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**Francisco Javier Delgado Cepeda**
**Full Profesor**
**Monterrey Institute of Technology and Higher Education**
**México**

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Athens Institute for Education and Research
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# Widget Based Learning in Math and Physics Undergraduate Courses as Blended Learning Approach

**Francisco Javier Delgado Cepeda**
**Full Profesor**
**Monterrey Institute of Technology and Higher Education**
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## Abstract

This work summarizes the didactic design and introductory outcomes in an educative program, involving the Math and Physics university courses for engineers, based on the use and construction of widgets. Widgets were generated under Project Oriented Learning and Blended Learning methodologies. In the program, widgets previously generated by teachers are firstly used by students to appropriate basic and middle concepts. After, students are requested to generate their own widgets to develop complex thinking skills, applying related concepts but involving alternative situations. Design is based on curriculum integration to build mathematical, technical and visual representations of the problems and concepts involved. Wolfram Alpha, Desmos and Mathtab widget developers are used to generate ad hoc activities in terms of their capabilities and course requirements. Results around students' value perception, differential gain in the general learning performance, as well as capitalization in terms of teachers' educative technology skills acquired are reported.

**Keywords***:* blended learning, higher education, mathematics, physics

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## Introduction

Nowadays, technology has a critical role in education. Departing from the adoption of computers in Education several years ago, the current mobile accessibility to information and online applications has increased the inclusion of technology in this arena. Today, the support of technological resources is part of a planned teaching strategy. Thus, in the contemporary education trends, deeper distinctions about learning styles have introduced flexibility and adaptability in learning. As a result, complementarity between technology and traditional education has generated practices as the Blended learning (Bartolomé, 2004; Buzzeto-More & Sweat-Guy, 2006; Allen, Seaman, & Garret, 2007), an educative approach emerged from technology to reach adequately the final recipients in a ubiquitous way. In the current days, mobile devices embody the convergence of many apps ready to enrich education: electronic book readers, annotation, creation, and composition tools, social networking communication, digital and editing tools, GPS, accelerometers, compasses, and extensible ports to connect sensors. All of them can be used creatively in the classrooms and labs.

The increasing demand of education has required accessible, cheaper and competitive online educative resources to reach educative goals in the best possible way. Normally, they are based on adaptive instructions assisted by technology (Johnson, Smith, Willis, Levine, & Haywood, 2011). Such flexible and effective education becomes more disruptive than face to face education, which is normally based on abstraction of detailed contents and a few times it is based on experimentation. In this sense, meaningful learning (Ausbel, 1963) is based on knowledge closely related with the environment student. Under a meaningful learning strategy, new learning material should be based on a previous cognitive structure and a deliberate effort to relate higher level knowledge with the daily reality, events or objects, generating an emotional connection with real applications. In this trend, a debate between meaningful learning versus a dense curricula (Gaer, 1998; Woessmann, 2001) is carried out in education.

In this philosophy, the Maker movement (Dougherty, 2012) is closely related with meaningful learning. In nowadays, the use of simulators, dedicated sensors and automated software has generated a decreasing action directed to solve practical problems. Then, technology sometimes induces an auto-generated passivity in learning: students passively learn information from teachers and then reproduce it on notebooks and computers, but rarely in the real world (Shibley, 2014). Thus, students become information recipients rather than developers of applied knowledge. Project Oriented Learning (POL) (Algreenand & Moesby, 2001) is an educative methodology based on Maker philosophy to develop the apprehension of knowledge as a result of prototypes, designs or software construction. This approach is an inheritance from technical disciplines.

A Blended learning strategy has been growing in the last years as a useful practice to reinforce or complement some aspects of face to face instruction

(DeNisco, 2014). But mobile technology is an ambivalent tool. There, only the most creative and engaging resources captivate to the users. Thus, teachers should prepare activities to fulfill learning processes and a ludic engagement in them. There are several approaches to a Blended learning strategy (Staker & Horn, 2012; DreamBox Learning, 2013), in terms of didactic orientation for the class, the amount of online contents, and the work being developed. Blended learning has been for the last years an amazing lab for teachers who are experimenting improvements in their classes supported by technology (Lothridge, Fox, & Fynan, 2013). Particularly, Blended learning has been used to develop and to train specific skills being developed in the curricula (DeNisco, 2014), an important issue in higher education.

Together, education in Science, Technology and Math has been revalued as a requirement of global competitiveness. STEM education (Gonzalez & Kuenzi, 2012) is an acronym of Science, Technology, Engineering and Mathematics. This movement began in Occident, but actually is spread in several regions of the world (Gonzalez & Kuenzi, 2012). The initiative attends the emergent necessities in the workforce market for the next years, trying to revert the current education data in the world. This initiative includes educational actions across all levels.

The aim of this paper is to propose a program based on the use and construction of widgets as a blended strategy for Math and Physics courses in the university. The proposal is based on a current project for the design of educative widgets. In the second section, the educative background and the blended scope are settled, together with the current research questions and objectives for this work. The third section deals with the contents coverage together with the technological design, tools and activities construction departing from a methodology of construction. There, the final didactic design and technological construction is sketched. After, the fourth section discusses the capitalization in terms of the teachers' experience, the student perception and some insight outcomes compiled on the basis of qualitative and quantitative aspects for the initial deployment. At the end, the conclusions about ongoing and future work are given.

## Background and Blended Learning Strategy

Educative online tools have been growing exponentially in the last decade with the ubiquitous connectivity (Edublogs, 2013). It is time for teachers to be familiarized with online resources and meaningful applications to improve the learning quality and the engagement of students, particularly knowledge related with contextual constructions (Engelbrecht & Harding, 2005; Conole, 2008). Among these technologies, apps to visualize concepts, letting interaction in addition, could serve for educative purposes. Widgets are apps to achieve specific tasks (Educastur, 2012), in particular, educational widgets focus on concrete knowledge development. They are constructed as specialized calculators or as interactive visualization tools around a technical problem or an abstract concept. iTec (2013), an initiative from the European Economic Community, has selected this trend as a key piece in learning.

