Web Framework for Developing Real Time Applications for Education.

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RESUMEN

SCALE-UP classrooms are designed to provide an environment for active and collaborative learning. These teaching techniques rely heavily on the collaboration between students, and implementing them in courses with a high number of students is a challenge. Therefore the use of technology is needed. In this work we have developed a modular education-oriented Web framework that provides: a real time communication infrastructure; a simple access mechanism; a user interface; and positioning and identification of students in the classroom. The framework is primarily (but not exclusively) intended to be used with the mobile devices that the students already have. The whole code is publicly available on the Internet under the GNU Affero General Public License.

On top of this framework, we are developing a set of modules to be used in SCALE-UP classrooms. This whole platform will provide a working environment for the classroom activities and, by monitoring the responses of students, the platform will make possible to identify students with different answers, encouraging discussion and collaboration among them.

PALABRAS CLAVES: Active Learning, Collaborative Learning, Learning Catalytics, Open Source, Real Time Interaction, SCALE-UP, Web Framework.

INTRODUCCIÓN

The concept "Active Learning" refers in general to all teaching methods in which the students take an active role in their education. "Active learning" has received considerable attention from the research community in education, as there exist evidence that it can produce good results in the student's learning [1] [7].

Among the teaching methods that can be classified as "Active Learning" the ones that stand out are: "Interactive learning with real-time response" [8], "Collaborative learning" [5] and "Problem-based learning" [7]. "Interactive learning with real-time response" refers to teaching methods using interactive technology in which students can interact
with each other and with the teacher, in real time. "Collaborative learning" corresponds to all teaching methods where students work together with a common goal. Finally, the methods grouped as "Problem-based learning" are those that present a problem at the beginning of each session in order to encourage the active development of the class. The works [1] [2] [8] [6] [9] indicate that the use of teaching methods such as "Active Learning" greatly improves participation and student learning. However, this does not mean that traditional teaching methods are not useful.

Sometimes, active learning methods can be difficult to implement, whether because of the high number of students or due to the distribution of furniture in conventional classrooms. These are designed for the current scheme of "presenter" and "public" but are not very useful in a paradigm of active and collaborative learning. An alternative to solve this problem is the use of SCALE-UP classrooms. SCALE-UP is the acronym for "Student-Centered Active Learning Environment With Upside-down Pedagogies" [12]. The SCALE-UP classrooms are environments created to facilitate the use of active learning methods in a workshop-type environment.
Commonly these classrooms have round tables in which students work collaboratively. They seat at each table forming groups, which become learning communities [1]. The figure 1 shows a

photo of students in a SCALE-UP classroom. The activities that can be performed in such classrooms are: small practical assignments, exercise solving, laboratory activities or problem solving. The teacher is not the center of the class, he/she is dedicated to timely give advice to the students, compare responses of different groups, identify the advanced groups that can help others, etc. In other words, the teacher must constantly interact with students, guiding them, receiving feedback of the progress of the groups and organizing interactions between students.

Figura 1: Students in a SCALE-UP classroom at UTFSM [1].

The emergence of various teaching methods classified as active learning and the development of SCALE-UP classrooms, correspond to a global trend called scientific teaching. This is a pedagogical approach through which teaching and learning are addressed with the same rigor as science itself. This approach formalizes the study of different teaching strategies, which allows real progress in this area. Today scientific teaching uses active learning strategies, and teaching methods that have been tested systematically and have proven effective in various types of student [4].

The situation described above opens the opportunity to develop a framework that could enhance the use of SCALE-UP classrooms by using the newly available real time web technologies. Emphasizing on the use of the smartphones that the majority of the students now owns.

There is a lot of software that aims to support education. Some projects simply try to illustrate concepts on a specific subject. Others focus only on a discipline such as physics, chemistry or language. On the other hand, there exist education management systems. These can cover a variety of needs, such as course management, content management, course enrollment or student evaluation.
There's even experimental software that tries new ways of teaching, such as ludification software [3].

Among the most popular education management systems, the vast majority of them meet the needs of organizing courses and content distribution. These solutions are very similar to the

Moodle platform, which in addition to being one of the most popular solutions in this area, stands out for being an open source application.

We have found two applications that aim to support the collaboration within the classrooms (which is the category in which this work is classified).

The first, with less similarity to what is described in this work, is called Plickers. This is a simple tool that allows teachers to collect assessment data in real time, without the need for students to have any device [11]. Plickers allows the students to answer alternatives questions, raising cards printed with codes. The teacher then uses the mobile application to read the codes through the phone's camera and get the answers quickly.

