The Teaching-Learning Process in the Classroom Using Smartphones: Challenges and Opportunities

I. INTRODUCTION

As members of the information society, everyone living in today's digital age assumes that reading a print newspaper is just a personal habit or routine that has little to do with the latest information being generated at the moment. It is widely known that, in the eight hours between when a newspaper comes off the press and when it reaches the vendors, breaking news has probably become ancient history. The world advances at breakneck speed, and all types of information-generating and information-gathering processes must stay flexible and versatile, or they soon become obsolete.

On the other hand, young people and students constitute the social group most caught up in the vertigo of today's society. If they are not constantly connected to a social network, a group of friends, or certain multidisciplinary or cultural platforms, they feel distanced from the world surrounding them—a bit isolated. Many personal activities that, until a short time ago, were done alone and in private now take place in vast virtual spaces where many others are present—and from within our own bedroom. Thus, interaction and ongoing intercommunication are a vital element of society.

As an academic institution that holds a society together in the present and projects its future, the university cannot be—and, in fact, is not—ignorant of these circumstances. Thus, whenever present-day technology has been adapted to the world of teaching, it is always an unmistakable sign of opportunity and an indication that the different disciplines at the university are up-to-date. As an organization, the university must evolve in parallel with society and, to do so, must know how to take advantage of the tools available in society that support its objectives: teaching and research. The university's ability to evolve and adapt, however, turns into complexity and stagnation when it comes to managing and even generating student test results, whether for evaluation purposes or not. It is in this context that the TASCA group [Tools and Strategies for Competences Assessment] is working toward integrating the currently existing technological resources with the teaching-learning process—specifically, immediate evaluation feedback (Ballester, 2011).

One of the steps taken to achieve this objective is creating tools with which students can connect to the UPV e-learning platform (PoliformaT) to complete simple surveys as well as ask more complex questions without needing to have a computer or any special hardware—for these tools are accessible online with a mobile device from any university classroom. There are systems known as Classroom/Student/Audience Response Systems (ARS) that are commercially available from EduClik (http://educlick.es), eInstruction (http://www.einstruction.com/), and SMART Technologies (http://smarttech.com/us), for example, and offer functionalities similar to the proposal for maintaining interactivity between presenter and audience. Figure 1 shows the basic architecture of these solutions. In essence, the presenter has a computer and a projector for showing the audience transparencies that support the lecture. In addition, the presenter has specially-designed software for introducing questions, such as true/false or multiple choice, that the audience must answer about the transparencies. The audience does so using a wireless device commonly known as a *clicker* (see Figure 2), which audience members receive at the beginning of the presentation.

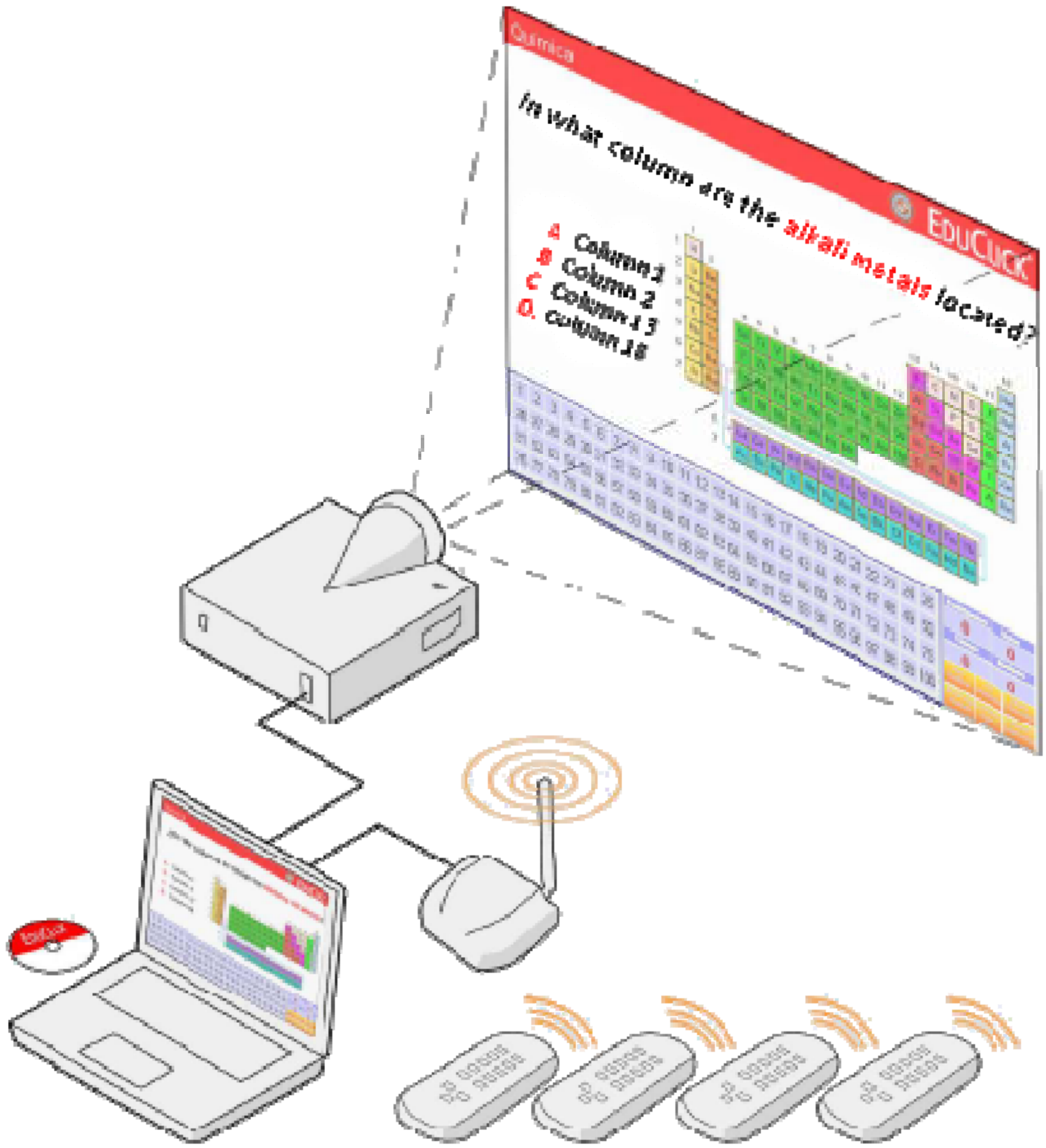

Figure 1. Basic architecture of Audience Response Systems.

Figure 2. Examples of commercially available clickers.

However, despite the wonderful instructional capabilities afforded by this type of system, a number of impediments make it difficult to apply them universally. Among these should be highlighted, on the one hand, the great difficulty involved in developing effective and motivating multiple-choice questions (Case, 2002) and the faculty's adaptation to using questions as a methodological tool. On the other hand, there can be insurmountable problems related to the equipment required and integrating it with the existing infrastructure. The average cost of a kit consisting of a receiver and 30 clickers is about $2,000, so from an economic standpoint, it would not be feasible to fully equip all UPV classrooms. Likewise, maintenance (batteries) and repair costs for these devices as well as costs of theft and loss must be taken into account. Moreover, because these are typically infrared or radiofrequency devices, configuration or poor performance issues may arise that are related to the existing infrastructure or conditions in the classroom. Lastly, integration with the *Learning Management System* (LMS) used—PoliformaT (a Sakai-based system, http://www.sakaiproject.org/) in the case of UPV—may be no small matter requiring continuous fine-tuning, and this could mean a considerable increase in the final cost of the system.