In terms of Blended learning, Widgets based learning is located between the Face to Face driver model and the online lab model (DreamBox Learning, 2013). In other dimension, widgets are based on the creation of personal environments of learning by letting each student experiment and to try the own learning registers (Person, Gkatzidou, & Green, 2011; Gkatzidou & Pearson, 2011). In fact, each widget covers a great extent in learning by introducing lots of variations, boosting the creativity and asking the internal questions of the user on demand. These elements let the teacher complement the class with directed activities but oriented to experimentation in the use of well constructed activities. Otherwise, they are directed to innovation, creativity and skill reinforcement when a user constructs widgets for others. For the teacher, widgets let him share knowledge and experiences which are not possible to include in the face to face instruction time (Young, 2008), in particular with the wide curiositythat his class requires. Marino (cited by Guess, 2008), has stated that widgets can close the distance with abstract concepts and situations in just a click. They encourage the curiosity and in nowadays they are really easy to construct.

The Monterrey Institute of Technology and Higher Education (Instituto Tecnológico y de Estudios Superiores de Monterrey, ITESM) is a university system continuously evolving its educative methodology in the last 20 years. In particular, for the engineering disciplines, Problem Based Learning (PBL) (Polanco, Calderon, & Delgado, 2001), Project Oriented Learning (POL) (ITESM, 2007), Curriculum integration (Delgado, 1999) and Use of educative technology (Delgado, 2011) have been strategies to improve the effectiveness, sense and quality of learning. The Physics and Mathematics department has emphasized the curriculum integration and the use of technology in the classroom as a builder of affective relationships between reality and abstract concepts (Delgado, 1999; Polanco, Calderon, & Delgado, 2001). The transversal use of professional software as Mathematica[1], a software to do analytical and numeric mathematics, has been used in associated courses to introduce curriculum integration by solving applied problems in context (Delgado, 2011), thus developing the upper Bloom’s taxonomy levels (Anderson & Krathwohl, 2001). While POL, as a didactic strategy, has been used as link between the Math and Physics curricula (ITESM, 2007).

Johnson et al (2011) established that mobile devices are the main tool to reach internet, generating ubiquitous connectivity and a large-scale development of applications accompanying all time to the users. Internet has too become the main unofficial source of learning. Since 2011, a program to boost mobile learning is being developed in Tecnológico de Monterrey (Delgado, 2014), based on academic research, sharing, training and assessment to improve mobile education. This effort developed digital competences for mobile learning in all discipline teachers, without previous knowledge. Today,

[1] http://www.wolfram.com

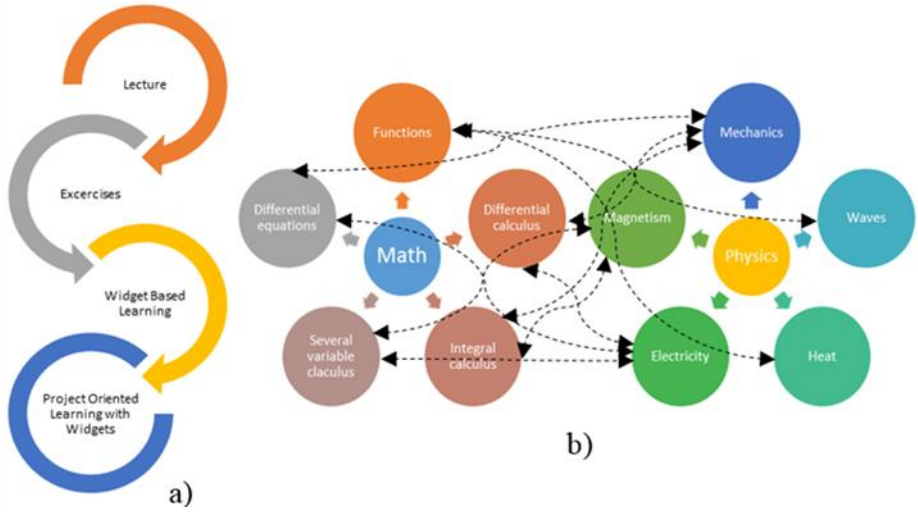
the program generates initiatives and educative trends pursuing an easy implementation by the faculty. Then, tools involved are required to be accessible, easy and useful for each discipline and learning activity, to scaffold the learning process as a premise.

In terms of the Math and Physics curricula, the contents are ambitious and not always based on applications or visualizations. Together, the use of Mathematica requires a sustained effort for teachers and students, mainly due to its syntax. Instead, a course based on the use of widgets, properly generated by teachers, could generate a better apprehension of knowledge. While the construction of widgets by the students, through concrete projects, could boost the analysis and creation in the Bloom taxonomy (Delgado, 2013a), last activity works as an affective link for the meaningful learning. Each widget constructed by the teachers fulfills specific educative goals (Delgado, 2013b). A complementary practice to construct widgets by the students could develop higher level comprehension through applied problems. In both schemes, use and construction, a better comprehension is achieved when each student uses widgets and then, new widgets are proposed, designed and constructed.

This practice is expected to promote a better domain of the basic concepts. Courses involved belong to the first four semesters of engineering programs: differential and integral calculus, several variables calculus, differential equations, probability and statistics, mechanics, fluids, heat and waves, electricity and magnetism. The final potential number of students involved in the program is estimated in 1,200 students. A detailed discussion in terms of courses and curricular integration is included in (Delgado, 2013a). The strategy includes these activities under a blended learning environment. Thus, lectures, solving exercises, use of widgets (widget based learning), and widgets construction (POL) are combined as global strategy (Figure 1a).

The main curricular relations are shown in Figure 1b, including representative topics and courses in both disciplines. As it was discussed in (Delgado, Santiago, & Quezada, 2015), the requirements in each course are different: visualization for calculus and probability courses, algebraic skills for differential equations and a blend between visualization, specialized algebraic and arithmetic calculations for Physics. Thus, a unique widget developer tool hardly completely covers this spectrum, so three different widget developers were finally selected: Wolfram Alpha, Mathtab and Desmos.

**Figure 1.** *a. Widgets Based Learning Embed as Strategy in the Course, b. Main Curriculum Integration Links in Widgets Design*




*Source*: Prepared by author.

