

Designing a Site to Embed and to Interact with Wolfram Alpha Widgets in Math and Sciences Courses

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Abstract

This paper reports design and implementation outcomes at middle development advance of an educative program based on use and construction of widgets on Wolfram Alpha platform at higher education level for engineering and sciences areas. Widgets were created around of Physics and Mathematics curricula under Project Oriented Learning and Blended Learning methodologies. Widgets constructed by teachers are first used by students to appropriate basic concepts of each specific course on a mobile learning basis and after, students construct their own widgets applying that concepts but involving different applied situations in it and related courses, working with curriculum integration. Two phases of this activity help to develop basic and high level thinking. Description of design combining Wolfram Alpha widget developer, Weebly and Jotform tools to set up the widgets, institutional current advances on teachers' training, courses involved and current outcomes of project are presented.

Keywords: m-learning, design, tools, mathematics, physics

1 Introduction

New generations have an increasing expectative about freedom to work, learn and study, anywhere and anytime. Technology has made easier last expectative, so some educative trends are identified with ability in use of technology, which are related with a more successful professional life. In Education, it establishes an increasing demand of easy accessible online resources. In nowadays, there are a higher value of digital abilities, higher pressure about cheaper educative services increasing student engagement in order to obtain best educative goals and higher demand on individually directed instruction [1], all of them assisted by technology.

In last decades, technology has an increasing role in education. Every day is more common to include online elements in courses at different levels as part of an oriented and planned strategy of education. With this, terms as blended and hybrid learning has been coined. Today, mobile technology is an option to be connected always with world and information. It is evolving into creative media on which education can to reach its final recipients. In 2011, mobile technologies were main media to access internet by around of 80% of users [2]. This arena has been developed and grown in the last decade, so actually there are lots of online tools for education purposes [3].

But what kind of learning promotes those tools or developments made with them? Actually, meaningful learning [4] is a consolidated term established as necessity in nowadays education. In the present time, knowledge is growing exponentially and university curricula is continuously changing and diversifying, so students should learn contents whose relationship with themselves, their environment and their future requirements is not only not clear but confuse [5]. For meaningful learning strategies, any new learning material should be based on a prior cognitive structure, to show a deliberate effort to relate it to structures of higher level thinking, to be related with experiences on events or objects, and to include an emotional connection toward the prior knowledge and real applications. Inclusively, many authors bring into question dense curricula as educative policy instead of meaningful learning [6, 7]. This trend states a reflection about the replacement of policy in some areas about pursuit learn an extended curricula instead of learn some meaningful skills for life through selected learnings. That appears true as in basic education as in university education where learning areas has been exploding and diversifying at least in last decade.

2 Project Background

In last twenty years, Monterrey Tech has been changing its education focus and strategies. Ten years ago, Problem

Based Learning (PBL) [8], Project Oriented Learning (POL) [9], Curriculum integration and Use of technology [10] for engineering disciplines [11] was introduced as strategy to improve learning times and quality, as well as meaningful learning. Recently, an in progress program for mobile learning seeks to use several technological tools to improve some aspects of education. That tool requires to be accessible, easy and useful for each discipline and learning activity.

Johnson et al have established [2] that mobile devices became the main tool to reach internet. This ubiquitous connectivity has generated a large-scale development of applications (Apps) which accompany users all time. With them, he interacts with its environment. For this reason, internet has become a not official source of learning. As consequence, teachers should be involved in the creation of resources and meaningful applications which could improve the learning quality, and encourage students to apply the knowledge in real and complex constructions at same time.

A tool which is thoroughly used in Monterrey Tech math courses is Mathematica [12]. This tool requires a sustained effort of teaching and learning, mainly due to its syntax, which remains viable under premises of periodical tracking and existence of a faculty with the same learning orientation. Wolfram Alpha [13] is a recent development with some similar characteristics but simpler and more specific. Wolfram Alpha is currently free for some of their main applications and has a widget developer with similar structures which are present in Mathematica [14]. These elements can be displayed on mobile devices when are embedded in applications as [15] and their use allows obtain or analyze information. In general, widgets and their construction could be focused strictly on the domain of knowledge to be shown. For this reason, iTec initiative [16] of the European Economic Community has selected widgets construction as a key piece in learning.