For all these reasons, the TASCA group proposes to implement reduced-cost alternatives to ARS by taking advantage of the university's existing infrastructure. The success of this initiative depends primarily on the proposed solution being economically feasible for the institution and involving no additional expense for students. Thus, the most practical solution, financially speaking, would be to use connectivity devices that students themselves already own and usually have with them in the classroom (smartphones, tablets, and netbooks, among others). Another consideration is that secure and no-cost Internet connectivity must be available. The infrastructure already in place supporting UPV's wireless networks would contribute these features—access to these networks is free for UPV students, and to get access via a secure connection, university credentials are required for user authentication.

II. Bring Your Own Device: opportunities, benefits, and applicability

The TASCA group's gamble—as risky as it is interesting—is not only the fact of using technology, in and of itself, but also placing the current technology's advantages and applications in service to the faculty. The advantage, namely, is its widespread use in society, thanks to its low acquisition and maintenance costs, its ease of use, its flexibility and immediacy in responding and communicating, and its versatility and multifunctionality. As Bain points out (Bain, 2005), this is a matter of creating, from the outset, an environment that facilitates natural critical learning. It appears that placing these technologies in service to the educator's task and capitalizing on their enormous potential for completing various evaluation tests (questions, questionnaires, objective tests, tests, practices, problems, analyses, individual, in groups, etc.) would guarantee improvement in instructional outcomes.

The phrase *Bring Your Own Device* (BYOD) refers to employees using their own mobile devices (portable computers, tablets, and smartphones) to access company resources, such as databases and email, as part of doing their job. Various studies (Citrix, 2011) show that, currently, this is a phenomenon that has spread to 92% of companies, with about 28% of employees using their own devices on the job—a figure expected to reach 35% in 2013.

The main advantages of BYOD policies include 1) the ease of doing out-of-office work; 2) the reduction in expenses for maintaining devices and training personnel to use them; 3) personnel being properly equipped; and 4) the ease of handling the proliferation of different devices.

Because of these advantages, the phenomenon is currently infiltrating various sectors of society and, not surprisingly, education is one of those sectors (LaMaster, 2012). The primary aspects to be taken into consideration when applying BYOD policies in the educational setting (Center, 2011) are those related to training faculty, the infrastructure required (bandwidth, service quality, security policies) and, of course, the availability of mobile devices among students—this aspect being the one that could limit the applicability of BYOD policies as an alternative to conventional ARS.

As shown in Figure 3, according to a study (Vision, 2001) of the penetration of smartphones—mobile phones with advanced communication and computing capabilities—63% of North American users and 51% of European users have this type of device. These data for the population as a whole find their reflection in various studies conducted with high school and college students (Yarmey, 2012), which show an even higher level of penetration among young people and students.

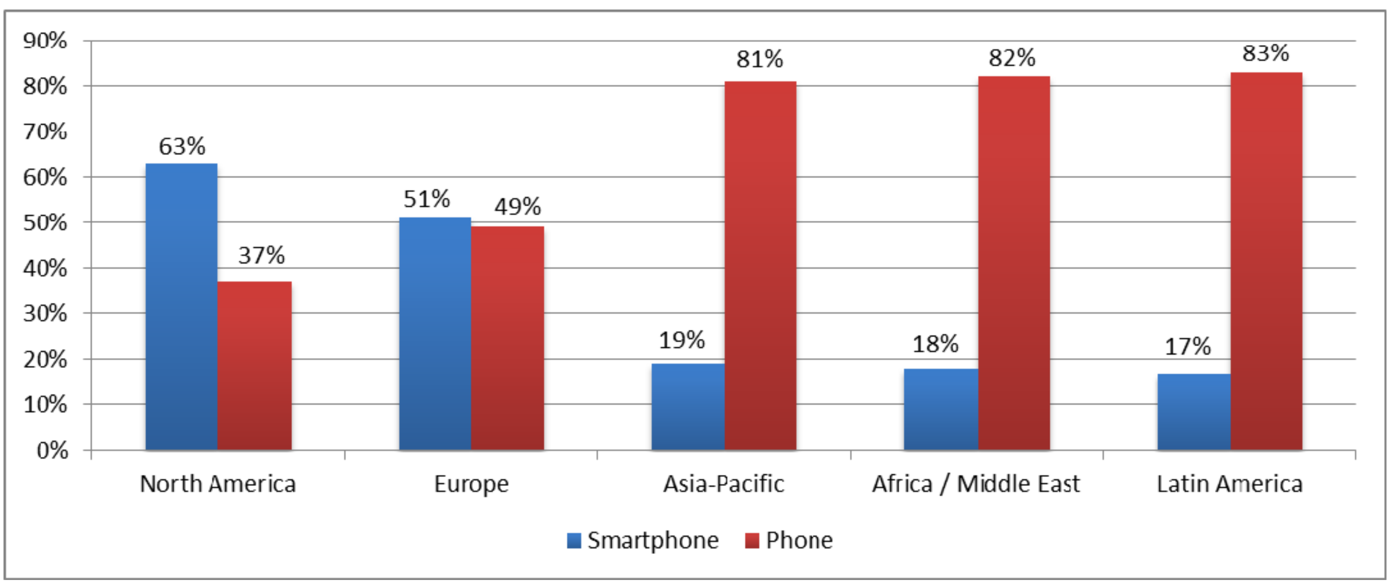

Figure 3. Smartphone market penetration.

Thus, the objective of the TASCA group's current project is the development and utilization of a computer support that would make it possible for students to respond via their mobile devices to surveys or multiple-choice questions the professor presents in on-campus classes. Through use of mobile terminals—currently used by the majority—an attempt is made to stimulate the student's in-class motivation and participation. Likewise, an attempt is made to facilitate and accelerate the obtaining and presentation of evaluation results, for once the survey is completed via the mobile device, the results would be available instantly. Among the benefits for the educator's task (Bruff, 2009), the following should be pointed out:

- Promoting the student's active in-class participation (Martyn, 2007). Currently, in an on-campus class with a large number of students, getting the student actively involved in the class can sometimes be complicated—especially in those cases where the professor gives the students open surveys or questions. Likewise, the evaluation process in this case is incomplete because neither the professor nor the student has the exact survey participation data—the number of correct and incorrect responses. The anonymous, discreet, and informal nature of the tests can also encourage participation of a timid, lazy, or passive student by creating a relaxed, interactive learning environment (Draper, 2004).
- Both the student and the professor receive immediate feedback on the teaching-learning process, which allows greater tracking of the student's learning (Taras, 2002) and promotes independent learning on the student's part. The student's academic performance improves with greater involvement in the class. In addition, it allows for checking students' level of comprehension and adapting the class so that the main aspects addressed may be clarified (immediate feedback). Learning deficiencies are immediately detected (Patry, 2009).
- Integrating and streamlining continuous, instructive, in-class evaluation of the teaching-learning process, where testing becomes a natural, routine part of instruction—loses its status as a special event and becomes something ordinary, as opposed to the slow and rigid procedure of traditional systems that always takes on too much importance and has too much control over how learning takes place (Boyd, 1985).
- A record of the results is obtained, which can be analyzed, managed, and handled for the purpose of achieving other objectives (Mohanan, 2005). It is possible to obtain a list of attendees; an indicator that assesses the results (progress, graphics…); permanent references of the evaluation process, including self-evaluation; and instantaneous data on particular critical or intermediate points in the learning process In short, it can have whatever degree of responsibility the professor considers appropriate, giving the corresponding weight on the final evaluation.
- The student takes part in post-test comments, with the results obtained. A space for reflection immediately after taking the test is generated, which is fundamental in the learning process. It is important to bear in mind that a task twice corrected is preferable to two different exercises (Morales, 2000). The more corrections a student receives, the more his analytical and critical skills develop and the more useful and effective this process of immediate feedback becomes.