The other, called Learning Catalytics, aims to support the collaboration within the classroom in a broader sense. In general terms, this application has thefollowing functions:

- Communication between students and teacher, during and after class.
- Positioning of students in the classroom.
- Sending activities to the students.
- Students can answer activities directly on their phones.
- It has a "don't understand" button to indicate that the student does not understand.
- It presents performance statistics from the students.
- Gives the possibility to share the activities written by the teacher with the Learning Catalytics teacher community.
- Create groups of students based on different criteria.

The Learning Catalytics functions are similar to what we want to achieve in this work. However Learning Catalytics is designed for conventional classrooms, is a proprietary solution (not open source), it's a fixed solution (we want to develop a web framework that can be used to generate real time education applications for a varied range of needs) and, to use it, one must pay a yearly subscription from at least 20 USD per student [10].
Under these conditions, the possibility to modify Learning Catalytics to achieve the objective raised in this paper is discarded.

[1] describes the different factors that were considered when implementing active learning methods at UTFSM, to improve the student's learning. The relation between these factors is described in figure 2. In this paper we added a new factor: real-time mobile Web technology. Our hypothesis is that the addition of this new factor can have a positive influence on the basic abilities developed by the students, the active learning methods used by the professors and the attitude of the students. All of which should improve the student's learning. The research question we want to address is: how does the mobile Web technology for real-time interaction enhance collaboration and student learning?

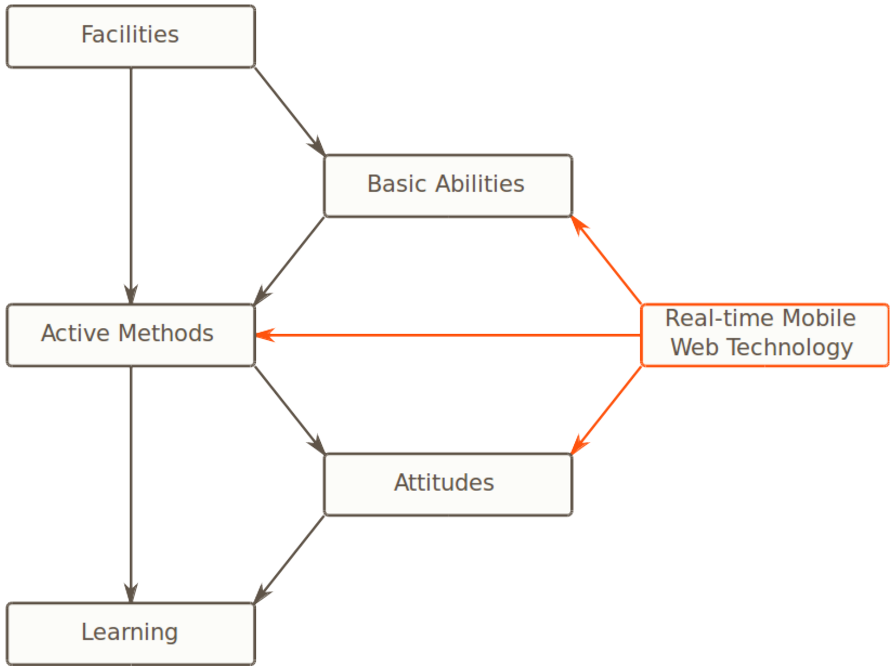

Figura 2: Relation between factors that were considered when implementing active learning methods at UTFSM [1], the "Real-time Mobile Web Technology" factor was added in this paper

In order to explore this question, we first have to develop a flexible and stable tool, that will allow us to implement new real-time Web mobile applications, which then can be tested on real classrooms. Concretely, we have designed a modular Web framework that provides a real time communication infrastructure, an extremely simple access mechanism and a fast and clutter free user interface. On top of our framework we are now developing a set of modules, designed for our University's SCALE-UP classrooms, which can show the potential of our Web framework. While the design and testing of our solution will be focused in this kind of classrooms, our solution is general enough to be used and adapted to a wide range of uses. This paper, which is part of a bigger work, will focus on the description of our solution. In the upcoming months we plan to test the application, and gather data about the student's response to this new tool. This upcoming work should be published in further papers.

This is an open source project, which means that the code is openly available to the community, without any copy or modification restrictions. This is usually beneficial for such projects because it increases the likelihood of a community forming around the project, which can maintain and improve it. For this project we have chosen the Affero General Public License. This is a derivative of the GNU General Public License. Both licenses allow commercial use, distribution and modification of the software and require the derivative works to be distributed with the same license as the original work. Any copy, distributed under these licenses, must include the source code of the software.