## Widget Design Methodology and Research Objectives

The development of the educative program presented was based on a mobile site[1] constructed on Weebly[2] (Delgado, 2013a; Delgado & Santiago, 2014) integrating the courses involved, their widget based activities (widget, didactic guide and widget proposal for the construction activity by the students) and a tutorial. The site includes forms designed with Jotform[3] to retrieve information and images. They are integrated with Google Drive as a repository. These interactions and tools involved, thus as their purposes, are thoroughly described in Delgado, Santiago & Quezada, 2015. Widget activities are divided by courses and each course contains between four and six activities. Each one contains: the widget, the didactic guide or questionnaire, the information retrieval form and the related activity to construct widgets (Delgado & Santiago, 2014).

The research questions that arise in the current work are based on the impact in some aspects of learning as a wide spectrum of experiences for the students. The curricular decisions were made on several goals pretended on the education for the targeted engineering students. Thus, instead of a unique final aspect for the learning impact, there are several related interests as skill developments, challenge curriculum integration experiences and useful engaging learning design activities. While, as an introductory research about widget based learning, an inquiry around the possible impact on the traditional knowledge is pursued, while it is supposed as an affective link to the classical contents in the courses being involved. Finally, in the domain of the faculty,

[1] http://itesmcem-fmwidgets.weebly.com
[2] http://www.weebly.com
[3] http://www.jotform.com

some feedback is required about the capitalization in the teaching skills development through this program. Thus, the objectives of the current research are: a. to obtain quantitative data about the students' perception of the program in aspects as skill development, challenge and meaningful learning activities; b. to get a quantitative insight evidence on the general learning performance in the course contents; and c. to get an account on the impact of teaching with technology skills development on the faculty.

The methodology is centered on the widgets activities design to get quantitative or qualitative evidence on the last issues. For that, a direct perception survey on specific dimensions was applied to students (without courses distinction) together with an analysis in their comparative performance in the widget activities and the whole course evaluation related with previous students who were not exposed to the widgets program. For the faculty, single participation statistical data are analyzed and a chronological map of skill development through the several initiatives in mobile learning training for teachers is compared. In the following part of the section, the widgets program strategy is depicted to arrive in the next section on the evaluation proposed in the research objectives.

*Site Design*

First part of each activity in the Physics and Mathematics Widgets site (Delgado, 2013b) embeds a widget constructed by the faculty, fulfilling two educative guidelines: a. it is oriented to identify relevant variables associated with a Math or Physics concept, and b. it lets us comprehend how this concept is related with a real situation. A questionnaire is included with each widget to generate an oriented and challenging interaction. Together, there is a delivery form to report the results and to get a receipt of acknowledgment (Delgado & Santiago, 2014). The second part is the complementary practice for widget construction to develop high level comprehension in an applied problem. Commonly, it integrates the concept on which the proposal is centered together with other concepts in related courses.

The courses involved in the program (transversal and sequential) required an initial construction of widgets based on some critical topics. The widgets let an online interactivity by exploring a concept through an interactive visualization attempting to develop complex thinking in a complementary activity when students construct their own widgets. Thus, widgets are embed in a didactic purpose to discover several aspects of the theory (Part 1) and then, to use more complex knowledge to design new widgets for specific concepts (Part 2). The main lines of project were depicted by Delgado (2013a). This construction philosophy could serve as a guide to other teachers adopting these ideas in other courses or disciplines.

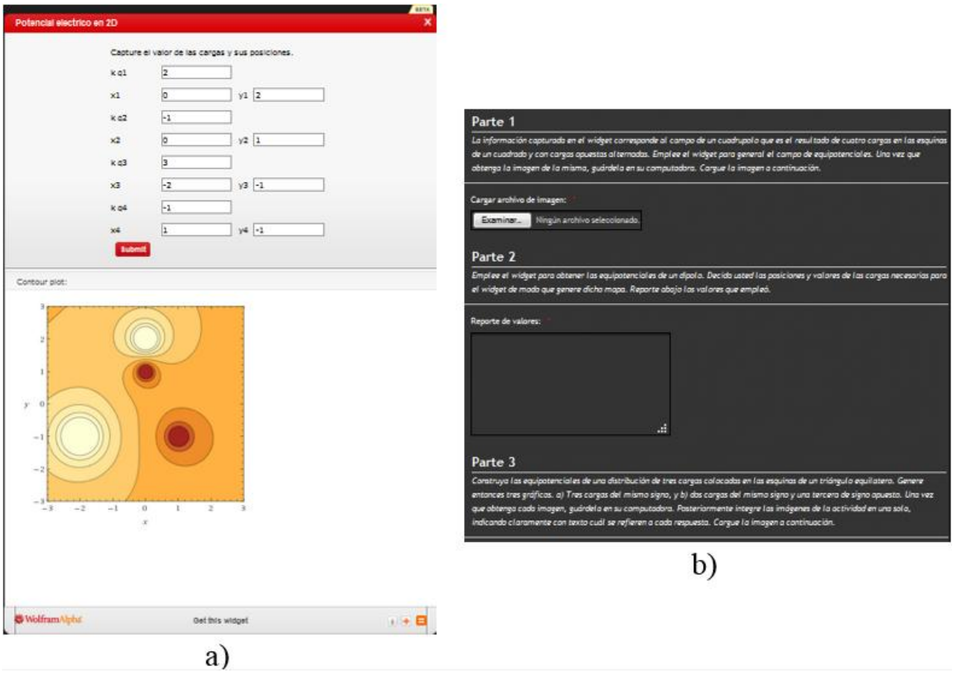
*Widgets Developers Related with the Project Purposes*

In the selection of widget developers, alternative tools were considered to fulfill specific necessities of each course. As a result, Wolfram Alpha[1], Desmos[2] and Mathtab[3] were included in addition. Widgets for differential equations, electricity, magnetism, and several variables calculus courses were mainly achievable with Wolfram Alpha; Desmos and Mathtab were used in the further courses, being the second most adequate for Physics courses. The following subsections briefly depict each widget developer, to discuss their use in the project.

Wolfram Alpha

Wolfram Alpha is a free syntax computational knowledge engine closely related with Mathematica, but simpler and with automated outputs. This has an associated widget developer whose products work as user interfaces to manipulate selected variables in the syntax. They can be embedded in websites.

