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EduTrends

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Challenge Based Learning

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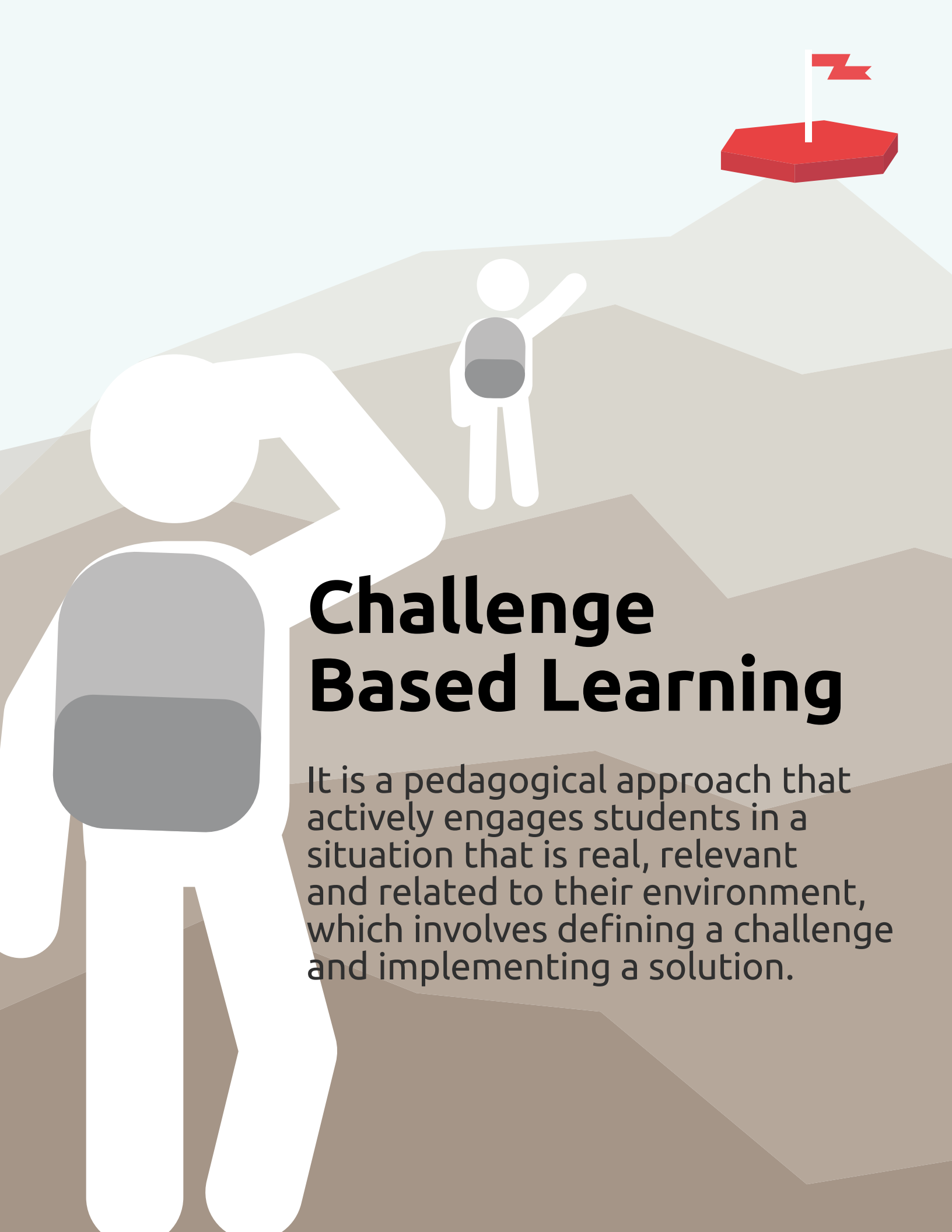


Challenge Based Learning

It is a pedagogical approach that actively engages students in a situation that is real, relevant and related to their environment, which involves defining a challenge and implementing a solution.

Introduction:
Challenge Based Learning from the perspective of Experiential Learning

The objective of this document is to showcase the Challenge Based Learning educational trend, which is part of the broader spectrum of Experiential Learning. We will first cover the elements of Experiential Learning, and then we'll steer the discussion to learning practices based on the solution of challenges. There are different perspectives on how to implement this approach, some of which will be explored in this document to engage discussion and reflection in the academic community.

Currently, students can access information in a substantially different way than a few years ago. They regulate much of their knowledge through informal learning and have gone from being consumers of information to being producers of it. As a result of this, traditional teaching-learning methods are being increasingly less effective to engage students and motivate them to learn.

In addition to this, higher education nowadays faces the significant challenge of preparing professionals to succeed in a world mediated by ever growing technological advancements. Students not only need to excel in areas like math, language and science, but they now have to possess transversal skills like critical thinking, problem solving, persistence and collaborative work. However, in many countries around the world, students are not developing these skills (World Economic Forum, 2015).

The situation is exacerbated by the gap between what students need to learn to succeed in global, more competitive work environments, and the education they are currently receiving. Students perceive the world as a place with abundant problems needing to be addressed and requiring solutions in which they can participate. They hope and expect school will prepare them for this scenario, and when it actually does so, their commitment increases drastically.

An alternative to strengthen the connection between the learning acquired at school and what students perceive outside of it is to leverage their ability to investigate issues and events occurring in their environment. In this context, the role of teachers is of great significance, since they act as facilitators in student-center practice communities, answering their questions one on one, and limiting the amount of help to keep their focus on a problem that might seem long and complex.

Challenge Based Learning is rooted in Experiential Learning, which has as its main principle the fact that students learn best when they participate actively in open learning experiences, rather than passively experiencing structured activities. In this sense, Experiential Learning offers students opportunities to use what they have learned in real situations, where they face problems, discover information on their own, try solutions and interact with other students within a specific context (Moore, 2013). Experiential Learning is an integrated holistic approach to learning, which combines experience, cognition and behavior (Akella, 2010).

In the education field, leading psychologists and philosophers like John Dewey, Jean Piaget, William Kilpatrick, Carl Rogers and David Kolb have made significant contributions to the theories of learning through experience. Kolb's model (1984) describes learning as the integral result of the way in which people perceive and process an experience. Figure 1 describes the four stages of Kolb's Model.

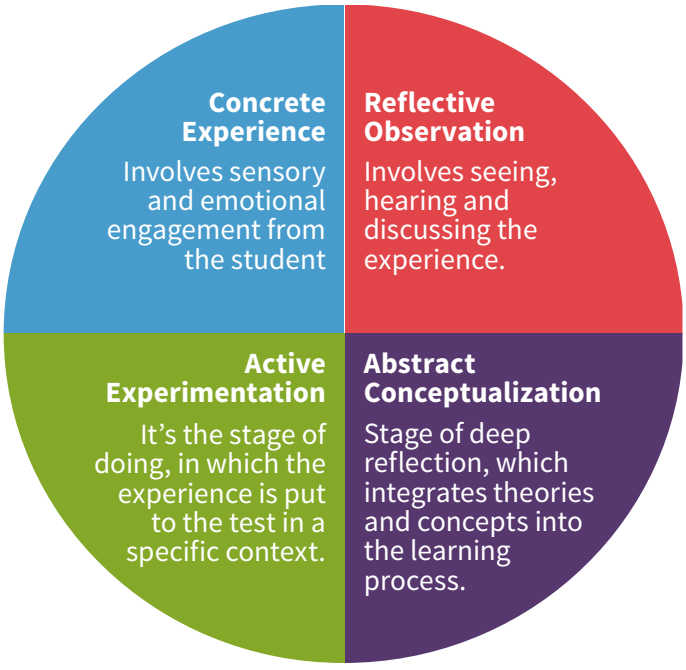


Figure 1. Kolb's Model: Learning through Experience.

