student because of a reward or punishment from an external source, or because of a positive mental attitude to perform a task either by itself or in a context. Self-determination theory [14] provides a further division of extrinsic motivation into four categories that vary according to the level of self-determination, which reflects the aspect of quality of motivation: external regulation, introjected regulation, identified regulation and integrated regulation. External and introjected regulations can be grouped in a controlled motivational profile, while identified and integrated motivations define more autonomous types of motivation [15].

The motivational factors evaluated in the experiments described in this paper are related to intrinsic motivation. In fact, there was no reward in terms of extra points in the final mark because of the participation in the experiments. The questions answered by students were (using a Likert-type scale [12]):

- How would you define your intrinsic motivation towards the use of mobile devices in class? (1. Very small, 2. Small, 3 Neither small nor big, 4. Big, 5. Very big)
- Comparing learning with mobile devices and traditional instructor based classes, what do you enjoy most? (Learning with mobile devices: 1. Much less, 2. Less, 3 The same, 4. More, 5. Much more)
- Would you be willing to do a second experiment like this in the future? (1. Strongly disagree, 2. Disagree, 3 Neither agree or disagree, 4. Agree, 5. Strongly Agree)

Table VI captures the answers of students. Students recognized that they were motivated by the use of mobile devices in class. Similar results are presented in [10] for the use of mobile phones and podcasts. However, students reported that they did not clearly prefer learning with mobile devices instead of learning in a traditional environment. Finally, students said that they would enjoy doing a similar experiment a second time.

TABLE VI. ANSWER OF THE STUDENTS TO MOTIVATION QUESTIONS

Questions	1	2	3	4	5	Mean
1	0	0.08	0.34	0.5	0.08	3.58
2	0	0.17	0.58	0.25	0	3.08
3	0	0.08	0.17	0.5	0.25	3.92

V. CONCLUSIONS

This paper has analyzed the use of mobile phones as a replacement of a human instructor for situated learning environments both in terms of learning gains and motivational impacts. Data from two experiments with third year Telecommunication Engineering students inside the “advanced telematic applications” course at the Carlos III University of Madrid have been presented.

The experiments have shown that students’ learning gains are similar in both cases. Replacing the presence of a human instructor by mobile devices interacting with tagged objects does not imply a detriment to the learning gain of the students. However, new flexibilities in terms of time management are introduced allowing students to learn when it is more appropriate for them and at the same time decreasing the burden of the instructor of the course.

The experiments have also shown that students are intrinsically motivated to learn using mobile devices. However, when the presence of the instructor is completely removed from the class, the intrinsic motivation of the student to use mobile devices is similar to the intrinsic motivation in a traditional learning environment with an instructor given lectures and no mobile devices in place.

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