All these advantages and benefits as well as the application of technological tools are of little relevance, however, unless appropriate and realistic strategies for the learning system are researched, planned, and designed. Advanced and relatively affordable technology must be a useful instrument that serves instruction and never the other way around—instruction should not be adapted to technology, nor should technology become an end in itself.

III. FEEDBACK (QUESTIONS) AS A DRIVING FORCE IN TEACHING METHODOLOGY

It is worth pointing out that any type of test/question can potentially serve as the driving force in the proposed teaching methodology and is, therefore, amenable to this instantaneous feedback system; its objectives, the timing of its use, and the handling of the results must be clearly defined, however. As already stated above, technology is in the service of pedagogy, which means that the presentation of tests will be defined by pre-established academic objectives—never will testing be adapted to the tool simply because it is there to be used or "taken advantage of."

The first step is to define the tests that are to be developed as a methodological tool. The TASCA group is approaching this issue by researching the most relevant features of different types of tests to establish valid and reliable guidelines and possible uses of these tests in the teaching context (Peña, 2012). It stands to reason that a wide array of possible test/question models should be covered so that they can then be adapted for the different disciplines, teaching styles, and learning objectives established (Bloom, 1956). Achieving this requires a proper methodological approach, of course—painstaking test planning and preparation, with its parts clearly structured and the explanation suitably expressive and clear so that presentation of the content is interesting enough to motivate students to learn the knowledge on the subject addressed. Above all, however, it must be an approach that overcomes passivity and portrays the session as a time of creative intellectual activity. Tests should be active, if, during sessions, there are certain times when the professor stops speaking so that students may speak, work, and elaborate knowledge. Moments for reflection, discussion, presentation, individual or group activities, for which it is absolutely necessary to prepare work materials and design tasks in advance to be interspersed between the parts.

A good test must allow time for doubt—doubt shown in the form of a question. A well-formulated question must fascinate the student, must force the student to respond by being impossible to ignore. It is crucial to comprehend that the question must match the student's interest—not the professor's interest. It must be inspired by the instructional objectives being followed and favor their achievement. It is also necessary to prepare subjective tests with different responses that lend themselves to debate for stimulating the student's critical skills when we are working with small, informal groups. It is also important to highlight that

there are various types of tests designed to enhance different aspects of knowledge. In this regard, it is essential to understand that we should choose different moments to present different objectives.
Each test may be utilized at a time the professor deems appropriate, depending on the objectives and approaches. So, given the different functions each of these parts has in promoting class participation, the type of testing chosen will vary.
Tests will be given to verify whether the previous session's content was understood and to what extent the suggested memorization tasks, analyses, readings, etc., have been completed. Tests or questions will be used that require memory, since this has to do with evaluating the lowest levels of Bloom's taxonomy: recall, recognize, identify.
Other tests to make the class more dynamic and participatory, being a very effective instrument for keeping students keenly interested. In addition, the primary objective of questions, at this point, should be to determine exactly what the students are comprehending of what the professor is attempting to explain. It will also serve to reinforce the content or it may bring doubts to light, and then the student may evaluate and verbalize them.
There will be tests that require comprehension skills to be activated—writing, association-differentiation, explaining, interpreting, describing, etc. And others that will require problem-solving, giving examples, and, in general, applying knowledge in cases assigned for practice.
At another scheduled time, tests will be needed for a concise review of the main points explained in the lecture. Also to find out how much of what was explained has been assimilated, or even to suggest points related to the subject matter that have not been addressed.
Also tests will be prepared that require blending/integrating skills: integrating concepts, combining, developing, improving, making suppositions or predictions, concluding, summarizing, etc. But also questions that fuel analysis using actions such as demonstrating, reasoning, arguing, inferring, organizing, etc. Lastly, questions or tests that demand assessment skills will also be useful: judging, evaluating, defending, criticizing, appreciating, selecting, deducing, deciding priorities, etc. With all the results obtained from the tests, the teacher will decide how to manage and use them, depending on the established plan or the results themselves.

IV. ANALYSIS OF THE LEVEL OF MOBILE DEVICE PENETRATION AMONG UPV STUDENTS

To estimate smartphone penetration not only university-wide but also by schools and by degree programs, the TASCA group developed a questionnaire (Ballester, 2011) to collect information on all courses taught by members of the team.

A. Survey Description

First of all, *type of mobile device*, which will provide information on characteristics of the presentation layer or the screens for interacting with the platform so that they can be adapted to the device's screen size, since the smartphone's display capabilities, resolution, and screen size are not the same as that of a tablet or netbook.
The second factor to consider is the *device's software platform or operating system*, which will condition the technical features and compatibility requirements to be met by the software used to develop the application. An example of incompatibility would be developments that use the Adobe® Flash® tool, which cannot be displayed on Apple® platforms.
Lastly, *connectivity* capabilities will confirm the extent to which it is possible to connect to one of the wireless networks available at UPV and will determine the need to find alternatives.
For each of these parameters, the most common existing options were identified, and on this basis the student survey was defined, as shown in Figure 4.

Type of mobile device	**Operating system**	**Data transmission capacity**
☐ Phone (Smartphone)	☐ iOS (iPhone y iPad)	☐ 3G
☐ Tablet	☐ Android	☐ WiFi
☐ Laptop	☐ Windows Phone 7	☐ Bluetooth
☐ None	☐ RIM Blackberry	☐ None
	☐ Symbian	
	☐ Other	

Figure 4. Survey form.

B. Courses

In an attempt to obtain valid results that were consistent with the diversity of UPV student profiles, it was necessary to conduct the survey among students in different courses and degree programs. In this phase of the project, only a few courses were selected: those taught by TASCA group members during the first term of the 2011-2012 academic year. The surveys were given in the following courses:

- **Database Design and Management** (DDM 1). 3rd year. Internship. Computer Science Faculty.
- **Database Design and Management** (DDM 2). 3rd year. Internship. Computer Science Technical School (*EUITI* [Spanish acronym]).
- **Telecommunications System Planning** (TSP). 3rd year. Theory. Telecommunications. Superior Polytechnical School of Gandía (EPSG [Spanish acronym]).
- **Mobile-Device-Based Applications Design** (MAD). 5th year. Theory and Practice. Superior Technical School of Computer Science (ETSINF [Spanish acronym]).
- **Computer Network Security and Reliability** (NSR). Masters in Computer Engineering. Theory and Practice. Superior Technical School of Computer Science (ETSINF [Spanish acronym]).
- **Social Research Technique** (SRT). 1st year. Theory and Practice. Business Administration and Management Faculty (FADE [Spanish acronym]).

Table 1 shows the number of student surveys completed in each case:

DDM 1	**DDM 2**	**TSP**	**MAD**	**NSR**	**SRT**	**Total**
9	19	12	24	6	57	127

Table 1. Number of UPV students who participated in the survey.

A total of 127 surveys were completed, which may be considered a sufficient number for this phase of the project, where the objective was only to get a very general idea of the types of devices at UPV, their operating systems, and their connectivity capabilities. In subsequent phases of the project, it would be advisable to conduct surveys in additional courses and degree programs to get better coverage of the broad spectrum of UPV students; this would allow comparisons to be made, for example, between different degree programs and student profiles.

C. Results

The proposal's viability can be determined through analysis of the data collected because both the level of mobile device penetration and the use of wireless communications will facilitate implementation and use of the tool developed to support the proposed teaching methodology.