However, Experiential Learning involves much more than just students “doing something”. According to the Association for Experiential Education, the key conditions to promote effective experiential learning are as follows (Association for Experiential Education, 2015):

- The designed or selected learning experiences involve activities of reflection, critical analysis and synthesis.
- The learning activities are structured in a way that encourages the student to take initiative, decide, and be responsible of the results.
- The student has active participation when formulating questions, problem solutions, and employs creativity throughout the experience.
- The student is involved intellectually, creatively, emotionally, socially and physically.
- Teachers and students may experience success, failure, uncertainty and take risks, since the results of the experience may not be completely predictable.
- The teacher recognizes and encourages spontaneous learning opportunities.
- Some of the teacher’s tasks include the formulation of the problem, setting limits, facilitate the learning process, provide support to the students, as well as ensuring their physical and emotional well-being.
- The learning results are personal and are the foundation for future experience and learning
- The relationship between the student and himself, other students and the world, are developed throughout the whole experience.

Challenge Based Learning is a pedagogical approach that has been integrated in disciplines such as science and engineering, and demands a real-world perspective, since it suggests that learning involves action from students on an issue (Jou, Hung and Lai, 2010). This approach provides a framework for student-centered learning that emulates the experience of the modern workplace (Santos, Fernandes, Sales and Nichols, 2015). Thus, Challenge Based Learning leverages the interest of students in a practical meaning for their education, while developing key competencies like collaborative work, decision making, advanced communication, ethics and leadership (Malmqvist, Rådberg and Lundqvist, 2015).

A **challenge** is an activity, task or situation that represents an incentive and an obstacle to overcome.

Approaches related to Challenge Based Learning

It's possible to identify the use of real-world problems to trigger the learning process in different techniques and contexts. Challenge Based Learning has elements in common with active learning techniques such as Problem Based Learning and Project Based Learning. It is also related to the Challenge Based Instruction at the VaNTH/ERC Engineering Research Center of higher education, and to Apple's Challenge Based Learning. Each of these approaches, in which learning is based on overcoming challenges, is briefly explained below.

Relationship with Problem / Project Based Learning

Challenge Based Learning shares characteristics with Project Based Learning. Both approaches engage students in real-world problems and encourage them to participate in the development of specific solutions. However, these strategies differ in that, rather than presenting the students with a problem to solve, Challenge Based Learning offers open general problems, from which the students can determine the challenge to be tackled (Gaskins, Johnson, Maltbie and Kukreti, 2015).

On the other hand, Challenge Based Learning also has some similarities with Problem Based Learning. The latter is a collaborative teaching-learning technique in which a problematic situation related to the physical or social environment is addressed (Vicerrectoría de Normatividad Académica y Asuntos Estudiantiles, 2014). A key difference between the two approaches is that Problem Based Learning often employs fictional cases; its goal is not to solve the problem itself, but to use it for the development of learning. The final product can be tangible or a proposed solution to the problem (Larmer, 2015; Lovell and Brophy, 2014).

Table 1 shows a comparison of the key characteristics of the three aforementioned teaching techniques.

Relationship with Challenge Based Instruction at the Engineering Research Center

The Engineering Research Center VaNTH ERC, comprising the Vanderbilt, Northwestern, Texas, Harvard and MIT universities, implemented in 2000 a set of educational innovations heavily based on two aspects: a framework called How People Learn (HPL), shown in Figure 2, and an instructional design known as Software Technology Action Reflection Legacy Cycle (STAR), described in Figure 3. The integration of both elements was called Challenge Based Instruction (Cordray, Harris and Klein, 2009).

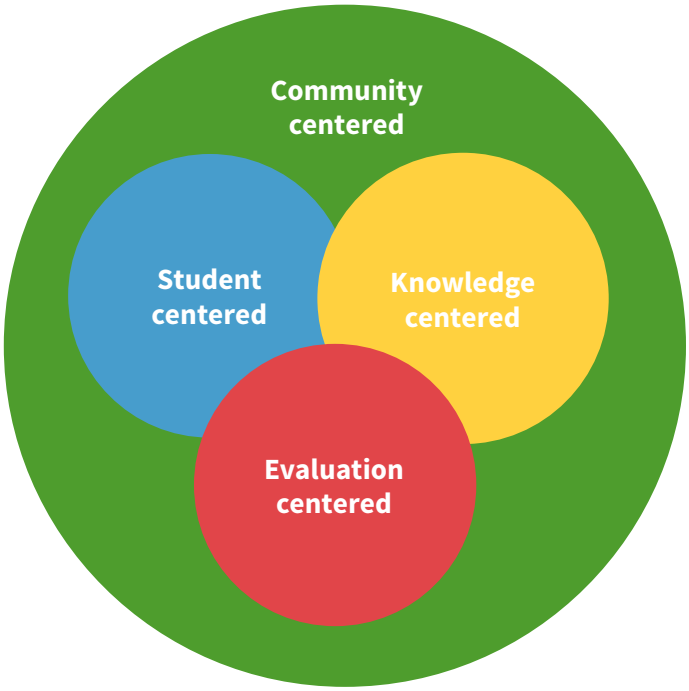


Figure 2. Perspectives on learning environments (Bransford, Brown and Cocking, 2000).

The framework How People Learn incorporates four elements working in synergy to optimize the learning process. When the four elements are properly integrated, students' knowledge increases, as well as their ability to apply it to new situations (Rowe and Klein, 2007).

According to these ideas, learning is enhanced when:

- Information is presented to the students in an appropriate manner, both in sequence and organized (knowledge-centered).
- The contents presented make reference to previous knowledge and is relevant to the students' life (student-centered).
- Opportunities are created for formative feedback for both students and teachers. Students benefit by corroborating their understanding and teachers by assessing the efficacy of the teaching process (evaluation-centered).

Technique/ characteristic	Project Based Learning	Problem Based Learning	Challenge Based Learning
Learning	Students build their knowledge through a specific task (Swiden, 2013). The knowledge acquired is applied to carry out the assigned project.	Students acquire new information through self-directed learning using designed problems (Boud, 1985, in Savin-Baden and Howell Major, 2004). The knowledge acquired is applied to solve the problem at hand.	Students work with teachers and experts in their communities, on real-world problems, in order to develop a deeper knowledge of the subjects they are studying. It is the challenge itself that triggers the generation of new knowledge and the necessary tools or resources.
Focus	It faces the students with a relevant situation and predefined problematic, for which a solution is required (Vicerrectoría de Normatividad Académica y Asuntos Estudiantiles, 2014).	It faces students with a relevant problematic situation, often fictional, for which a real solution is not needed (Larmer, 2015).	It faces students with an open, relevant, problematic situation, which requires a real solution.
Product	It requires the students to generate a product, a presentation or an implementation of the solution (Larmer, 2015).	It focuses more on the learning processes than the products of the solutions (Vicerrectoría de Normatividad Académica y Asuntos Estudiantiles, 2014).	It requires students to create a solution resulting in a concrete action.
Process	Students work with the assigned project so their engagement generates products for their learning (Moursund, 1999).	Students work with the problem in a way that tests their ability to reason and apply their knowledge to be evaluated according to their learning level (Barrows and Tamblyn, 1980).	Students analyze, design, develop and execute the best solution in order to tackle the challenge in a way they and other people see and measure.
Teacher's role	Facilitator and project manager (Jackson, 2012).	Facilitator, guide, tutor or professional adviser (Barrows, 2001 cited in Ribeiro and Mizukami, 2005).	Coach, co-researcher and designer (Baloian, Hoeksema, Hoppe and Milrad, 2006).