**Figure 2.** *a. Wolfram Alpha Widget to Obtain Equipotential Curves for a Set of Point-Like Charges, b. Questionnaire and Interaction Form Linked to Google Drive*




*Source*: Prepared by author.

Because Wolfram Alpha interprets queries and then obtains processed information (inclusively in a mathematical or statistical way), it can be oriented to show the analysis of the solutions for mathematical problems. The initial

[1] http://m.wolframalpha.com
[2] http://www.desmos.com
[3] http://mathtab.com

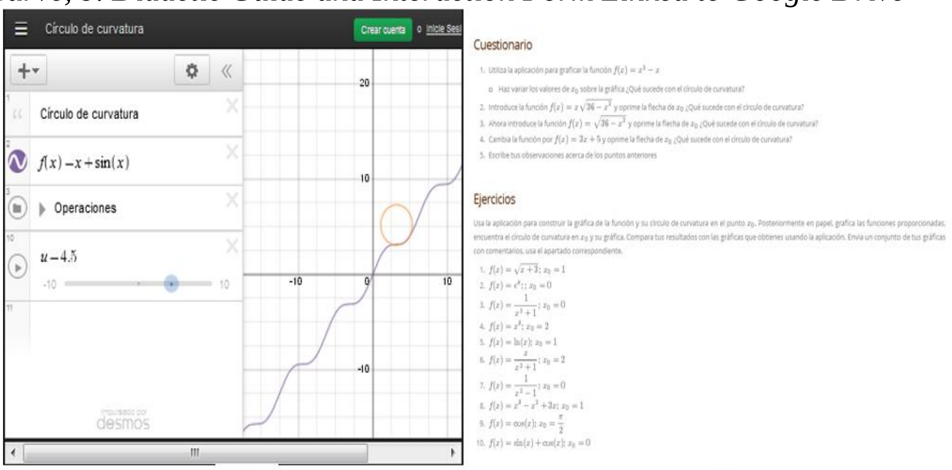
inspiration to develop the widget program due to its similarity with Mathematica came from Wolfram Alpha widgets. After, other tools were necessary to reach more specific goals. Figure 2a shows screenshots for the widget activity in the Electricity and Magnetism course generated with this tool. In it, positions and strength charges should be captured to obtain an equipotential map. A widget is accompanied with a questionnaire to interact and a delivery form to report the outcomes sending individual student reports to Google Drive (Figure 2b). Nevertheless the complex mathematical outcomes can be reached. The outputs are limitedly in control of the design teacher who just selects them from a predefined set. Normally, this issue restricts the possibilities to create some widgets, in particular for elaborated issues as those for Kinematics or Dynamics. Animations are rarely obtained.

<u>Desmos</u>

Desmos is a tool oriented to visualize mathematical concepts and objects in an attractive graphical and interactive way creating geometric visualization departing from algebraic expressions. Parameters can be introduced to generate automatic interactivity and movement. Nevertheless their narrow diversity oriented to manipulate only this kind of objects, is valuable in calculus, differential equations, probability, and statistics courses.

Figure 3a illustrates a widget showing the concept of the curvature circle. The widget interactively changes the parametric curve and the point in which circle is tangent. All calculations are analytical. Nevertheless the aesthetics and the wide spectrum to visualize mathematical concepts in an automated way, it is not always easy to represent more complex problems than those closely related with mathematical objects. Despite, Desmos widgets are excellent elements to show Calculus in movement. The didactic guide (Fig. 3b) can include many exercises including several variations.

**Figure 3.** *a. Desmos Widget Showing the Circle of Curvature for a Parametric Curve, b. Didactic Guide and Interaction Form Linked to Google Drive*



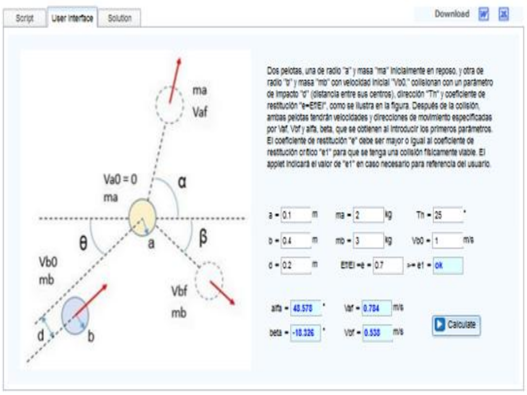

a) b)

*Source*: Adapted from Delgado et al., 2015.

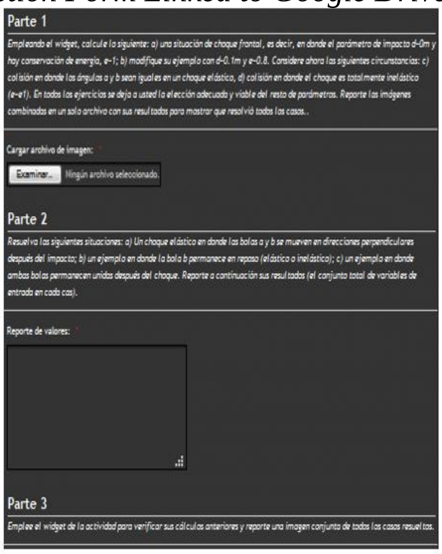
Mathtab

Mathtab is a tool oriented to generate specialized calculators and 2D animations. It includes a user interface, worksheets and classical programming when it is necessary. Mathtab becomes ideal for Physics widgets, solving quantitatively the behavior of complex systems with multiple outputs. Mathtab widgets are used with a two folded way: a. to review direct exercises by introducing the precise input values to then obtain the output ones, or b. to review more complex problems where students first should develop the whole calculations departing from a set of output values to obtain the correct input values. Nevertheless Mathtab has a limited graphic interface to show objects and graphs in two dimensions, its capability in programming allows really complex situations to be included. Figure 4a shows a dedicated widget to relate the group of variables in a non-central collision in two dimensions. Mathtab is considered to construct specialized calculators to set a group of input values generating another group of output values. Mathtab lets us define user functions and procedures by programming, so numerical complex capabilities are possible in principle. Didactic guides can be constructed to obtain and to report different solutions in an applied multivariable problem. These calculators could be used in a direct way to simply review the result of a straight problem or to review the concordance of variables in a specific situation (when only a part of input and output variables are known). As before, retrieval information forms help to report results or images (Figure 4b).