In the next section we will discuss the context in which our project will be used. To do so, we elaborated a small survey. Next, the architecture of our proposal will be explained. This will be made from different perspectives, ranging from how the internals of the framework are designed, to explaining the access and module architecture. Finally, in "Conclusion and future work", we discuss the actual state of the project and what remains to be done.

CONTEXTO

The first part of this work was to elaborate a survey in order to gather the necessary requirements to start the software development process. We made two types of questions: about preferences regarding the classes and about the use of different technologies. Some questions targeting specifically teachers or students, were added too. The audience that the survey was oriented to, were users of the SCALE-UP classrooms in our University. Therefore it was decided to survey all students and teachers who used this type of classrooms in a period of one week. At the end of the week the number of survey respondents was 609.

Also, a visit to an active learning physics class was made, with the goal of having an approach to the activities that take place in these classrooms. From the analysis of the survey and the visit to the active learning class, we got the following conclusions:

- The framework must be able to show slideshows and videos.
- Teachers should be able to send assignments to students.
- The agility of the system is a very important attribute, it should be developed with this in mind.
- It is good to allow the anonymity of the students.
- The framework must enable the teachers to better utilize their time in the classroom.
- The framework must be very stable, even if it is necessary to sacrifice some functionality.
- The application should use standards that guarantee correct operation in the modern browsers and future compatibility in the less modern ones.
- The system must be robust to losses of Internet connection.

Finally, a minimum set of modules, that meet the current needs of SCALE-UP classrooms, was designed. These modules will be described in detail in the "Module architecture" section.

PROPOSED SYSTEM.
FRAMEWORK ACCESS.

The framework was designed in a way that simplifies the access of the users. The goal is being able to enter the application as quick as possible without having to remember a web address. This system consists of QR and/or NFC codes stuck to the tables in the classrooms, one code in front of each seat. When the students scan the code corresponding to their seat with their smartphones, the application starts automatically. In addition, there is a code on the door of the classroom, which should be used by the teacher to open the application and start the class. In the particular case of the NFC codes, opening the application implies the simple gesture of putting the smartphone on the table.

The figure 3 shows a diagram of the access system described in the preceding paragraph. The square on the left represents a SCALE-UP classroom, with tables (circles), the QR and/or NFC codes, the smartphones and its door. Each smartphone is connected wirelessly over the network to the server.

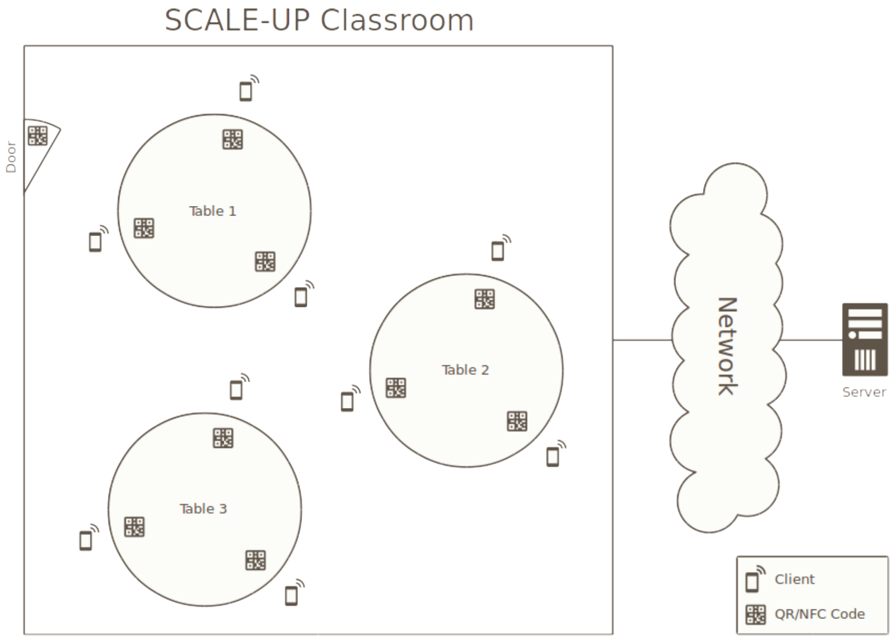

Figura 3: System access diagram

The codes store a web address that allows the application to start, knowing the code from which it has been launched. To accomplish this, the web address contained in each code has a unique identifier that consists of five alphanumeric characters. From now on the word "code" will be used to refer to the unique identifier, unless otherwise stated.