Table 1. Comparison chart of Project, Problem and Challenge Based Learning.

- An environment conducive to learning in a collaborative manner is created (community-centered).

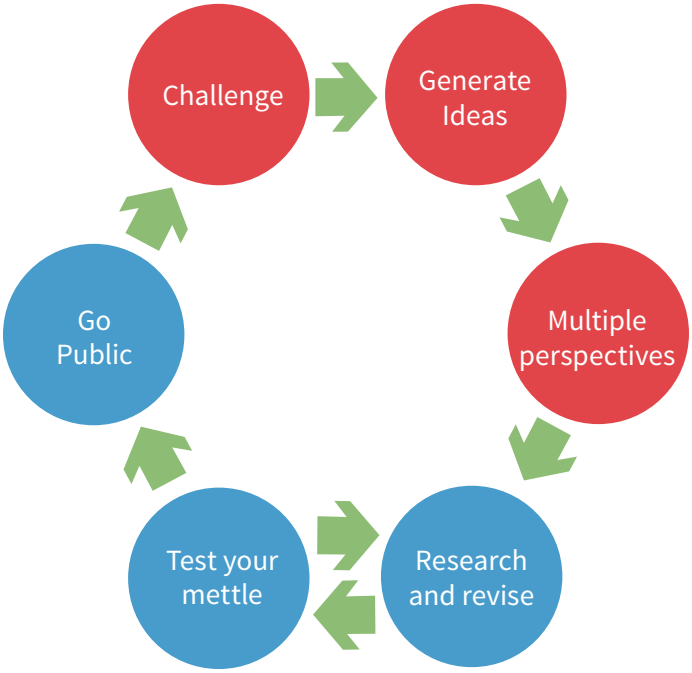


Figure 3. STAR Legacy Cycle (Cordray, Harris and Klein, 2009).

The STAR Legacy cycle provides a scenario that allows students to get involved in a collaborative manner in the solution of a problem or challenge relevant to them, while giving them the opportunity to self-evaluate (Rowe and Klein, 2007).

The elements of this cycle are:

- **Challenge:** Problem and definition.
- **Generate ideas:** First thoughts on the challenge.
- **Multiple perspectives:** Different approaches to the challenge and possible ways to address it.
- **Research and revise:** Participation in data and information research and revise activities.
- **Test your mettle:** Self-assessment by the student.
- **Go public:** Publication of the products and results.

The Challenge Based Instruction at the Vanth ERC Engineering Research Center is an inductive learning method with real challenges, which provides the conditions and motivation to introduce new concepts and reinforce previous knowledge. Problems are designed in such a way that, in order to be solved, students must be exposed to new course material. This method was developed with the intention of improving the skills of engineering students to solve new problems and transfer their knowledge from one context to another (Cordray et al., 2009; Roselli and Brophy, 2006).

Relationship with Apple's Challenge Based Learning

The term Challenge Based Learning is often attributed to the Apple company, and its methodological contributions to this model are also well known. This approach was presented as a practical framework in which students work as a team with other students, teachers and experts both local and international. The purpose of this initiative of educational collaboration is to encourage a deeper knowledge of the contents being studied, identify and solve challenges in their communities, as well as sharing the results with the world (Johnson, Smith, Smythe and Varon, 2009). .

This model makes learning relevant, since it provides students with significant enough problems to learn new ideas and the tools to solve them, but at the same time, close enough to them so they find it worthwhile to reach a solution. This approach can be used on many curricular contents, since ideas are generated from real-world situations that students must translate into solutions to apply locally. In this way, students are able to investigate an aspect of the challenge in terms of the events that occur around them, strengthening the link between what they learn at school and what they experience outside of it.

Technology access is an integral part of Challenge Based Learning, since not only does it provide students with the means to explore different information sources while generating new ideas; it also provides them with the necessary tools to communicate their work. An important aspect of the methodology described by Apple is the presentation by students of different solution strategies for a real, relevant problem (see fig. 4). A common practice when implementing Challenge Based Learning is to publish the solution strategies through media platforms such as YouTube (Apple, 2011; Johnson et al., 2009; Johnson and Adams, 2011).

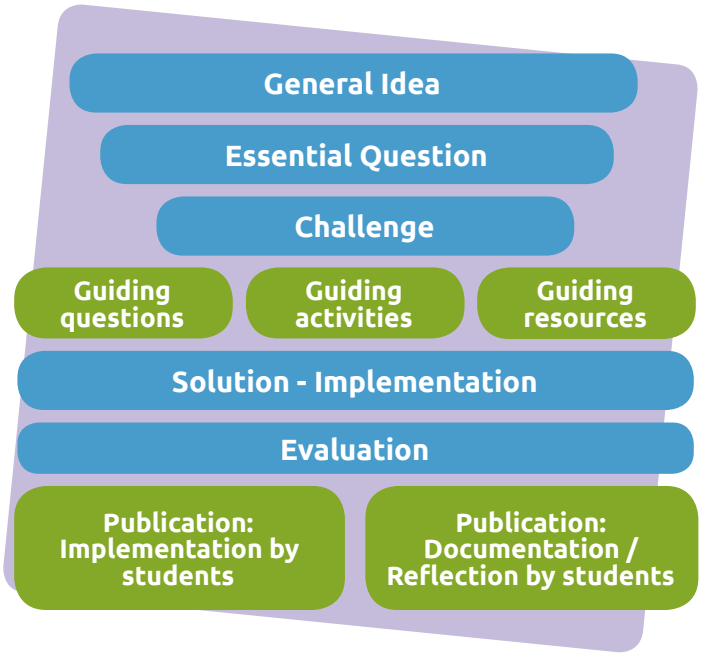


Figure 4. Methodological Framework of Apple's Challenge Based Learning (2011).

The elements of the framework proposed by Apple for Challenge Based Learning are:

- **General idea:** It's a broad concept that can be explored in multiple ways; it is attractive, relevant to students and to society. It is often a topic of global significance, such as biodiversity, health, war, sustainability, democracy or resilience.

- **Essential question:** By design, the general idea allows for the generation of a wide variety of questions. A delimitation process yields an essential question, which reflects the interests of the students and the community needs. It creates a more specific focus for the general idea and guides students toward more manageable aspects of the global concept.

- **Challenge:** It arises from the essential question, when stated it involves students in the creation of a specific solution that will result in a concrete and meaningful action. The challenge is designed to address the general idea and the essential questions using local actions.

- **Guiding questions, activities and resources:** They are generated by the students, they represent the necessary knowledge to develop a successful solution, and they provide a roadmap for the learning process. Students identify lessons, simulations, activities, and content resources to answer the guiding questions and thus establish a foundation to develop innovative, deep and realistic solutions.

- **Solution:** Each established challenge is broad enough to allow for a variety of solutions. The solution must be thoughtful, concrete, clearly stated and feasible in its implementation in the local community.

- **Implementation:** Students try the efficacy of their implementation in a realistic environment. Its reach can vary greatly depending on the time and resources available, but even the smallest amount of effort carrying out the plan in a real setting is valuable.

- **Evaluation:** It can and must be conducted through the challenge process. The results of the formal and informal evaluation validate the learning process and support the decision making as we advance in the implementation of the solution. Both the process and the product may be evaluated by the teacher.