**Figure 4.** *a. Mathtab Widget to Analyze Non Central Collisions in Two Dimensions, b. Questionnaire and Interaction Form Linked to Google Drive*




a)




b)

*Source*: Adapted from Delgado et al., 2015.

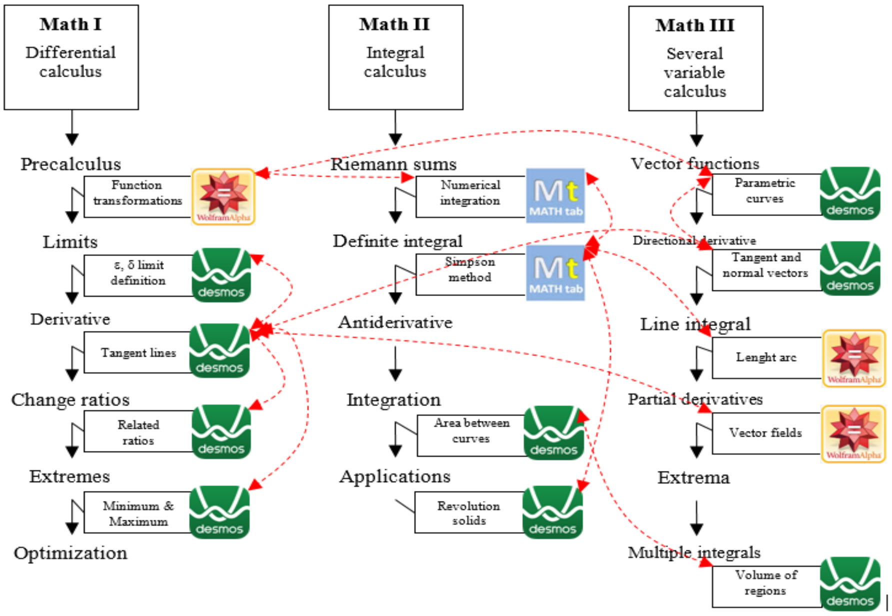
*Didactic Site and Structure*

The widgets project was centered in the development of widget activities for all courses appointed. They were located and ordered by course in the mobile widgets program site (Delgado, 2013b). This site contains: a. a tutorial, b. a FAQ blog, and c) activities of analysis by a course and by widget built by the faculty. They are based on strategic and representative topics selected for this program. Each widget includes a didactic guide of interaction, which is sometimes a questionnaire or an exercise series requiring the use of the widget. Questions were designed to generate interactivity. Together, this is an online report form embed in the same activity page. Each activity in this site includes supplementary activities to develop one new additional widget by the students. This site and their sections were depicted in Delgado, 2013a.

Curricular Design of Math Widgets

Calculus courses are the most representative in Math University, having several related concepts and weakness in their abstraction. Widgets could contribute to both: visualization and algebraic experimentation if they are based on experiential learning styles (Kolb, 1984). In addition, visualization and in particular continuity are underlying issues on which learning should be focused. The last concepts are applied in a differential equations course. Thus, a net of widget activities were created to give a whole picture of Calculus. Figure 5 shows a simplified scheme containing the main themes in the calculus courses, their curricular associations and the widget developer were used in each specific activity. The associated widget construction could be addressed on a different developer depending on the aspect being realized. In that design, not only the topics were selected, but the best widget developer to fit its attributes with the activity purposes. Thus, Wolfram Alpha widgets let to create automated math outputs to show elaborated graphics or algebraic calculations despite its limited animation possibilities. Instead, Desmos widgets were able to show delicate and attractive animations in an interactive way. Both developers were used in several activities in agreement with the learning focus.

**Figure 5.** *Schematic Curricular Design for the Activities in the Main Math Courses, Showing Deliberate Curricular Relationships with Dashed Lines*

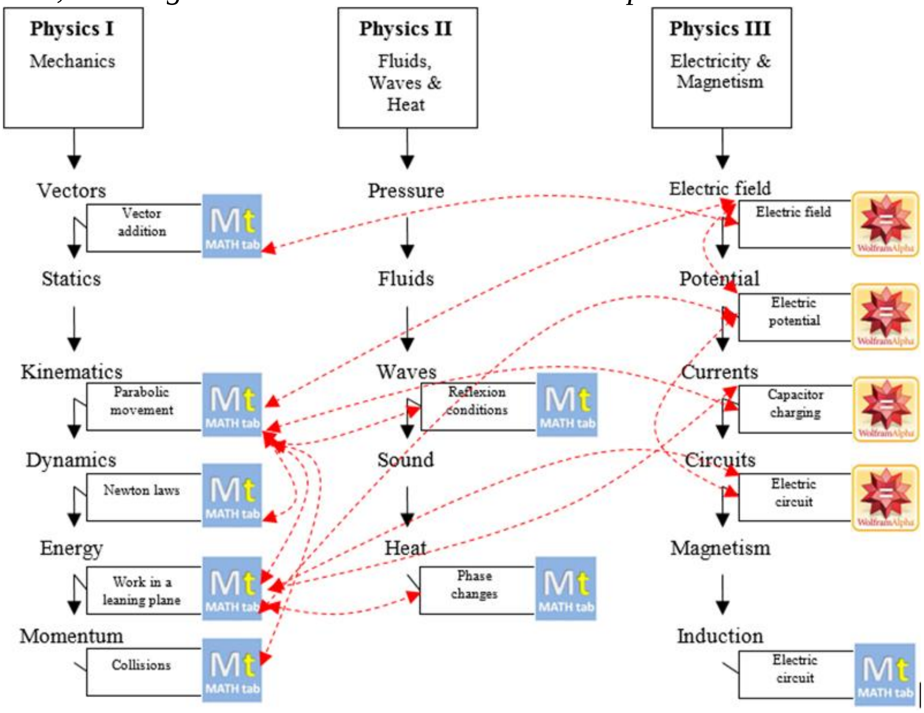



*Source*: Prepared by author.