To be specific, and as shown in Figure 5, about 80% of students surveyed have a mobile phone with advanced features (smartphone), and about 50% bring their own portable computer to class. Thus, despite the fact that not all students would be able to participate in the proposed activities, it would indeed be possible to sample a significant portion of the class or have them work in pairs, for example, to facilitate participation of the entire class.

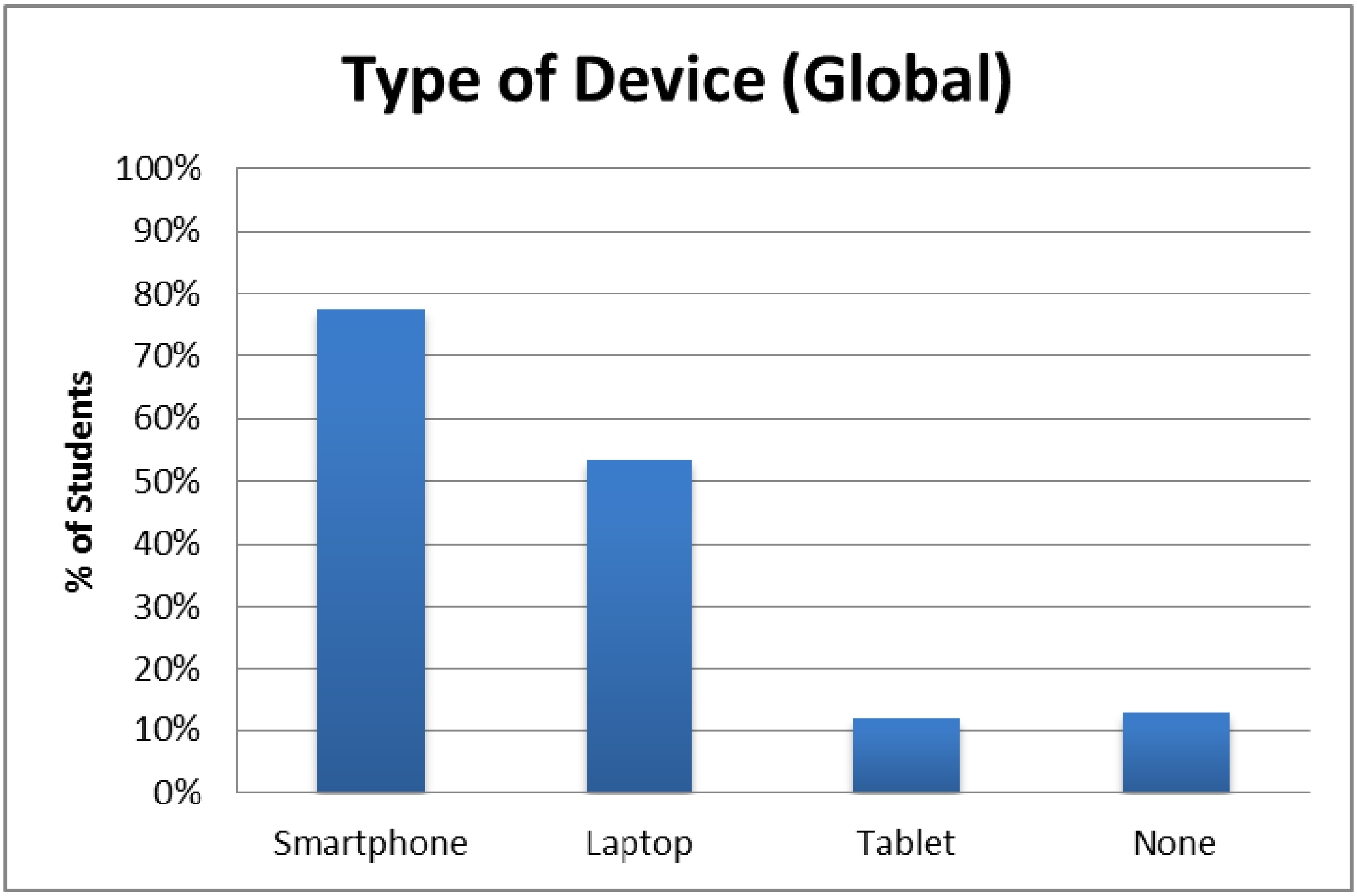

Figure 5. Type of mobile device UPV students have available.

With regard to the main operating system used in smartphones, we can point out, as shown in Figure 6, that Android is the most popular, with iOS a distant second. This is as expected for students, owing to the low cost of Android terminals compared to the high cost of iPhone devices. Based on these data, the dilemma lies between 1) developing a native application for Android that could capitalize on this device's capabilities, though it would be impossible to use other kinds of terminals, and 2) developing a multi-platform application that would allow any kind of terminal to be used, though we would not be able to access specific functionalities of the device or adapt the tool precisely to its screen characteristics. Bearing in mind the objective of enabling the greatest possible number of students to actively participate, it was decided to adopt the second of these options and take a multi-platform approach.

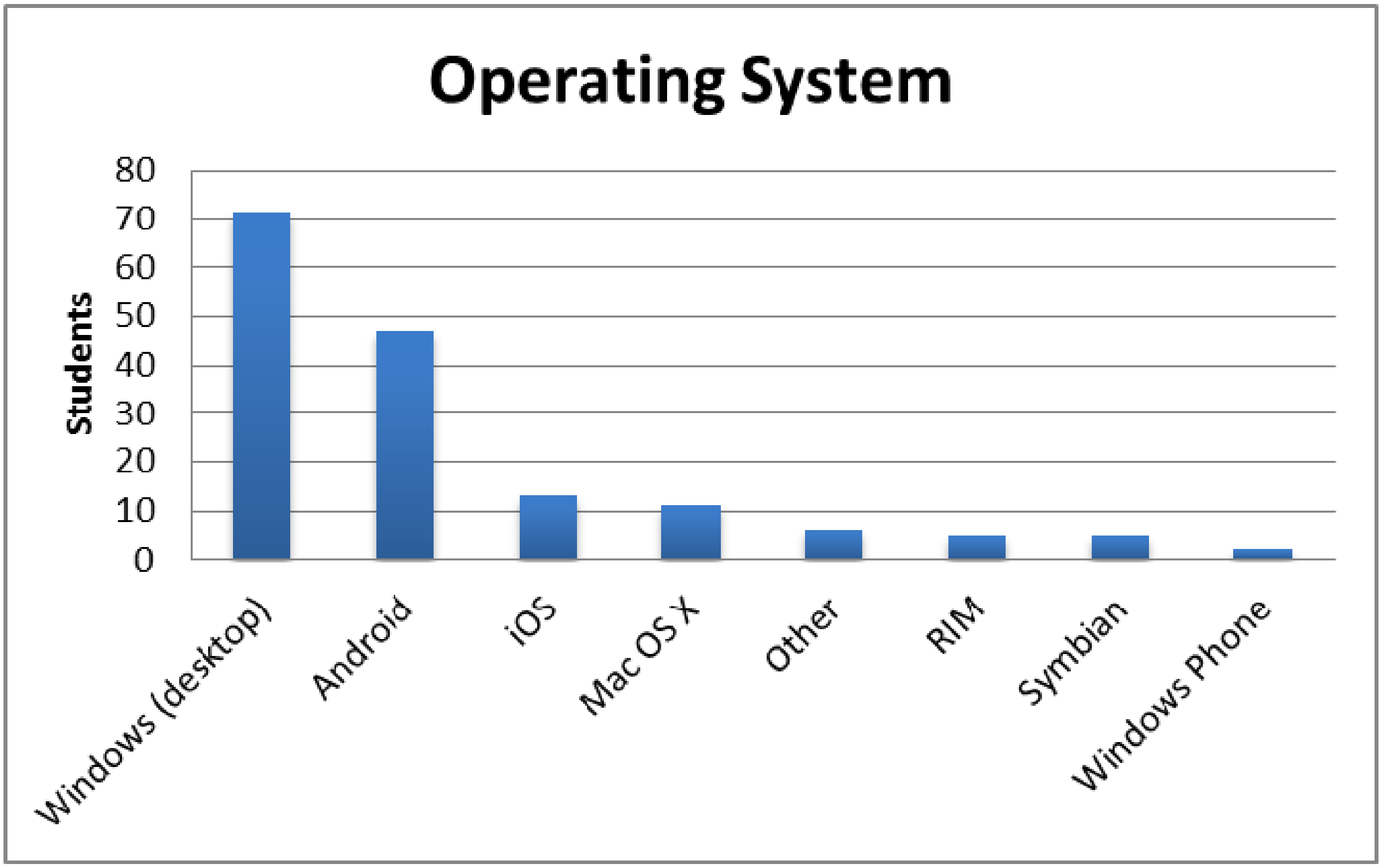

Figure 6. Operating system of mobile devices UPV students have available.