- **Validation:** Students judge the success of their solution by using various quantitative and qualitative methods, including surveys, interviews and videos. Teachers and experts in the field play a vital role in this stage.

- **Documentation and publication:** These resources can be used as the basis for a learning portfolio and as a forum to communicate their solution to the world. Blogs, videos and other tools can be used.

- **Reflection and discussion:** Much of the deeper learning takes places during this stage, as students reflect on their own learning, their relationship with the content, concepts and experience, and their interaction with other people.

Benefits of Challenge Based Learning

The main benefits of this approach are:

Students achieve deeper comprehension of the subject. They tend to diagnose and define problems prior to suggesting solutions, and they also develop their creativity (J. Icaza, personal communication, June 1, 2015).

Students get involved both in the definition of the problem and in the solution they develop (Gaskins et al., 2015).

Students become more aware of a particular situation, they develop research processes, they create and implement models, and work multidisciplinarily and collaboratively (O. Olmos, personal communication, May 12, 2015).

Students become more involved with the reality of their community, they establish relationships with experts in the field, contributing to their professional growth (L. Probert, personal communication, May 13, 2015).

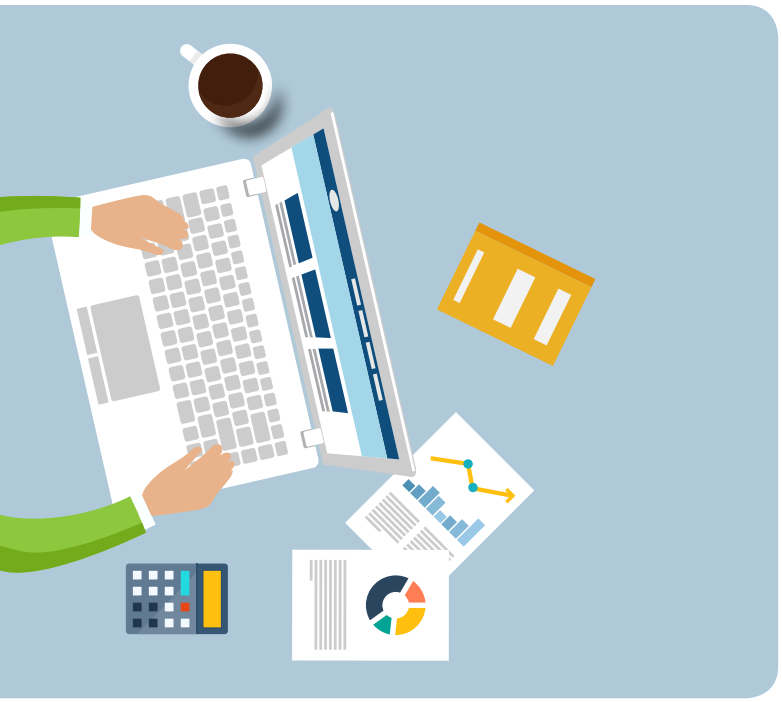
Students strengthen the link between what they learn at school and what they perceive in the world around them (Johnson et al., 2009).

Students tend to develop a higher level of communication skills, through the use of social tools and media production techniques, in order to create and share the solutions they come up with (Johnson et al., 2009).

The teacher's role

In Challenge Based Learning, teachers are more than just information experts: they turn into learning collaborators, they look for new knowledge with the students, while shaping habits and new ways of thinking. This approach may increase motivation and generate a positive attitude in the student and the teacher toward learning (Apple, 2011; Martin, Rivale and Diller, 2007).

Teachers who have jointly implemented this approach report that collaboration with other teachers is one of the most beneficial and enjoyable aspects for their professional growth and development (Johnson et al., 2009). Therefore, this approach is particularly effective when teachers from different disciplines work together.



According to some teachers from the Tecnológico de Monterrey who have implemented Challenge Based Learning in their courses, interviewed in 2015 by the Observatory of Educational Innovation, the main functions of the teacher when using this approach are:

- Proposes the theme of the challenge or the challenge itself together with the students, other teachers or external experts.
- Makes sure there is a clear relationship between the learning objectives, the challenge's general idea and all its stages.
- Integrates the key competencies that the students will develop by taking on the challenges.
- Encourages students to be responsible for their own learning, and to be involved in the development of the challenges.
- They are a facilitator during the development of the challenges, supervise activities, review teams' progress, and guide the students by using trigger questions, but without spelling out the answer or solution.
- Collaborates as a team of specialists with teachers from different disciplines to help students.
- Provides advice or facilitates tutoring from other colleagues.
- They are an intermediary between the students and associations involved in the projects.
- Together with other teachers and external evaluators, they assess the solutions provided to address the challenge and ensure this evaluation is carried out using a previously defined scoring rubric.
- They are a mentor throughout the entire learning process, seek to guide the work teams, channel their efforts and provide feedback on the students' proposals.
- Fosters a sense of collaboration among the team members to reach a common goal.
- Provides support in conflict resolution, facilitates third party spaces, advisory and resources.
- Motivates students to work in the solution of a real problem in a small or large scale.
- Encourages critical thinking that includes risk taking and experimentation.

In addition, the implementation of Challenge Based Learning requires from teachers the following actions:

- Give up having the usual amount of control of the class in order to guide students throughout the entire process.
- Allow students to make mistakes so later on they can realize their error and correct it themselves.
- Do some research in the event students choose a topic they are not very familiar with or involving technology that is beyond their area of expertise.
- Work collaboratively with other colleagues from different areas, since challenges are often multidisciplinary.
- For both teacher and student this approach involves a greater commitment of time compared to more traditional academic activities.

The role of the teachers in the implementation of Challenge Based Learning is crucial; the nature of their function in this process evolves as students advance through each of its stages (Apple, 2011):

The role of the teacher will transition into one of product director, providing support for the students as they implement, evaluate and publish their solutions and results.

Final stage

Students are deeply involved with their work, while the teacher makes sure they have the knowledge and skills required by performing the appropriate evaluations.

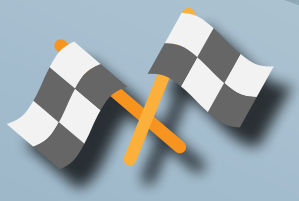
Advanced stage

Students are in charge of planning and doing their own research work; teacher acts mainly as head of the project and mentor, works together with the students, helps them with the difficult parts and encourages them along the way.

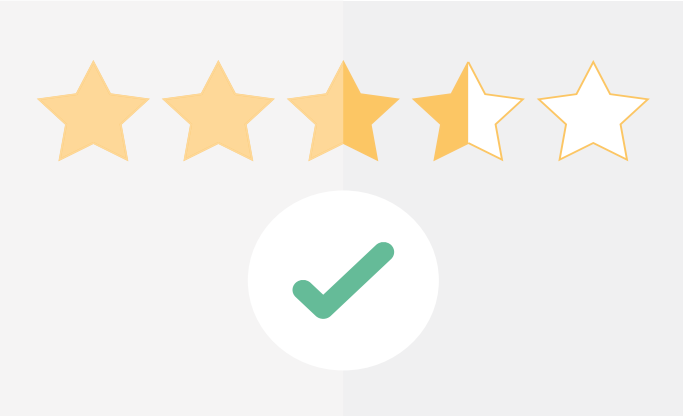
Intermediate stage

Teacher presents the students with the Challenge Based Learning approach, explains how it works, poses the problematic situation, helps in the definition of the challenges and informs students what is expected of them.