Curricular Design of Physics Widgets

Physics scenarios for Mechanics, Waves, Fluids and Heat are more quotidian, so visualization is superseded by dominion of laws underlying and the complexity of associated calculations. Then, a specialized calculator is more practical than an animated simulator. In contrast, Electricity and Magnetism concepts require the visualization of abstract elements and their mathematical relations involved. Figure 6 shows the simplified curricular design for the widgets net constructed for Physics courses and their curricular relationships. In those terms, Mathtab was an excellent developer to include widgets working as specialized calculators for Physics I and II, while Wolfram Alpha was reserved for the Electricity and Magnetism course because Vector fields, Contour curves and other related Math concepts were deeply involved and they should be presented as visualizations.

**Figure 6**. *Schematic Curricular Design for the Activities for the Physics Courses, Showing Deliberate Curricular Relationships with Dashed Lines*




*Source*: Prepared by author.

## Outstanding Results in an Introductory Research and Analysis

The physics and mathematics widgets program has generated notable outcomes during an introductory inquiry through an initial controlled and limited deployment. In this section, we describe briefly the most important ones.

*Outcomes Related with the Impact on Student Learning*

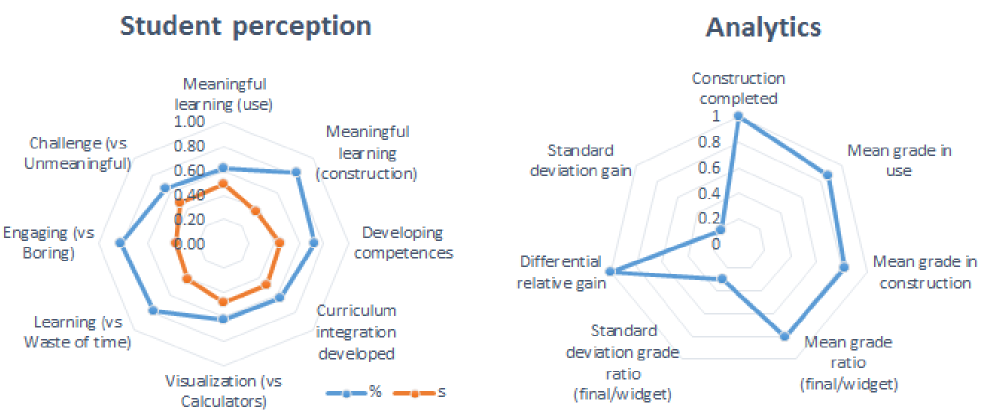
A more detailed report of findings in the student learning impact was reported in (Delgado, Santiago, & Quezada, 2015) as part of an introductory deployment. Based on a one year research on six pilot groups and using several widget activities constructed, a perception evaluation was also applied. In addition, a quantitative exploration of the possible impact in learning compared the historic results in the course with the current courses using widgets. Inquiry was applied on three different courses (143 students in two different semester periods) using and constructing widgets: Differential equations course, Numerical Methods and Physics.

<u>Students’ Value Perception</u>

For the student perception evaluation, several dimensions were defined in the inquiry and evaluated on a 0-1 continuous scale: a. the meaningful learning value for the widgets use activities, b. the meaningful learning value for the widget construction activities, c. the affectivity on the skill development of the program, d. the strength of the curriculum integration on the widget activities (use and construction), e. the relative value for the visualization approach in the widgets program (versus the calculator approach in it), f. the learning value (versus no meaningful learning or waste of time perception), g. the engaging activity perception (versus boring activity perception), and h) the challenge activity perception versus (no meaningfully difficulty). The outcomes are reported clockwise in the Figure 7a based on the perception averages in each dimension (%), thus as the corresponding standard deviation (s). All results are shown in a 0 to 1 scale (0-100% for percentages in questions a-d; and 0-1 scale for dichotomy questions, e-g).

The Results show that perceptions about Construction (b), Engaging (g) and Learning value (f) are outstanding and mainly consistent through the students. While the worst aspect evaluated are Use (a), Visualization (e), Curriculum integration (d), and Challenge (h). Nevertheless all averages are evaluated over than 0.6. Despite, aspects as Visualization (e) and Meaningful learning in widgets use (a) exhibit large dispersion. As a clear result in this introductory insight, widgets construction appears as a valuable and engaging activity working well for learning, at least compared with the use of widgets, which is only mildly well evaluated.

**Figure 7.** *a. Perception Dimensions of Students around Several Aspects of Widget Activities, and b. Key Analytics Related with the Impact in Learning*




*Source*: Prepared by author.

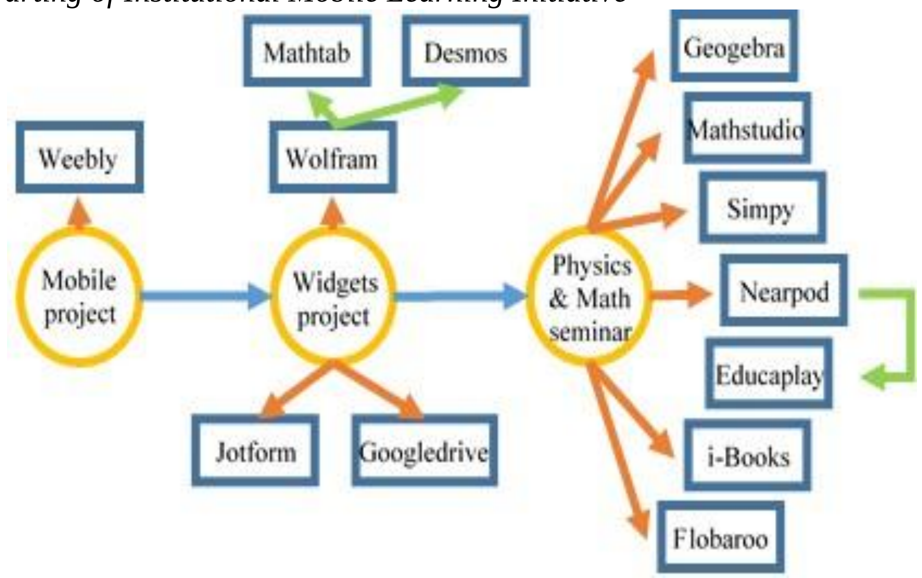
<u>Impact on General Learning Performance</u>