Lastly, and as shown in Figure 7, almost 80% of students use WiFi communications as the primary means of exchanging information with their mobile devices. What is more surprising is that almost 50% of them also use 3G technologies for information exchange, which shows the high degree of penetration of the various mobile phone service providers' data plans, and surely this figure will increase considerably in the near future. This means that the option to use UPV wireless networks for conducting surveys is guaranteed, so there will be no need for students to make any investment whatsoever for communications (as is the case with 3G technology).

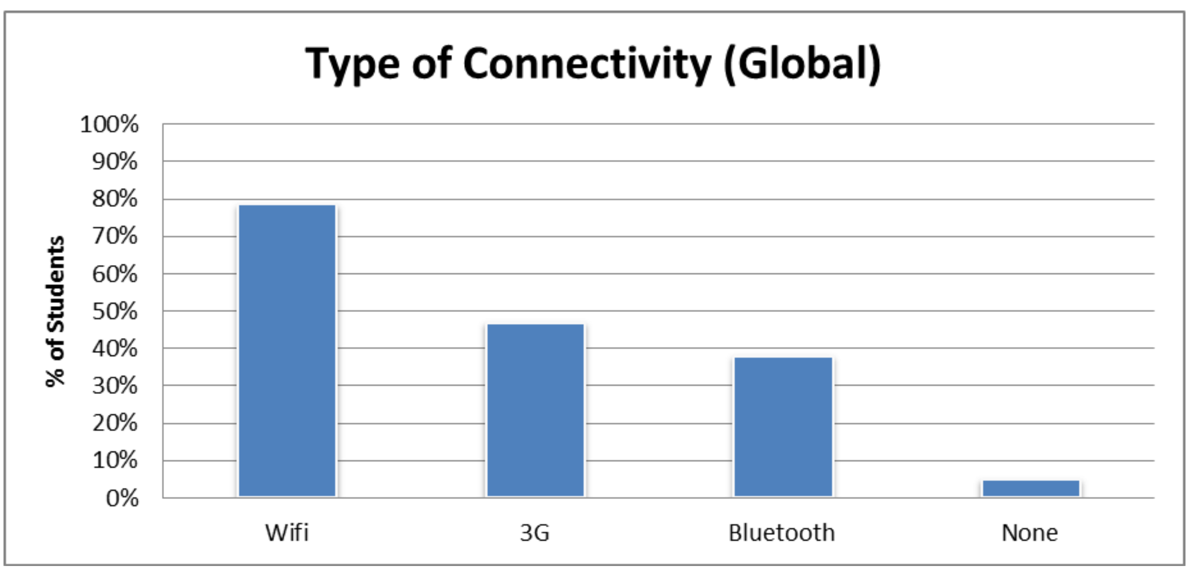

Figure 7. Connectivity used by UPV students with their mobile devices.

So, the results obtained show clearly that, based on the UPV student context, the proposal made is viable. It will be necessary to develop a multi-platform mobile application for accessing UPV's e-learning environment (PoliformaT) so that students can retrieve and respond to questions the professor makes available on this platform.

V. MULTI-PLATFORM MOBILE APPLICATION AS AN ALTERNATIVE TO CONVENTIONAL AUDIENCE RESPONSE SYSTEMS

UPV's e-learning platform PoliformaT (Sakai-based system) already has tools for presenting questions: *Polls* for simple questionnaires and *Test & Quizzes* for more complex questionnaires. So, needing nothing more than a mobile device with wireless communication capabilities, students could access PoliformaT's web interface, via UPV's wireless network, and respond to questionnaires posted there.

A. Accessing PoliformaT from a smartphone via the Web

PoliformaT offers a web interface that is adapted to conventional computers but not to tablet-type devices or smartphones. Accessing a questionnaire on PoliformaT from a smartphone via the Web is not very practical because the content is not adapted for the device's characteristics; as Figure 8 shows, in order to navigate and use content comfortably, the screen must be continually resized (every time a new link is accessed).

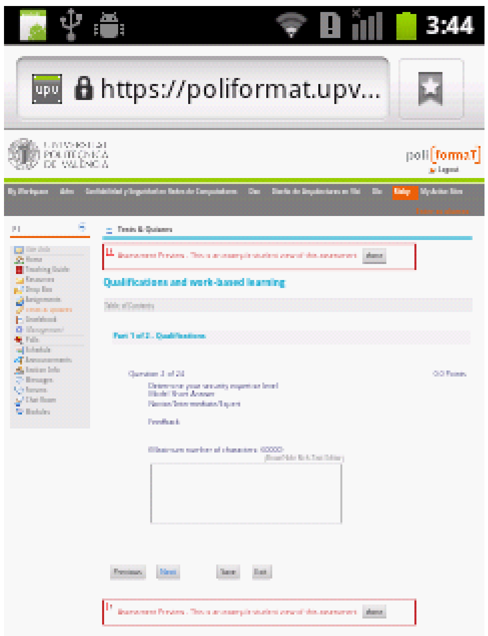

Figure 8. PoliformaT questionnaire on a smartphone. 3.2-inch screen. Full View mode (actual size).

To solve these problems, PoliformaT has a stylesheet-based view for mobile devices. These views are not fully developed for all the tools, however, so accessing questionnaires is still not very practical and using them regularly in teaching is not feasible (see Figure 9).

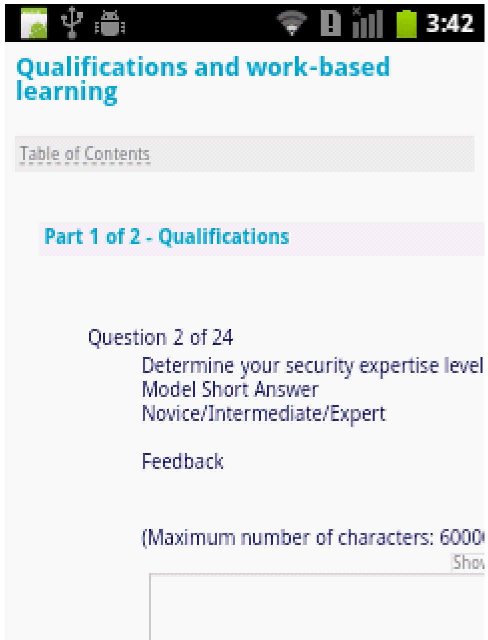

Figure 9. PoliformaT questionnaire on a *smartphone*. 3.2-inch screen. Mobile View mode (actual size).