Initial stage



Evaluation



One of the crucial aspects of Challenge Based Learning deals with the evaluation process. In a general sense, this pedagogical approach does not a have an overall, unified evaluation scheme. However, there are common strategies used by teachers, academic leaders and researchers to evaluate the processes and products of the implemented solutions, as well as to provide feedback for each of the stages involved in the students' learning process.

It's important to remember that the definition and formulation of the challenge, and the knowledge and skills employed to solve it, aim to develop competencies that show evidence of the learning acquired. In this sense, choosing and designing evaluation tools must take into account the relationship between the products of the challenge solution and the competencies to be developed throughout the process.

The implementation of Challenge Based Learning must also incorporate metacognitive aspects in its evaluation, which would allow the student to reflect on the learning acquired during the process, or lack thereof. Awareness of the learned lessons, the knowledge acquired while carrying out the solution and of transversal skills like teamwork, effective communication, or efficient use of technology, are of particular relevance in this approach. Upon testing the challenge solution designed by the students the results might not always be favorable or successful, therefore it is important to use the experience to develop resilience and tolerance to frustration.

In general, the evaluation of the work by teachers and students must consider two types of assessment strategies: formative and summative. Formative evaluation occurs continuously during the entire process, guiding and facilitating learning; summative evaluation, on the other hand, assesses progress at key points or at the very end of the process (Apple, 2011; Johnson et al., 2009; Johnson and Adams, 2011).

Formative Evaluation

Since Challenge Based Learning is based on the use of information and communication technologies, students often work in informal or online collaborative environments. For example, in addition to teacher feedback, they also receive comments from other students working in the same physical and virtual spaces, through wiki pages, blogs, verbal interactions or audio and video messages. More structured formative evaluation sources vary widely, and they include student journals, peer reviews, teacher observations, teacher-student meetings, and gradual work reviews using scoring rubrics, among others.

With the goal of preparing students to interpret and use all the feedback properly, it is recommended to schedule regular times to review the progress of the project, both with the team and individually. This is done to help them clarify objectives, stages and deadlines, and to encourage reflection. While Challenge Based Learning places great responsibility in the hands of students, it is important to mention that the teacher's role is vital. The more the teacher knows from each group's progress and of the feedback they're getting from various sources, the better the guide he or she will be able to offer when students finally need it.

Summative Evaluation

In Challenge Based Learning, summative evaluation involves the completion and implementation of a solution. The solution must be validated in the real world and offer students direct and immediate feedback. There are important considerations in how students are evaluated, both individually and as a group.

Students can be evaluated using traditional assessment methods to determine their content knowledge. Other options include oral tests, challenge presentations, work evaluation for the specific roles they performed within the team, etc. It is important to define the summative evaluations during the planning process

and present them to students through scoring rubrics and specific explanations.

Alternative evaluation tools

Although traditional evaluation methods may be useful to provide process' feedback, the Challenge Based Learning experience allows for the integration of a wide variety of alternative evaluation tools. Such tools are based on the fact that students not only will gain new knowledge; they will also apply it to solve real-world problems or situations. These tools also provide a source of information for in-depth assessment of the acquired learning and its evolution.

Some alternative evaluation tools that can be used when solving challenges are:

One of the evaluation tools that has been used to facilitate and document authentic learning experiences are the e-portfolios, also known as electronic or virtual portfolios. The use of this assessment tool in higher education has gained wider acceptance as an alternative tool to traditional learning (Díaz Barriga, Romero and Heredia, 2012). In general terms, an e-portfolio is a digital collection of evidence, which includes demonstrations, resources, and achievements by the students (Reese and Levy, 2009).

These resources can be used to keep track of the learning process, highlight achievements, document self-assessments, etc. Virtual portfolios focus on the processes rather than on the products, valuing what students do, exploring the construction of knowledge, the implementation of projects or problem-solving. This resource allows more comprehensive assessment records that include both disciplinary and transversal competencies.

E-portfolios can be an appropriate evaluation tool to demonstrate the development of skills through Challenge Based Learning. This tool allows teachers and universities to (Reese y Levy, 2009):

- Ensure the curriculum values both learning processes and products.
- Demonstrate the development of transferable skills.
- Incorporate evaluation tools in line with Experiential Learning experiences.
- Value students as global thinkers and critically active participants.
- Evaluate different moments of the challenge solving process.

The very nature of basing learning on solving real-world problems allows for the participation of third parties external to the university in the evaluation of the results. The evaluation of implementations of this approach often relies on experts in the field, critics, juries, clients, industry, government and civil society. Feedback from an evaluator external to the academic environment offers a unique learning experience for students. Furthermore, solutions to challenges have been evaluated through contests and competitions among students, through which they can receive economic incentives, meet others' solution alternatives, and show their work to the community.

Relevance of Challenge Based Learning for the Tecnológico de Monterrey

With the objective of creating competent professionals up to the demands and requirements of today's global society, the Tecnológico de Monterrey has launched the Tec21 Education Model. It is a flexible model in terms of curriculum that encourages the participation of students in interactive and challenging learning experiences. This model also includes elements related to learning spaces and state of the art classrooms with a high degree of interaction, skillful use of technology, and the contributions of highly skilled, innovative teachers fully experienced in the practice of their profession (Tecnológico de Monterrey, 2015a)

The institution is currently experiencing a transitional state toward the Tec21 Educational Model. At the undergraduate level, one of the key dimensions of this model is the addressing of challenges by students to develop disciplinary and transversal competencies. It is important to highlight that the focus on challenges is one of the elements of the Tec21 Educational Model for undergraduate studies. This model is currently being defined through consultations and in discussion spaces with teachers and principals of the institution.

Challenge Based Learning promotes the development of competencies. That is why this pedagogical approach becomes extremely relevant within the context of the Tec21 Educational Model in the institution's undergraduate level. Some of the key benefits of the learning experience for students are:

- Exposing students to real-world problems, which allows the development of both disciplinary and transversal competencies.
- Achieving reflective and inclusive learning, since overcoming the challenge involves carrying out research, structuring, implementation and reflection processes.
- Experiencing and achieving education of a higher order, through the implementation of complex cognitive processes to analyze and solve the challenge at hand.
- Exposing the student to situations of uncertainty and, in some cases, of tolerance to failure, as a means to develop their resilience.

In this context, learning experiences offered to the student must be tightly related to their environment and provide value to it. By giving students the opportunity to focus on a challenge of global significance and to apply the learning process to the development of local solutions, the institution creates a space for them to direct their own research and to think critically about how to apply what they have learned.

It is important to mention that the nature of the challenging and relevant learning offered to students exceeds the standards faced by students in a traditional academic environment. Beyond the development of disciplinary skills, this pedagogical approach encourages students to learn because of the connection with their immediate environment. At the same time, the process of solving the challenge promotes innovation, collaboration and multidisciplinary work.

Adopting the trend

The Tecnológico de Monterrey has demonstrated a constant interest in the design and implementation of solutions to relevant problems of the students' environment, who participate in the process by applying their knowledge and skills. Throughout the history of the institution, it is possible to identify numerous efforts aimed at the development of disciplinary and transversal competencies in students through experiential learning experiences. The vertical workshop, and more recently, Innovative Week and Innovation Week are initiatives that can be identified as precedents of Challenge Based Learning in the institution.

▲ Vertical Workshops

Vertical Workshops are academic spaces where creativity, innovation, leadership and the strategic vision of student groups, teachers and experts meet to identify opportunities, plan strategies and solutions of relevant value for the Tecnológico de Monterrey community and its strategic partners.