The second inquiry, a comparison based on analytics between the classes involved and other old classes for the same courses, used as reference, were based on the following dimensions: a. Widget construction completed, b. Average grade in widget use activity, c. Average grade in widget construction activity, d. Ratio between grade in the course final grade and in the average widgets activities for each student, e. dispersion of the last indicator (standard deviation), f. relative differential gain between introductory and final exam grades in the course g. and the dispersion of the last indicator (standard deviation). Results are shown clockwise in Figure 7b. As before, a 0-1 scale has been used. Results in a, b and c show that these activities are well completed and graded with satisfactory notes in average, so they appear as achievable activities for most of the students. In addition, they appear consistent with the whole final evaluation, suggesting that these activities are neither extremely complex, neither trivial. Note that dispersions in d and f are low, being consistent through the students. For indicator f, gain is defined as the difference between both exams depicted (the introductory one is an initial evaluation applied to all students in the first class week with eight years of following-up). Differential gain is the difference of average gains between the widget classes with respect to the historic classes. The relative gain is then calculated as the ratio between the differential gain in relation with the historic gain. Surprisingly, the average gain became double in the widget groups, so the relative gain was 0.99 in the current scale. In fact, the historic gain is in average $\mu$=4% with $\sigma$=2.1%. For groups in the widgets program it gave $\mu$=8% with $\sigma$=3.2%. Despite the sample not being meaningful for this research, it suggest a possible improvement in the general learning performance in the courses where the widgets program was applied, but more extent analysis should be developed in the future with large samples.

<u>Outcomes Associated with Development on Teachers' Technology Skills</u>

Mobile revolution has required that teachers should be involved with technological tools to create new educative resources and with meaningful applications to potentially improve or wide the learning quality. It requires adequate training and a change of mind to be supported by technology. Boosted by an institutional initiative to develop mobile learning, several projects were transversely promoted. Widgets Project was one of those. As a result, in addition to some courses directly developed in the institutional effort, a local faculty seminar on some mobile technologies was conducted, mainly due to the widgets Project (Delgado, 2013a), the introductory workshop on widgets became a rich training experience. It was developed as a weekly seminar during one semester. 22 Math and Physics teachers on educative mobile technologies were participating. It became centered on different tools and activities in which teachers could be aided by technology inspired in the widgets experience: Mathics, Simpy, Math Studio, Geogebra, Wolfram Alpha, Mathtab, Desmos, Siminsights, Google-Classroom, Nearpod, i-books Author, e-Page, ExeLearning, Mathematica CDF's, Google-Forms, Jotform, Flubaroo and EducaPlay. A summarized genealogy about the tools learnt by the Math and Physics faculty is presented in Figure 8. It shows as this single effort has deeply boosted an exponential knowledge in those trends, crystallizing other related projects by using and combining these technologies: Online Calculus lab, m.physlab (a Physics challenge lab) and several personal mobile courses (under blended learning approaches) as a teachers' initiative. Despite the last results, full time faculty is mainly involved with technological teaching developments (100%), while partial time faculty is still poorly involved in the new and owns educative projects implementing these approaches (less than 10%).

**Figure 8.** *Chained Advancement in Teachers' Mobile Learning Technologies Departing of Institutional Mobile Learning Initiative*




*Source*: Prepared by author.

<u>Boost of Derived Educative Projects</u>

The outcomes of widget program extended the teachers' skills in technology. Two new technology projects arose from the widget program. The first is the Calculus lab (Santiago and Quezada, 2014), a creative experience of didactic design for 21 themes covering differential, integral and vectorial calculus, all of them based on Desmos widgets. The second was m.Physlab, a mobile physics lab proposing 12 challenge real experiments in the lab physics with support on a mobile site including video tutorials for each experiment, initial and final automated evaluation of the theory involved, online developer of the experimental report, and embed specialized calculators of experimental techniques based on Mathtab.

## Conclusions and Future Development

Education cannot be isolated from the daily scenario where mobile technology is present in almost each aspect of our life. This experience includes many tools able to generate educative resources easily available to teachers. Issues related with quality and depth of education should be addressed by new and old generations of teachers together. Although technology could be a creative tool to boost education by engaging to students, its limitations should not trivialize the knowledge, instead they should potentially improve the students' comprehension.

The widget program is an arena where students and educators have still much more to explore. Each student can spend time reflecting how to construct and use each widget by learning the underlying concepts. While for faculty, it can help to develop curriculum integration and reinforce different course concepts into concrete and real applications. Together, for teachers, it has been an initial introduction to learning mobile technologies. In the road, several tools letting technology integration, embedding, submitting, stocking up and gathering analytics open a creative world to be combined and assembled. Here, Wolfram Alpha, Desmos, Mathtab, Weebly, Jotform and Googledrive construct easily a more complex product with deeper educative goals. In the current program, widgets appear as a valuable learning activity based on visualization, exploring and tutoring. This knowledge, for teachers, normally boosts other ideas about alternative educative projects.

Definitively, computer technology is exponentially growing and spreading. In parallel, it is specializing and adapting to different teaching and learning styles. Continuous search of technological resources for the development of educative materials by teachers should be adopted as a modern educator value (Laurillard, 2002). A future work for this program will be based on to extend it until the greatest possible group of faculty, at least with other associated initiatives. Additionally, widget program should include a more extensive evaluation of educative outcomes by collecting and analyzing the results and the work of students in a follow-up study based on a more robust model to evaluate complex thinking acquisition as suggested by the preliminary outcomes presented here. Despite, in the current experience, widget project has been an example of new technological developments being carried out completely by teachers as a coordinated group, to learn, design and construct educative resources, with not just a modest technological assessment but with a rich teacher’s sharing and interaction.

## References


Allen, K., Seaman, J., & Garret, R. (2007). *Blending in: The extent and promise of blended education in the United States*. USA: Sloan Consortium. Retrieved from http://bit.ly/1KETCsp.