MODULE ARCHITECTURE

The architecture that is described in the previous section, allows the design of module groups and their relationships in an abstract way. The set of modules shown in figure 4 was designed using the previously obtained requirements. There are two service modules: *Presentation* and *Remote Control*. Both modules provide a service to other modules.

The *Presentation* module is a panel that can display content in full screen. One can display any HTML element on it, whether it is text, images, videos, simulations or games.

The *Remote Control* module allows other modules to display buttons. Its aim is to provide a panel from which you can access the most important functions of the application.

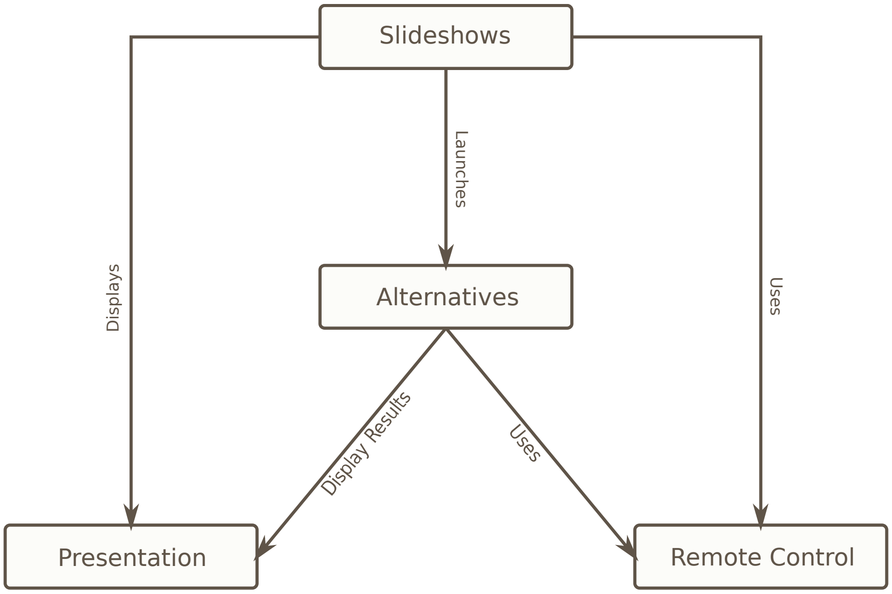

Figura 5: Module architecture diagram. The arrows show how the different modules relate to each other.

The *Slideshows* module can load slides in different formats into the system. It uses the *Presentation* module to display a slideshow file. It also uses the *Remote Control* module to instantiate buttons that can be used to control the presentation. The *Slideshows* module will be loaded in the client only when the user is a teacher. It is also possible to display a slideshow on a computer while the smartphone is used as a remote control.

Finally, by using the services provided by the *Alternatives* module, the *Slideshows* module allows to send questions to the students. In addition, it is possible to display the results of the questions in the *Presentation* module, using a button instantiated in the *Remote Control* module.

There is a set of system modules that has not been mentioned and does not appear in the figure 5. These are:

- Courses
- Router
- Critical
- Home
- Lesson Setup
- Loading
- Student Setup
- Connection Indicator
- Don't Understand
- User

These modules provide system functions and part of the user interface, but they are not of major importance in regard to what the application can do.

Conclusion and future work

During development of this work the project has grown to become a robustframework, dedicated to the development of tools for collaboration within the classroom and in real time. The actual value is not only in the user modules, but also in the ability to provide an open environment where new modules can be developed depending on the needs of the community.

A considerable amount of time has been invested on the scalability and robustness of the core architecture. Which is reliable, easy to use and has few barriers to adoption among users.

Because of the self-contained nature of the modules, the development of new ones is a simple task. It also helps the automatic documentation system and the CLI, both included with the framework. In the framework's CLI one can execute common commands and inject code while the application is running, making the debugging process easier.

Today the application has the necessary modules to create and use courses and presentations. However much remains to be done:

- New modules should be developed to complement existing ones. Such as the questions module, students communication modules or modules that can integrate the framework with other services.
- Currently the *Slideshows* module supports a single presentation format. However, this module is extensible, being able to easily write new parsers for different file types. It would be good to add a few more parsers to this module.
- The ratio of documentation lines to code lines is currently 0.24. Which is still very low, being desirable a ratio of more than 1.
- New question types should be added in order to take advantage of the mobile devices. The types of questions that could be implemented are: drawing, selecting areas in images, numerical questions, etc.
- Details should be adjusted in some existing modules, such as: add buttons to remove presentations and courses, and automatically update the list of courses in the student view.

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