These spaces provide challenging learning experiences of great interest for students. One of the main objectives of vertical workshops is to connect the teaching-learning processes with real practices at companies, institutions or in the community. Vertical workshops are a source of transcendent

projects of academic connection with the industry and institutions. It provides students with practical experiences in real operation environments, participation in collaborative and disciplinary activities, and having a positive impact on their community. Therefore, these workshops represent an academic exercise in line with the activities of the Tec21 Education Model. Some of the activities and projects carried out through vertical workshops are:

Vertical Workshop 2011 in Campus Guadalajara, in which about 700 students from the Industrial and Systems Engineering and Industrial Design programs participated. In this multidisciplinary project, students from both areas developed modules to help with numerous public service procedures in the areas of tourism, roads, museums and entertainment venues, government forms and hospital services, via the development of special kiosks for the IBM company (León, 2011).

Vertical Workshop 2013 in Campus Cuernavaca was a space for interaction between Architecture teachers and students, which culminated in an architectural design competition. The project consisted of a redesign of the Plaza, Palace and Municipal offices of Mazatepec, with feedback provided by the architect Axel Arañó, renowned architecture critic and theorist, who served as judge of the competition (Loewe, 2013).

Vertical Workshop 2014 in Campus Querétaro, a yearly event in which Industrial Design students participate. On that occasion, the theme of the workshop was the design and production of exhaust hoods in conjunction with the Italian manufacturer Elica, with the objective of improving the quality of air at home (Identidad Campus Querétaro, 2014).

Vertical Workshop 2014 with FEMSA, was an academic exercise in which over 100 students from Campus Guadalajara and 40 students from Campus León participated in business and social care challenges. The objective of the projects was to fight childhood obesity in Mexico, presenting proposals to the organization in the areas of food, children's games and mobile applications (León, 2014).

Vertical Workshop 2015 in Campus San Luis, was an activity that aimed at updating the learning process of Marketing and Communications and Digital Media students with actual practices within a company. For this project, students presented an advertising campaign and marketing strategy to two hotel companies, and representatives of these companies served as evaluators of the proposals to be implemented (Pacheco, 2015).

▲ Innovative Week

It consisted of a week dedicated to innovation, in which students participated simultaneously in various challenging activities of experiential learning, from September 22 to 26 of 2014, in Campus Guadalajara. This space hosted a set of practical activities aimed to strengthen the competencies of students (Portal Informativo, 2014). In this exercise 5,500 students from 23 undergraduate programs participated, as well as 260 teachers, 50 companies and institutions and an educational platform that included nearly 205 activities. It is worth mentioning that about a third of these activities were carried out outside of Campus Guadalajara.

The set of activities designed and implemented during Innovative Week belong to the academic area as much as to the culture, sports, student leadership and internationalization areas. The aim of this exercise was to create conditions and institutional and academic processes in a formal and limited period, in order to develop and implement innovative, high-value activities. These activities have an impact on the development of competencies in students by encouraging analysis, application and creation of concepts hardly achieved in a classroom context and a traditional school calendar (García, 2014).

The activities that took place during Innovative Week shared the following characteristics:

- They are linked to the professional practice.
- They encourage international competitiveness.
- They require collaborative work.
- They are multidisciplinary.
- They are based on real problems or situations.
- They foster human sense.

▲ Innovation Week

Innovation Week is an initiative part of the Tec21 Education Model. It took place from April 13 to 17 of 2015 in Campus Cuernavaca. During this week, students stopped attending regular classes to devote themselves entirely to solving challenges and activities that could contribute to their integral development. It was attended by about 1,000 students and touched on issues such as energy and intelligent use of resources; health and safety; environment and infrastructure; mobility, transport and intelligent society (ITESM Campus Cuernavaca, 2015). This space prompted students to live challenging, interactive and innovative learning experiences to develop and strengthen the competencies required for their professional future. The purpose of this exercise was to promote multidisciplinary teamwork, integrating different generations of various programs, guided by teachers and a group of experts in their respective fields.

▲ i Week and i Semester

Under the Tec21 Educational Model framework there are two initiatives designed to expose students to challenges, in order to develop their graduate competencies. i Week and i Semester are academic spaces that encourage learning experiences outside a traditional academic environment, they will be held on all campuses of the institution and will include 100% of the students. i Week was simultaneously held on all Tecnológico de Monterrey campuses from September 21 to 25 of 2015.

i Week. It is a week in which students of all undergraduate programs simultaneously participate in disciplinary, multidisciplinary and challenging learning activities. During this week, the regular academic activities stop so students can be involved full time in the challenging experience they signed up for. The activities during i Week are aimed at:

- Enhancing the education and competency profile of the student through innovative and challenging learning experiences.
- Developing disciplinary and transferable competencies.
- Promoting collaborative and multidisciplinary work.

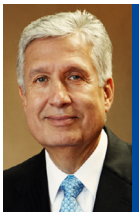
Over 50,000 undergraduate students from 26 Tecnológico de Monterrey campuses participated in the i Week activities. Over 3,000 teachers assisted in the development of over 1,800 projects. Students chose one or two activities among the options offered on their campuses, including projects with local, national or foreign companies or organizations.

i Semester. It is a project or learning experience aimed at addressing a real, challenging situation, which would allow students to develop their disciplinary competencies and strengthen transversal competencies. The project is supported by modules covering specific knowledge needs to complete the project, while addressing the educational requirements of the student.

i Week

SALVADOR ALVA
President

i Week activities involve more than 2 million man hours, and they are oriented to the professional practice and to experiencing situations from real-world companies and organizations (Tecnológico de Monterrey, 2015b).



DAVID NOEL RAMÍREZ
Provost

i Week is an opportunity for teachers and students to experience uncertainty, restlessness, risk, challenges and obstacles; but also the great satisfactions of achieving results through innovation and transforming education and our own country in today's world (Tecnológico de Monterrey, 2015b).

DAVID GARZA
Viceprovost for Undergraduate education

Many of the activities experienced during i Week are connected with about 200 institutions and have presence in 10 different countries. In addition to the development of disciplinary competencies, students also develop and strengthen the ten competencies we have adopted as part of the Tec21 Educational Model (Tecnológico de Monterrey, 2015b).

Undergraduate students	50,000
Teachers	3,000
Projects	1,800
Tecnológico de Monterrey campuses	26

Challenge Based Learning in the Tecnológico de Monterrey

There have been several initiatives at the Tecnológico de Monterrey on the exploration and implementation of Challenge Based Learning as a teaching technique. Here are some examples in which a challenge was added as a trigger of the student's learning process. The examples cover the three educational levels: high school, undergraduate and graduate, with emphasis on the undergraduate level.

In some cases, teachers applied the proposal promoted by Apple, while others made adaptations or adjustments using other methodologies.

▲

Redesign of the distribution network of Holanda Ice Cream in Mexico

Professor Luis Enrique Herrera
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Campus Ciudad de México
Industrial Engineering
Advanced Courses

In this challenge, students learned about the problems the company was facing in relation to the distribution of frozen products on a network of over 80,000 points of sale. The challenge was to diagnose the current situation and propose ways to improve the system, which required a high level of innovation and lateral thinking. The challenge was defined jointly by the teacher and the business entity. The assessment of the challenge was performed as follows: 50% the teacher, 35% the company, 10% other teachers and 5% students. After solving this challenge, the most notable benefits for students were: a deeper and updated understanding of the issue, development of critical thinking, leadership, tolerance to frustration and oral and written communication. The roles that the teacher had in implementing the challenges were: challenge designer, mentor, instructor and evaluator.