In view of all these issues, the TASCA group has detected the need of developing an application for smartphones that acts as an interface toward PoliformaT content—questionnaires, specifically—allowing it to be properly displayed on this type of device. Similar initiatives, such as CLE-Mobile (https://confluence.sakaiproject.org/display/CLEMBL/Home) and Mobile Oxford (http://m.ox.ac.uk/), allow partial access to the tools provided but are still under development.

B. Accessing PoliformaT via a smartphone application

The wide variety of operating systems available for smartphones, such as iOS (Apple, http://www.apple.com/ios/), Android (Google, http://www.android.com/), and Windows Phone (Microsoft, http://www.microsoft.com/windowsphone/), means that many native applications would have to be developed for each operating system taken into account. Consequently, it would be very costly to update all these different applications to introduce improvements and changes. This would be the price to pay, however, to make the application usable for the majority of smartphone users. As an alternative to developing native applications, and to avoid problems associated with market fragmentation, the concept of a *mobile web application* has emerged (Power, 2011). This type of application is stored on a web server, where the smartphone can access and download it and then execute it in the device's web navigator. In this way, using web technologies, such as *HyperText Markup Language 5* (HTML5), *JavaScript*, and *Cascading Style Sheets* (CSS), the following benefits are obtained: 1) the applications can be executed on any device and with any operating system; 2) a single implementation is available, which facilitates maintaining and updating it; and 3) the time and cost of personnel training and development are lower because these technologies are widely used and personnel will be productive from the very first moment. The main drawbacks are that people usually are not accustomed to being able to access all of the hardware capabilities available on the device; that the look and feel of the application is not identical to that of native applications; and that its performance may be degraded. In the situation that concerns us, however, none of these drawbacks really matters because of the simplicity of the application to be developed. Among the frameworks supporting development of mobile web applications, such as LungoJS (http://www.lungojs.com/), Sencha Touch (http://www.sencha.com), and JQuery Mobile (http://www.jquerymobile.com), the latter is the one that has been chosen for development of the application required.

Integrating this tool with PoliformaT (Sakai) requires that a *proxy* be developed for accessing the web services available on this platform so that students can be identified, the courses they are enrolled in can be determined, and the questionnaires available in those courses can be retrieved. This information will be displayed on the student's mobile device, and the student will then be able to complete the questionnaires, check the results of questionnaires already completed, save the questionnaires on the mobile device itself so that they can be completed offline at any time, and transmit the results of questionnaires completed offline to the server for storage and correction. The architecture defined for this solution is shown in Figure 10.

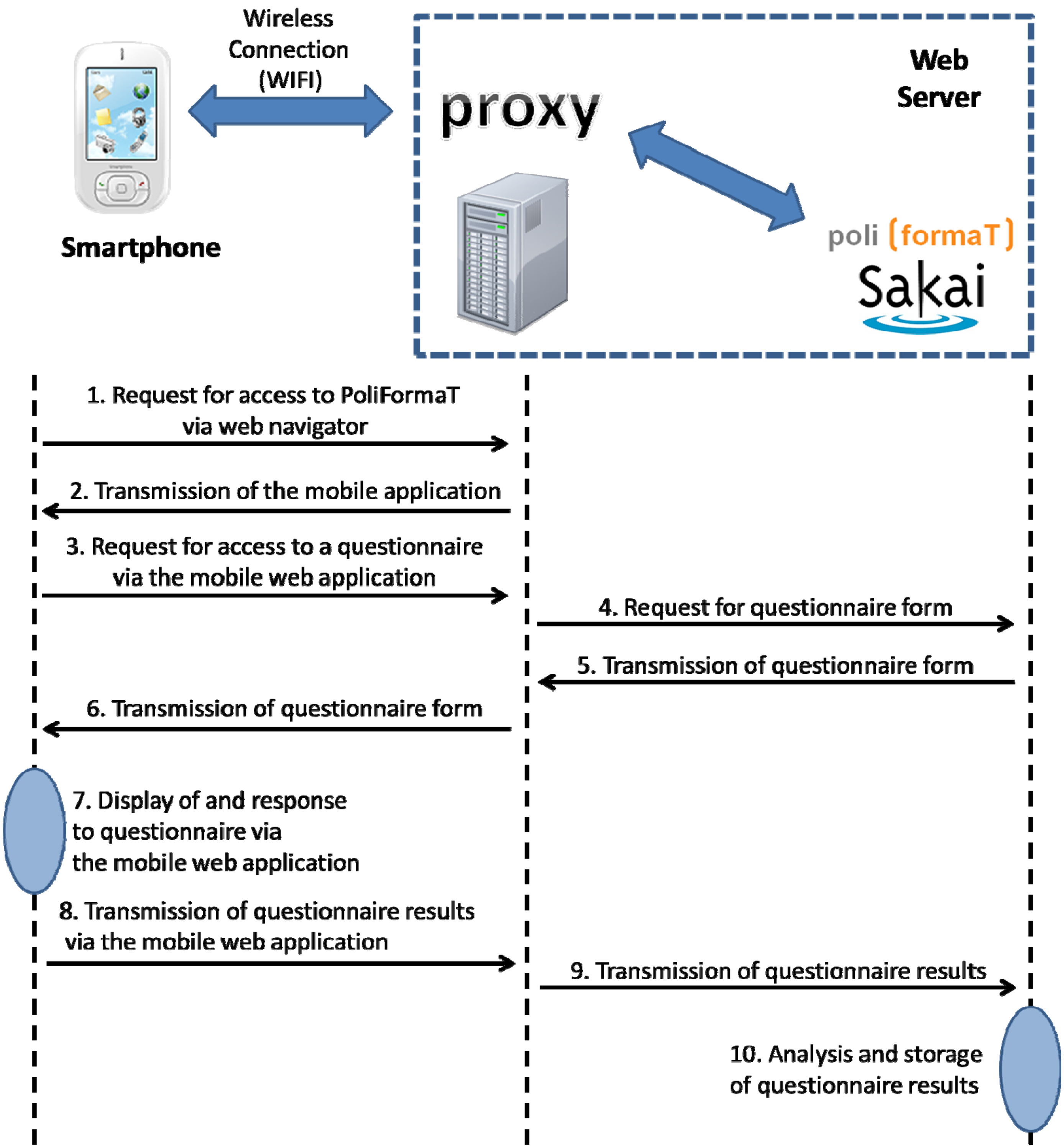

Figure 10. Architecture of the solution proposed to facilitate integration of mobile applications with PoliformaT.

Figure 11 shows how the application developed adapts the questionnaire to be displayed to the capabilities of the mobile device being used and displays it in the best possible mode so that the user may respond to the questions presented.

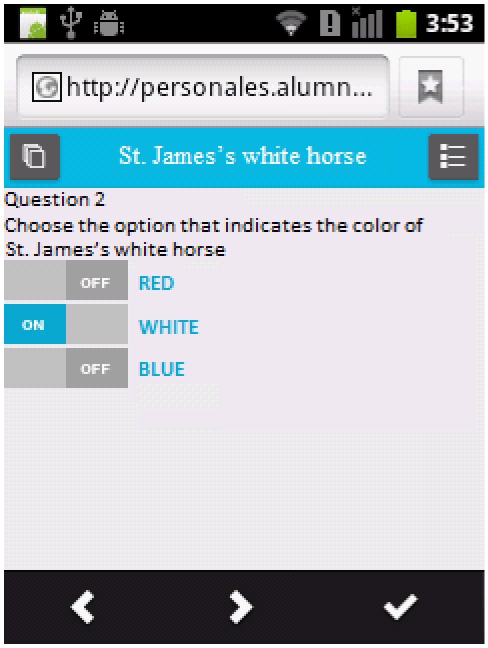

Figure 11. PoliformaT questionnaire on a smartphone. 3.2-inch screen. TASCA prototype (actual size).