Since 2011, an institutional effort to develop a transversal educative program based on mobile learning in all disciplines has been generating several initiatives and work lines, much of them pursuing an ease implementation by the general faculty not necessarily specialized on this kind of technologies. In this immersion process, use of online tools developed by third parts are been useful to reach last condition. In addition, the main intention of this program is that mobile resources to be considered should be useful to cover learning weaknesses in each course.

Widgets are Apps which let to achieve a specific task. Particularly, Wolfram Alpha widgets let an online mathematical educative interactivity in two ways: a) to explore an abstract concept in some interactive visualization developed by a third part (teacher or another student), and b) to develop complex thinking when student develops his own widget departing of some abstract concept into real visualization. In this educative project, widgets are embed in a didactical purpose where student is encouraged to discover first some aspect of theory and after, to use their knowledge to design new widgets to visualize related concepts. It is the aim of project been considered here which main lines was depicted in [17]: basic construction for four courses in November 2013, teacher training to future development in December 2013 and whole courses development in July 2014 to cover around of 1300 students.

Widgets for Math and Sciences is an educative initiative following last technology trends and pretensions. The aim of this paper is describe the final didactic and technologic design for the implementation of this project as a suggestion for related faculties. In the next section a brief description of project context is stated. After, the tools involved are discussed while the final structure of each activity is presented. After, the basic construction for the whole site is shown. At the end, some outcomes at this phase are shown related with a partial implementation, including teacher training program and further recommendations. Paper is closed with conclusions about last implementation phases in terms of student outcomes and future work.

3 Project Advances: Design and Training Program

Mathematics and Physics curricula in Monterrey Tech is ambitious and requires a heavy training by students to appropriate concepts, laws and algorithms taught. They are not always based on applications or visualizations, neither the use of this knowledge to develop a higher level thinking. An educative program based on use of widgets generated properly by teacher will permit a better apprehension of knowledge by students. In addition, student generation of widgets, through small projects in courses, would allow learning processes at the level of analysis and creation in the Bloom taxonomy. This element would work as well as a strong affective and meaningful learning toward the concepts being involved.

Inclusion of growing contents and skills development in mathematics and science courses, together with reduction in effective hours in them has generated some weaknesses in concepts comprehension, so students requires more educational elements as support. The inclusion of use and development of mobile widgets contributes to improve that comprehension through visualization of theoretical concepts in two ways: from application to theory when student uses a widget, and from theory to application when student design and construct own widgets. This two folded intention closes the learning process around a theoretical concept.

3.1 Technologic elements to reach educative goals

In the first part of each activity, each widget constructed by teachers fulfills two educative goals when is used: a) to identify relevant variables associated with some abstract concept, and b) to comprehend under interactivity, how an abstract concept is related with an element of reality. This part should be accompanied by a questionnaire to generate a directed interaction with the widget. Both elements should appear together to let: 1) interaction, 2) report information and results from students (text, images), and 3) get a receipt of acknowledgment for student and confirmation of submission for teacher. This integration could be solved with Weebly tool, which let construct a site with different elements embed in their pages. Thus, Wolfram Alpha widget could be included together with instructions contained in that page. Similarly, Jotform tool [18] lets embed submission forms into Weebly, which could include data and files. In addition, this platform lets to send receipts and alerts of submissions as is desired.

The second part of activity, the complementary practice in widget construction by students, develop in them a high level comprehension based on: a) identify the full set of variables to visualize an applied problem, and b) integrate the main concept on which is centered, with other concepts in related courses. Construction and comprehension order are normally inverted: widget construction is possible just if student has used some of them; but when construction is made, then other student can obtain a benefit with its use [17]. In this case, description of activity and a form to submit information and to report the widget externally constructed in Wolfram Alpha should be provided in this section. This requirement could be covered with Jotform. In such form, the link of widget constructed in Wolfram Alpha widget developer page is reported with the complementary information of student. Figure 1 resume interactions generated in the whole activity, their relation with the three tools used in the implementation and delivered products.

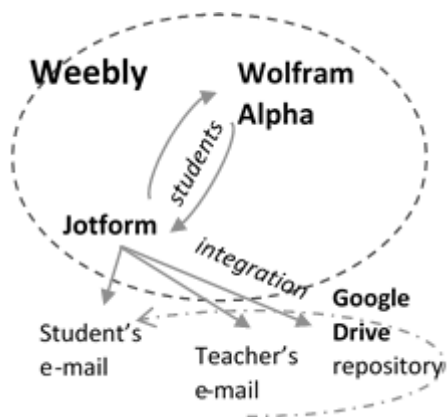


Figure 1. Pictoric description of interactions between student and widgets site through different tools integrated on Weebly.