The methodology followed was established by the teacher with the following steps: 1. Identify the problem situation of the company; 2. Make a connection between the problematic situation and the contents of the academic course. From this connection the challenge was created; 3. Define a schedule of actions and products.

▲

Audiovisual Production Challenge for Seven Up's company (MOFILM). International campaign to be used in Great Britain (2014-2015)

Professors Juan Carlos Olmedo (jolmedo@itesm.mx), Miguel Nájera (minajera@itesm.mx) and Arturo Rendón (arturo.rendon@itesm.mx).
Campus Ciudad de México
Open registration course for Tecnológico de Monterrey students

In this challenge, students lived a real-world crowdsourcing and crowdcreation experience, in which they were responsible for the production of a 90 second commercial for the Seven Up brand, through the creation of original images and sounds. Students from different programs and semesters participated in this experience of active learning, which lasted five days. The challenge sought to develop in students disciplinary competencies such as: development of creative, administrative and research skills, and techniques to conceptualize an audiovisual project and carry it out under specific criteria and guidelines. Transversal competencies were also addressed, such as teamwork and innovation. The assessment of the challenge was linked to the competencies to be developed by

students, and a scoring rubric that reflected the criteria, academic and innovation goals, was designed. This rubric was evaluated by teachers, representatives of the brand and MOFILM, and there was also a process of self and peer assessment of the audiovisual projects.

Each team had a tutor; scoring rubrics were used for all processes (immersion, study, proposals and prototype) and group performance was also evaluated. In the final presentation phase the end beneficiary of the project and an external judge evaluated the results. Some of the benefits for students were a new awareness of real-world problems, they developed research skills, were now able to create models and build them, they worked collaboratively and in a multidisciplinary environment, they developed creative thinking skills and managed to implement technical knowledge.

▲

Challenges address megatrend problems such as education, business productivity, social development and sustainability

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Campus Toluca
Physics and Mathematics programs of the Basic Sciences Department

These challenges were generated in two ways: one option was to draw up lines of action and students proposed scenarios of their environment to solve; another option was for students to propose attribute-based challenges to overcome. The methodology used borrowed elements from different strategies, as each phase required different emphases. A hybrid approach was used, which fused elements of problem-based learning, project-oriented learning, service-learning and research-based learning.

▲

Ethics Lab : Reading and Writing Workshop

Faculty collegial work. Base team: Luz Graciela Castillo, (lcastillo@itesm.mx); Jesús Baca (baca@itesm.mx), Sheilla Quintana (sheillaqr@itesm.mx), Mercedes Caraballoso (mcarabal@itesm.mx)
Campus Estado de México
Ethics, person and society course

Students from various disciplines made a social contribution, working on strengthening basic competencies (reading, writing, math, learning skills) with underprivileged children and youths in need of support to develop and master these competencies The intent of the challenge was to make students reflect on the dignity of people and the importance of citizen participation through concrete actions.

The challenge was defined collegially by the ethics faculty and students helped fine-tune it. Therefore, proper coordination and constant communication between them was very important. Teachers established the basic guidelines and follow-up structure. Students achieved a better understanding of the issues, which could be seen in the written essays used to evaluate the course, while improving their collaboration skills, decision making and leadership.

▲

Looking for the ideal candidate

Professor Fany Eisenberg Glantz
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Campus Estado de México
Organizational Psychology program
Interview workshop

The challenge had a duration of a month and a half. It was proposed by the course's teacher and the participating companies. For the challenge implementation, an inductive based methodology was used: a general idea is proposed, then guiding questions and, finally, the teacher guides students in their activities. The results were very satisfactory, since some of the students were hired by companies such as Ford Motor Company to structure the profiles and job descriptions of the company.

Working on this challenge got students to make an effort far greater than they are accustomed to in traditional classrooms. Students also strengthened their teamwork and tolerance for frustration, given the difficulties faced in the companies chosen for the challenge.

Challenges: “City-Campus” (diagnosis and proposal for urban image, mobility, transportation, public space and urban integration) “Eco-Campus” (diagnosis and proposal for sustainability, energy, water and green areas)

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Campus Guadalajara
Vertical Workshop “Campus 2030”
Department of Architecture

The Vertical Workshop “Campus 2030” was implemented over one week. 36 teams were formed, each composed of 11 students. The members of each team belonged to different semesters, from first to tenth. The challenges were proposed by the director of the Department of Architecture, PhD. Arch. Laurence Bertoux, and the coordinator of the Vertical Workshop, M. Arch. Julia Astengo Noguez. Collegial work was also done with the coordinators of the faculty teams. The challenges were evaluated along each of the project stages: stage 1: analysis; stage 2: synthesis; stage 3: solution, proposal development; and stage 4: presentation of the project, evaluation of products. Students developed skills such as teamwork, communication, leadership, creativity, critical thinking, ability to identify and solve problems, capacity for decision-making, responsibility, work culture, commitment to sustainable development and a clear awareness of the needs of their locality or immediate environment.

Development of physical engineering products, such as: a gear pump and a bottle opener for senior citizens. Identification of a need and creative solution, such as: aileron redesign for dragster cars, toy design based on specific needs

Professor Luis Fernando Vargas
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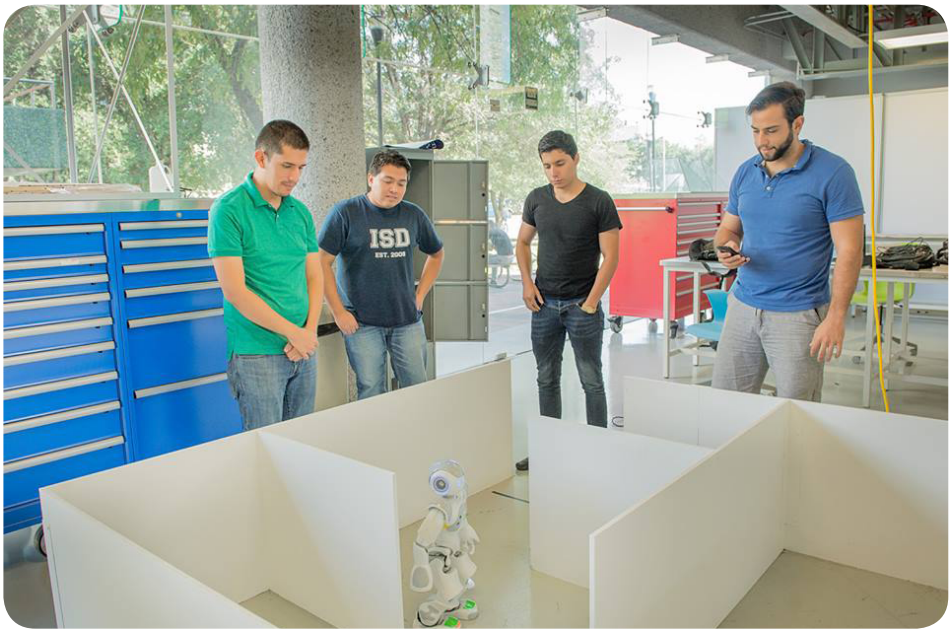
Campus Estado de México
Design Methodologies Program

The challenges lasted an entire semester and were defined by students, the teacher or program directors. Two methodologies were used for the implementation: Engineering Design, suggested by George Dieter, and Stanford’s Design Thinking. In general, the stages of the implementation had the following structure: idea - questions- challenge - solution - action - evaluation. Students learned to solve real-world problems with little initial information. They sought data and researched topics, developed critical thinking and collaborative work, and learned to incorporate ethical and sustainable development dimensions to engineering proposals.