VI. RESULTS OBTAINED ON TESTING OF THE FIRST PROTOTYPE OF THE TOOL DEVELOPED

A demonstration of the first prototype of the tool was given at the *Jornadas de Innovación Educativa* [Innovations in Education Conference] held at UPV in 2012 to confirm that the tool was functioning properly, to show its existence and capabilities to other UPV professors, and to find out their impression of it and gather indications of possible interest in using it.

For this demonstration, professors belonging to the other UPV Innovation and Educational Quality Teams were provided with a smartphone and a tablet they could use (if they did not have their own device) to access the questionnaire that had been prepared. This questionnaire consisted of three questions designed to determine 1) what use UPV professors make of questions in their teaching methodology so as to be able to determine the scope and opportunity for use of this tool; 2) an estimate of the number of students in these professors' courses who have a smartphone, to validate the results obtained on the first survey conducted; and 3) the actual interest among faculty in participating in pilot testing of the tool. A total of 14 professors representing the various UPV Innovation and Educational Quality Teams participated in the demonstration and used the tool to complete the survey.

As shown in Figure 12, the results obtained for the first question indicate that 57% of faculty use questions to get feedback from their students, on the basis of which they can correct the direction of the class, as necessary. Despite the fact that this appears to indicate a promising future for use of the proposed tool and methodology, it should be pointed out that 36% of faculty do not use questions as a pedagogical resource; besides being worrisome, this indicates that effort will have to be put into training courses to motivate professors, for example, and make them aware of the importance of using questions as a methodological tool in their classes.

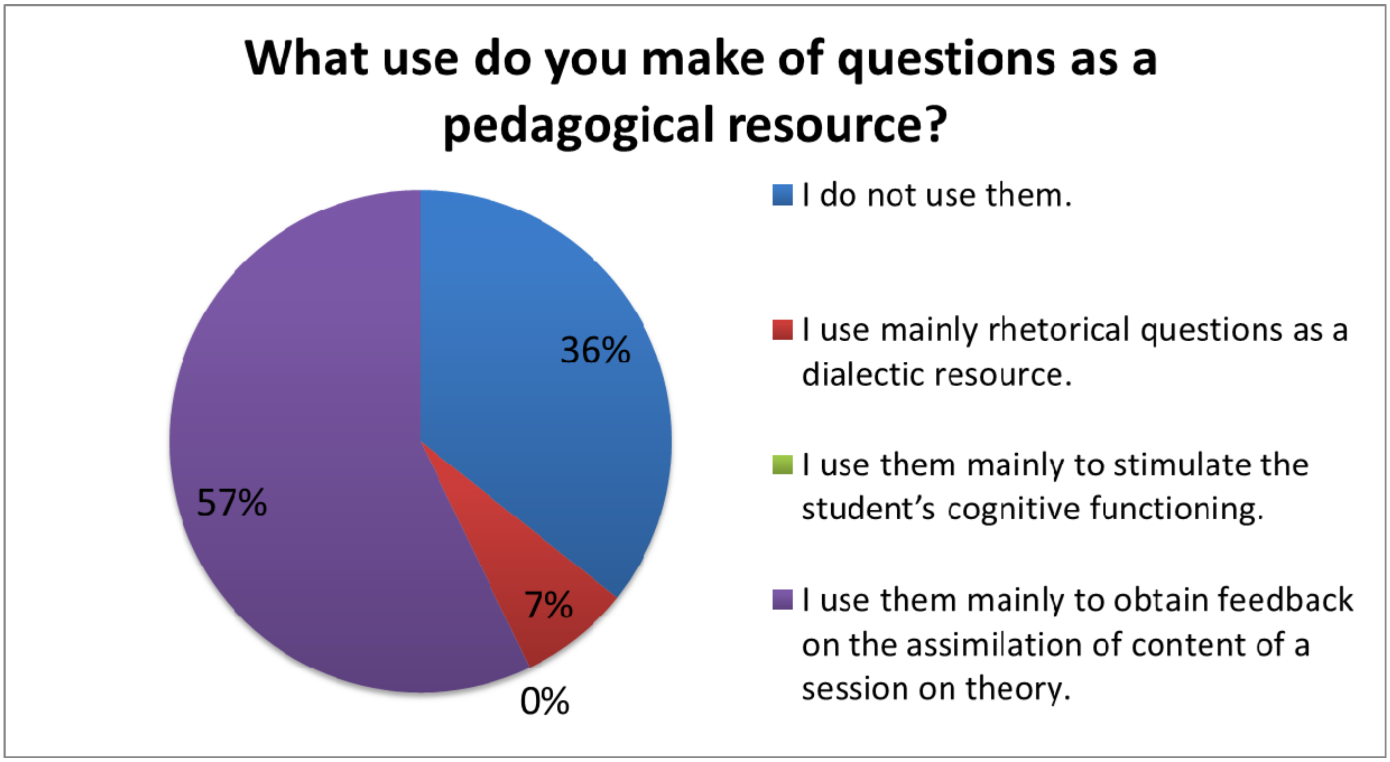

Figure 12. Use of questions as a pedagogical resource at UPV.

Based on the percentage of students at UPV who have a smartphone (see Figure 13), we may conclude that the estimate obtained on the first student survey conducted was meaningful. Almost all the professors who participated in the survey believed that more than 50% of students have a mobile device with the capabilities necessary to be integrated into the proposed methodology. Only two professors indicated a lower percentage of students, which perhaps could be attributed to UPV degree programs with less technological profiles, such as Fine Arts and Business Administration. These data demonstrate that using the existing infrastructure to integrate student-owned mobile devices into everyday teaching practice is a viable proposal.