3.2 Design of site and activities

A program to set up a POL based on use and construction of widgets should involve a group of courses (transversal and sequential) in which integration of concepts would be present. It requires an initial construction of widgets based on some critical or main topics, at least in some courses which regard some curricular relation. This base construction could serve as guide to other teachers for extend this program to other courses. The final impact includes 25 teachers, 51 groups and approximately 1200 students, which constitutes 80% of students in Physics and Mathematics department's courses, and a 30% of whole student population. In this first phase numbers cover around 30% of that statistics.

In addition, use and development of Wolfram Alpha widgets in parallel courses will promote curriculum integration in basic and engineering sciences courses. This aspect will be outstanding in students and will promote a better domain of the basic concepts toward the second third of their academic program. Courses involved and their curricular relations which could suggest curricular integration to follow when a specific widget is constructed was described in [17].

Based on the global plan for the project, the actual advance was centered in the first goal: a site of program with mobile access integrating Mathematics III, Electricity and Magnetism, and Differential Equations courses contains [19]: a) Tutorial of use. b) Activities of analysis by widget built by the teacher on strategic and representative topics. It includes the interactive widget, questions associated to generate interactivity and an online report format directed to teacher since same site. It includes too, complementary activities of widgets development by students, suitable for analysis and concepts comprehension which were taught. Each activity should be fully developed in mobile way as was discussed before. c) Section to publish help between users as a FAQ blog. Further development will be include courses as Differential and Integral calculus, Probability and Statistics, Mechanics, Fluids and Thermodynamics. Didactic guides for each widget are being designed. In addition, each set of topics in each course has been grouped in four blocks (in agreement with the chronological advance of contents) as proposed brief projects to be developed in each course. Each block should be developed by students as a monthly project.

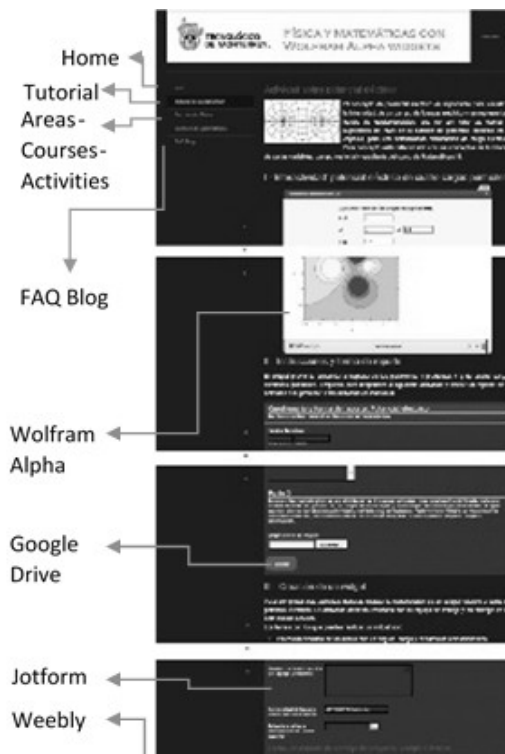


Figure 2. Sections of the basic structure of an characteristic activity page including widget, interaction questionnaire, and widget construction.

Construction of a critical number of widgets for each course in the first phase was planned to be deployed in January 2014. At this time, this construction has been fully developed for the first phase and teacher's training course is ready to be offered. Figure 2 shows sections of a characteristic activity page, as was developed in Weebly,

showing the general menu of site (Home, Areas and Courses, FAQ blog) and sections of each activity (Widget, Part I and Part II activities with associated forms in Jotform). An important aspect is that Jotform lets make an integration between submission and different external repositories as Box, Dropbox, etc. Google Drive was used in this project, so a Gmail account for each course is required. Actually, the first three phases are complete to begin the initial implementation and use with students on August 2013. Training program was designed based on 70% about the use of Wolfram Alpha Widget Developer and 30% in Weebly. This last content is no so relevant because the general format of activities is now created and is applicable for the whole courses with just minor adaptations. This training includes an extended workshop of following, until teams of teachers complete each one of the defined activities by semester.