Algreenand, H. & Moesby, E. (2001). *POL assessment guide for students*. Technical report. Aalborg University, Denmark. Retrieved from bit.ly/23WswDx.

Anderson, L. W. & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching and assessing: a revision of Bloom's Taxonomy of educational objectives*. New York, USA: Longman.

Ausbel, D. (1963). *The psychology of meaningful verbal learning*. Oxford, England: Groaning & Stratton.

Bartolomé, A. (2004). Blended learning, conceptos básicos [ basic concepts]. *Pixel-Bit Revista de Medios y Educación, 23*, 7-20.

Buzzeto-More, N., & Sweat-Guy, R. (2006). Hybrid learning defined. *Journal of Information Technology Education, 5*, 153-156.

Conole, G. (2008). The student perspective: the ever-changing landscape of technology use. *ReCALL, 20*(2), 124-140.

Delgado, F. (1999). Principia program: experiences of a course with integrated curriculum in collaborative environments and with use of technologies in learning. *Proceedings of the II Congress of Scientific Research in the Metropolitan University*. Universidad Metropolitana, Caracas, Venezuela.
Delgado, F. (2011). Curricular changes generated by the use of technology in the teaching of numerical methods. *Proceedings of the XXXVIII National Conference Engineering*. ANFEI, México.
Delgado, F. (2013a). Meaningful Learning of Math and Sciences Using Wolfram Alpha Widgets. In Jan Herrington et al. (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2013* (pp. 1794-1799). AACE, Chesapeake, VA, USA. Retrieved from bit.ly/1Q6UaU3.
Delgado, F. (2013b). Physics and Mathematics widgets: internet site. Retrieved from bit.ly/1j4H4vJ.
Delgado, F. & Santiago, R. (2014). Designing a site to embed and to interact with Wolfram Alpha widgets in Math and Sciences courses. *Proceedings of Mobile Learning International Conference 2014* (pp. 266-270). IADIS, Madrid, Spain. Retrieved from bit.ly/1orjpKQ.
Delgado, F. (2014). Actualización docente en tecnologías educativas y aprendizaje móvil: Desarrollo de un programa institucional [Upgrade teaching in educational technologies and mobile learning: Development of an institutional program] . *Revista de Formación e Innovación Educativa Universitaria*, 7(4), 211-226.
Delgado, F., Santiago, R., & Quezada, L. (2015). Widget based learning to develop meaningful comprehension in Math and Science courses. *Proceedings of INTED 2015*, 0750-0758. IATED, Madrid, Spain.
DeNisco, A. (2014). *Different faces of blended learning*. District Administration. Retrieved November 11, 2014 from bit.ly/1jAWlVA.
Dougherty, D. (2012). The Maker movement. *Innovations*, 7(3), 11-14.
DreamBox Learning. (2013). *6 Models of Blended Learning*. DreamBox. Retrieved from bit.ly/1j9hdBa.
Edublogs. (2013). The Edublog awards. USA: Edublogs. Retrieved from bit.ly/1ucFQiK.
Educastur. (2012). *Use of widgets*. Department of Education and Science of the Government of the Principality of Asturias, Asturias, Spain. Retrieved from bit.ly/20KRiHS.
Engelbrecht, J. & Harding, A. (2005). Teaching Undergraduate mathematics on the internet. *Educational Studies in Mathematics, 58*(2), 253-276.
Gaer, S. (1998). Less teaching and more learning. *Focus on basics*. USA: NCSALL. Retrieved from bit.ly/1T6KoGX.
Gkatzidou, V. & Pearson, E. (2011). A community approach to the development of widgets to support personalised learning for disabled students. *Proceedings of ascilite 2011*. Retrieved from bit.ly/1RoOH0f.
Gonzalez, H. & Kuenzi, J. (2012). *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer*. Congressional Research Service Report. Retrieved from bit.ly/1PkxAKw.
Guess, A. (2008). A widget onto the future. *Inside Higher Education*. Retrieved from bit.ly/1WdTil5.
iTEC. (2013). *Smart widgets for the iTEC project*. Lisbon, Portugal: European Schoolnet.
ITESM. (2007). *Project Oriented Learning*. ITESM, Monterrey, México.

Johnson, L. Smith, R., Willis, H., Levine, A. and Haywood, K. (2011). *The 2011 Horizon Report*. Austin, USA: The New Media Consortium.

Kolb, D. (1984). *Experiential learning*. New York: Prentice Hall.

Laurillard, D. (2002). *Rethinking university teaching: a conversational framework for the effective use of learning technologies* (2nd ed.). London: Routledge Falmer.

Lothridge, K., Fox, J., & Fynan, E. (2013). Blended learning: efficient, timely, and cost effective. *Journal for Forensic Sciences*, *45*(4), 407-416.

Pearson, E., Gkatzidou, S., & Green, S. (2011). Widgets to support the concept of an Adaptable Personal Learning Environment. *Proceedings from the IEEE International Conference of Advanced Learning Technologies* (ICALT). IEEE, Athens, Georgia, USA. Retrieved from bit.ly/1Q6TOgk.

Polanco, R., Calderon, P., & Delgado, F. (2001). Effects of a Problem Based Learning program on engineering student' academic achievements, skill development and attitudes in a Mexican university. *Proceedings of Annual Meeting of the American Educational Research Association*. AERA, USA.

Santiago, R. & Quezada, L. (2013). *Calculus Lab: internet site*. Retrieved from bit.ly/1IDuoFD.

Shibley, I. (2014). *Putting students in the driver's seat: technology projects to decrease passivity*. *Faculty Focus*. Retrieved from bit.ly/1p5hZ5z.

Staker, H. & Horn, M. (2012). *Classifying K–12 Blended learning*. Innosight Institute, Inc., Harvard, USA. Retrieved from bit.ly/1iizZmP.

Woessmann, L. (2001). *Why students in some countries do better*. USA: Education matters. Retrieved from bit.ly/1orgLos.

Young, J. (2008). *Professor Uses Web 'Widgets' to Share Course Content*. The chronicle of higher education. Retrieved from bit.ly/23WtK1M.