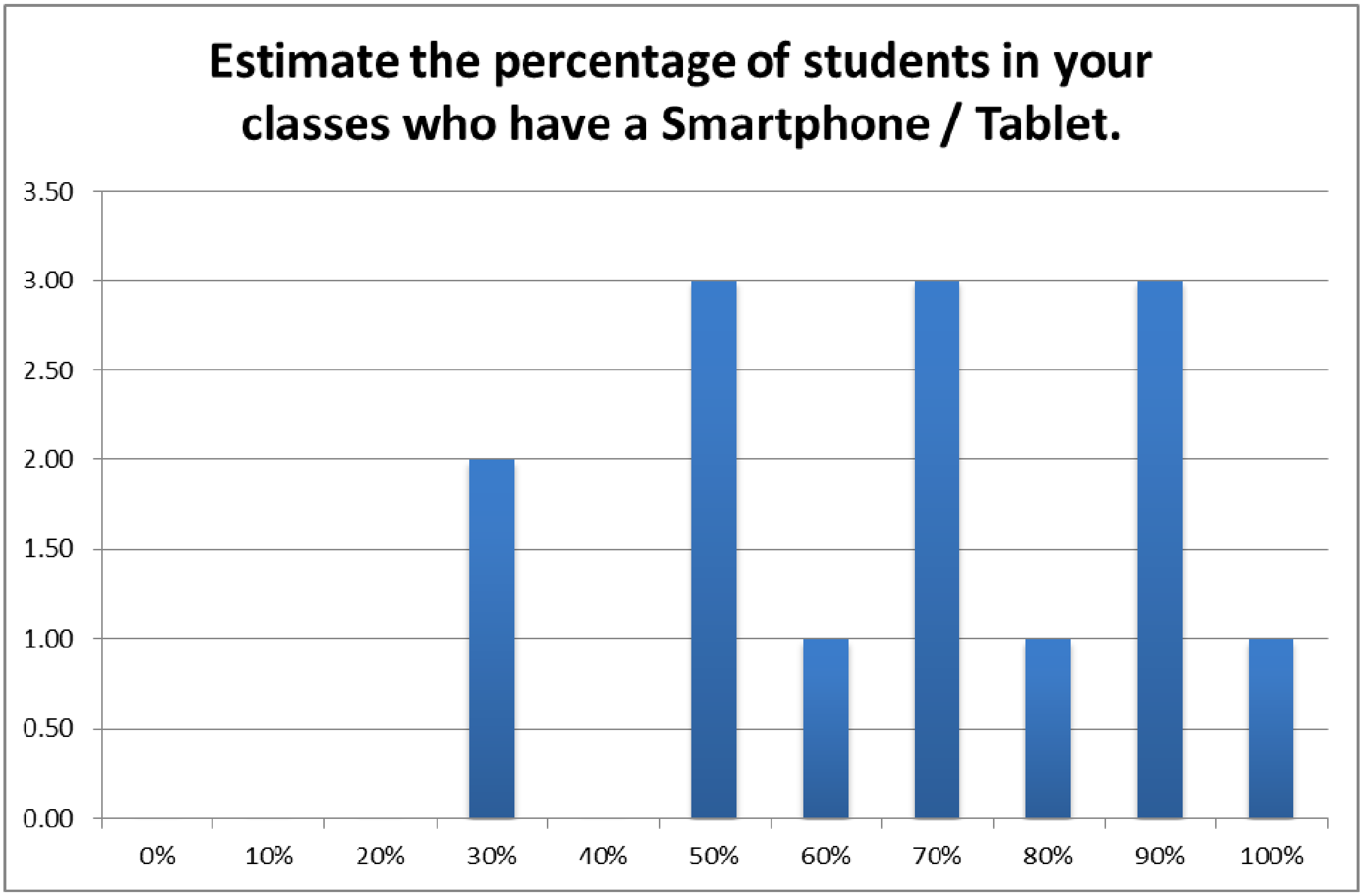

Figure 13. Estimate of the percentage of UPV students who have a smartphone.

Lastly, as shown in Figure 14, almost 80% of the faculty who participated would be willing to participate in launching the tool and doing the appropriate testing in their classes. This shows the motivation and interest aroused by the tool we hope to integrate into teaching practice during the upcoming 2012-2013 academic year.

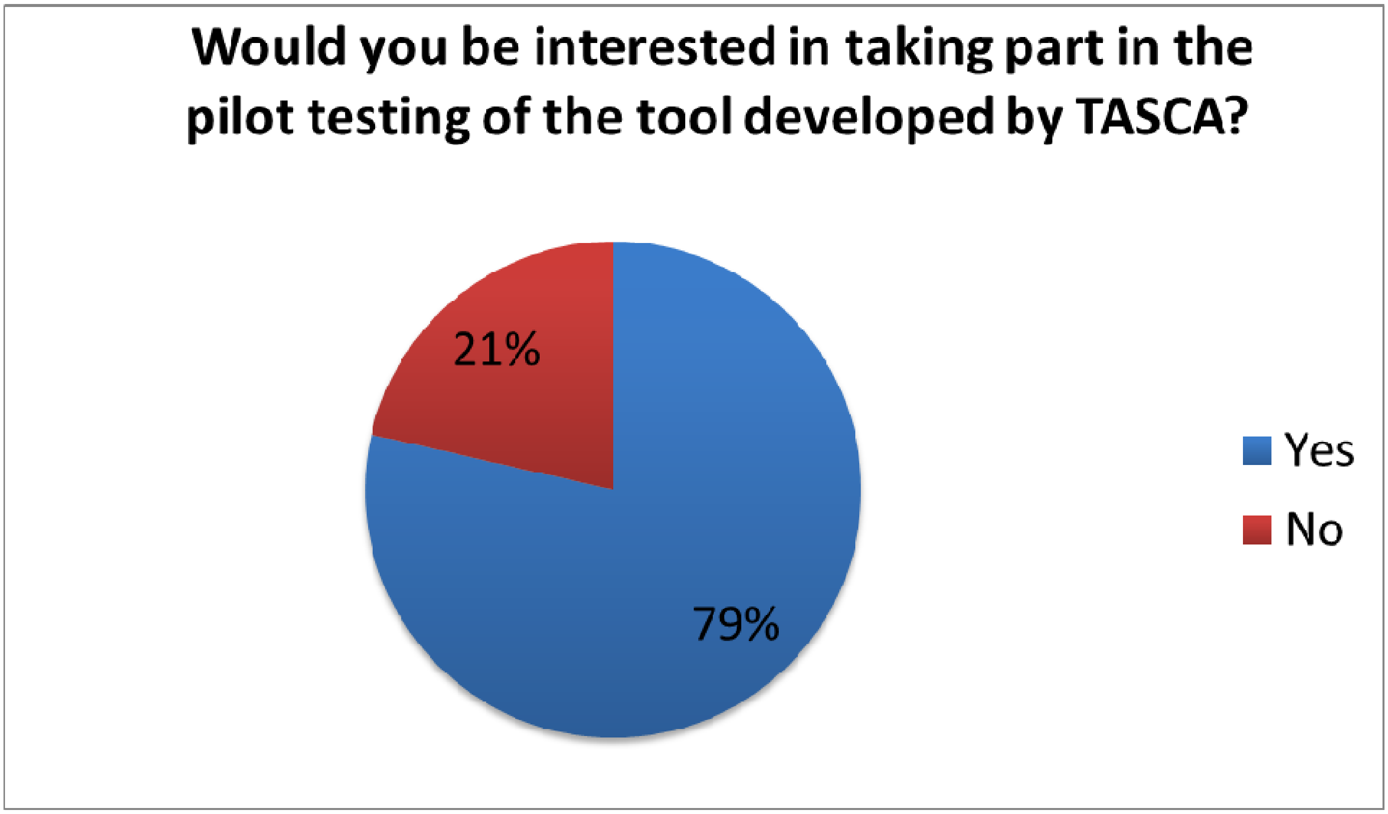

Figure 14. Indication of the interest.

VII. CONCLUSIONS AND FUTURE WORK

From a teaching standpoint, ARS offer capabilities that make them a very attractive way to promote student activity in the classroom and to obtain immediate feedback, when necessary. The high cost of these solutions, however, means that large-scale implementation of them is not feasible at universities—at UPV, in particular.

The TASCA group has taken on the challenge of developing low-cost alternatives to conventional ARS. The main idea is to integrate student-owned mobile devices (portables, tablets, and smartphones) into the teaching methodology, along the same lines as BYOD policies in the business world.

Based on the studies conducted, we can confirm that the majority of UPV students have a mobile device with Internet connectivity, so there should be no problem integrating the methodology with its supporting tool into typical faculty teaching practices. Moreover, even though not all students have one of these devices, all of them will be able to participate in the tests and activities by working in pairs or in groups; thus, a significant portion of the class can be sampled, even for completing evaluation tests, although their results cannot be used as "grades" with actual value on the student's definitive evaluation. There is still a small percentage of students who do not have one of these devices, however, so the design for evaluation activities affecting the course grade will have to wait because all students must be guaranteed the chance to complete them.

Once a functional version of the prototype is available, future work on the project will focus on its validation and fine-tuning as well as the gradual integration of this solution into the teaching methodology employed by members of the group so that its possible applications and its impact on the achievement of student learning objectives may be analyzed. From a teaching perspective, the capabilities afforded by intelligently combining the tests to be completed with the most conventional technology used in our society creates a very interesting alternative for fostering student activity in the classroom and getting immediate feedback, if required. It is absolutely necessary, however, to develop work materials, design attractive assignments, and plan times for putting it into action.

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