3.3 Teacher training

Project dissemination require an adequate teachers training. Actually, a central group of teachers, working in phase I, are fully trained. For the whole remaining faculty, this training will result in the creation of collegiate mobile sites similar to previous, now for Mathematics I and II, Physics I and II, and Probability and Statistics courses. This part of development will require the design of similar sites, organized by a selected teacher as team leader. This project will promote support to teachers in other areas such as Economics, Administration and Finance by creation of small Apps for those areas. In the past, they had been limited in generating these resources directly on mobile devices because complexity related with programming. Training of Physics and Mathematics teachers in December 2013 will be fulfilled in January 2014. Some other interested viable areas in these developments (Mechanical engineering, Mechatronics, Economics, etc.) could be included. Training comprehend the following elements:

- Obtaining a Wolfram Alpha account
- Generating a Wolfram Alpha widget for Physics or Mathematics: hands on examples
- Sharing a Weebly account of project: presentation of last version of site
- Basic use of Weebly for this project: cloning and editing existing pages
- Sharing and assigning a Jotform account for each course
- Basic use of Jotform: creating, cloning and sharing existing submission forms
- Integrating of Jotform with Google Drive
- Making a full activity in a selected course

Actually, a set of Gmail and Jotform accounts were generated for each course in order to clone existing forms

used in each basic course in order to ease the further development process.

4 Conclusions and Future work

Mobile and Educative tools are spreading for different purposes, so everyday much more technology is easily available to teachers in order to generate lots of education products. Wolfram Alpha widgets let to teachers to show different concepts through visualization and to let students explore and to interact with these bridges between theory and reality. In addition, a higher level comprehension is achievable when loop is reverted in order that students generate widgets related with similar concepts because this activity requires a deep understanding of concept and a deep analysis about the critical variables to control the interaction that is being constructed.

But visualization normally goes faraway. To reach a good level in the representation, other related elements should be present. It means that concept being represented will require additional mathematics. In this sense, teachers could generate some level of curricular integration, which is an added educative gain in this project, in particularly when it is conducted by the same faculty and collegiate groups are conformed because these group are able to decide each construction based on a selected group of concepts in parallel and related courses. Curricular integration is normally warranted based on the selection of courses depicted for this program. Nevertheless, design of activities has taken care to emphasize that kind of relationships in the curricula. As was mentioned, this was easy because all teachers involved are part of the same department and some of them teach courses in the two areas: Math and Physics.

Nevertheless the Mathematica power, actually this tool still could be exceeded for educative projects in some courses because time to be spent by student and teachers can make inadequate. Wolfram Alpha developer has an advantage, is relatively easy and I is programming free. Last means that the whole extent of faculty could generate their own widgets. In addition, each student will now spend just the time reflecting about how construct each widget, in order to integrate the different contexts involved in almost just one instruction of Wolfram Alpha, but gathering the several variables and concepts which are relevant to represent each problem in the visualization. In this sense, that investment should be continuously recovered through periodic activities of learning which let to student the opportunity to deep in the course concepts and applications associated.

In the past, those constructions were more related with more complex tools and normally with programming involved. In nowadays, there are a lot of compatible tools which can interact between them in order to develop a more complex educative idea, which in addition is every time more free from hardware and operative systems, so their extension to mobile devices is automatic.

Such is the case with tools used to solve and develop the interaction requirements stated here: integration, embedding, submitting, stocking up and gathering. In this sense, the knowledge about tools as Wolfram Alpha, Weebly, Jotform and Google Drive lets construct a more complex product for educative goals in an easy way. This knowledge could to boost other educative projects or give to teachers more ideas about further development in this same project. Note that training could be directed to the main keys to extend the project into other courses, nevertheless, tools involved are so friendly that normally teachers could learn much more of them. Anyway, in this project, training was designed to be easiest possible.

Future work will be based on two aspects: a) to extend the program to the whole courses of Physics and Math department, and b) to include the evaluation of educative outcomes by collecting and analyzing results of students. A follow-up study should be carried out before and during the initial and global deployment.

Computer technology has been rapidly developed and this project is an example of such technological developments being carry out exclusively by teachers as a collegiate group, any technological assessment has been provided more than teacher's interaction.

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