Window-cleaning robot. Fish tank, pool or pond-cleaning robot

Professor Alfredo Santana
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Campus Toluca
Automation Logic Lab Course;
Actuators Course

The duration of the challenges was one semester. The results obtained were encouraging, as students improved their learning, searched for solutions, experienced and acquired engineering best practices. The methodology followed was a combination of problem-based learning, collaborative learning and a French university model technique (1/3 course, 1/3 guided practice, 1/3 practices to be solved by the students themselves). The students self-evaluated according to the initial section of the project, which covered operation, manufacturing, energy use, results, and report.

Solution proposal to reduce the impact of Campus Cuernavaca’s people on the environment

Professor Ramona Fuentes
(rfuentes@itesm.mx)
Campus Cuernavaca
Vertical Workshop

The duration of the challenge was one week, with 90 students participating in 10 teams. The conditions to create the teams were: form multidisciplinary teams with members from different programs and different semesters. The type of challenges was proposed by a group of teachers (administrative) and

was shared with the leader teachers, who continued with refining the aspects involved in the challenge. The students were guided by teachers and groups of experts to design a solution proposal to the challenge assigned. The structure of the challenges was held in XPRIZE form (http://www.xprize.org/): the students received the description of the challenge, the context of the problem, its background, the issues that should be addressed in the solution and its impact. Among the benefits are: strengthening and developing leadership, tolerance, respect, responsibility, time and resources management, critical thinking, learning to learn, problem solving, use of new technological tools and teamwork.

1st Latin America Innovators Challenge: Turn your ideas into world changing products

Participants in the design and implementation of the program: Arturo Molina, PhD (armolina@itesm.mx); Raquel Castaño, PhD (rcastano@itesm.mx); Carlos Téllez, PhD (carlos.tellez.mar tinez@itesm.mx); MS Patricia Mora (smora@itesm.mx); MS David Romero (dromero@itesm.mx); MS Claudia Quintanilla (claudia.quintanilla@itesm.mx); MS Miguel Ramírez (miguel.ramirez@itesm.mx); Rafael Batres, PhD (rafael.batres@itesm.mx); Alejandro Ríos (alejandro@muvexperimento.com); Pedro Ponce, PhD (pedro.ponce@itesm.mx); Eduardo González Mendívil, PhD (egm@itesm.mx)
Vice provost of Research, Graduate and Continuing Education

It is the first online certification course from the Tecnológico de Monterrey presented as a challenge for innovators in Latin America, designed with a structural gamification strategy. To participate, candidates had to go through a pre-registration selection process. The content was imparted completely online with weekly synchronous sessions. The expert group that designed the course also did the tutoring. The program's goal is to develop a prototype of an innovative product by applying various tools and a process of innovation, which is carried out through four challenges:

Challenge 1. Imagination: justification of the innovative product idea to be developed.
Challenge 2. Concept generation: conceptual development of the innovative product.
Challenge 3. Design: script of the innovative product.
Challenge 4. Creation: functional prototype of the innovative product and registration file.

A methodology for rapid development of innovative products was employed, which has been developed by experts in innovation leveraging 15 years of experience. The audience for this program includes entrepreneurs, professionals, and researchers who want to develop a product to market. The participants of the three best projects have the opportunity to present their product to investors.

Identify an interesting educational situation to research and publish the results at an international conference and/or an article in an academic research journal

María Soledad Ramírez, PhD (solramirez@itesm.mx)
Online programs. Education Management Models for Masters in Education; Integration of emerging technologies for educational processes of Masters in Educational Technology

To carry out the challenge, students worked in teams with other geographically distant students. The course duration was 16 weeks, but students managed to develop the entire project in 12 weeks. The strategies used were project-based learning, research based learning, evidence-based educational innovation and collaborative work. Three factors were taken into account for the definition of the challenge: first, teachers had to consider the issue to be addressed and its relationship with the course's content. Second, students had to take into account the international requirements of the Opportunity project (Alpha European project which defines the needs and problems of the international environment in the field of education); third, the areas of opportunity in which students can propose a solution to a problem.

Additionally, students decided which challenge to work on, how to do it and the solution to the environment's problem. The teacher's role in the challenge was to provide guidance and the basis for the challenge, inviting teams to discussion, reflection and collaborative work. The assessment of the challenges was conducted through formative evaluation, peer review, self-evaluation and a final evaluation. The biggest challenge faced by students was the scientific and academic writing required to document the results of their research. Students gained a deeper understanding of the issues covered in the course and the development of substantial competencies, like critical thinking, designing innovative projects, research competency and communication skills.

Create a waste sorting company to contribute to a greener Monterrey and promote the recycling culture

Professor Lucía Probert
(lprober t@itesm.mx)
Campus Santa Catarina

Entrepreneurship in a global world course

This challenge aimed to solve, in the span of a semester, a real problem in the community. Teams of four students participated in the planning, implementation and feedback of the project. The benefits for the students were: they employed their creativity, overcame obstacles, got closer to the reality of their community, strengthened teamwork and leadership, gained a deeper understanding of the course contents, networking with people specialized in the area and professional growth. The methodology promoted by Apple was used and the project was grounded using SMART designed objectives. Next, the challenge was implemented, a review using evidence was performed and feedback was provided to further improve the project.

Relevant cases of Challenge Based Learning in other education institutions

Cincinnati University

In 2014, the Challenge Based Learning approach was used in a training program for teachers, in order to teach and understand the mathematical concepts of exponential growth and decay. The program was aimed at teachers of upper secondary education to improve their understanding of the relationship between engineering and mathematics, as well as to provide the necessary resources to use similar concepts from both disciplines in the classroom.

The main challenge of the course was to design a circuit to model a real-world problem to put into practice the two concepts. The challenge inspired a wide variety of real-world problems, such as the loss of water in lakes located near the deserts, the angle of inclination of the Tower of Pisa, decay rates of drugs in the body, control the population of invasive species, etc. Instructors designed guiding questions and then led the students (teachers) to recognize how an exponential function could be connected to a real problem and how the solution to these problems is also connected to areas of engineering (Kastner, Kukreti and Torsella, 2014).

Montana State University

The University conducted a study with first year Physical Sciences students, implementing a Challenge Based Learning project. The aim of the study was to evaluate the effect of this educational approach on the students' performance and motivation.

During the study, participants were asked to design and implement an environmental project that would benefit society, so they chose a challenge and presented the proposal to the rest of the group in a short video. In this audiovisual material, they presented the challenge, its objectives and invited other participants to join in. The students then defined a list of guiding questions, following Apple's proposed methodology.

The implementation took six weeks, during which students used the answers to their guiding questions to propose a solution to the challenge. The results of the study indicate that the Challenge Based Learning strategy increased student motivation and kept steady achievement levels, even when participants invested 50% more time compared to the traditional curriculum of an introductory class of Physical Sciences (Swiden, 2013).

Pontificia Universidad Católica de Río Grande del Sur

The University conducted a study with 94 participants, focused on the development of mobile applications through the implementation of Challenge Based Learning. Given the popularity of mobile application development and an easy access to the market, there is a growing need to find new ways to prepare developers, as well as new development approaches.

The study results indicate that an environment of teaching and learning based on practical experience,

combining Challenge Based Learning with the Scrum process (an approach to developing agile, iterative and incremental software) is an effective model to teach students how to develop applications efficiently. This combination not only was beneficial to the learning process; it also resulted in a new effective approach to agile development and high-quality applications (Santos et al., 2015).

President's Challenge 2015 (Harvard)

It's an initiative that lists several challenges offered by the Harvard Innovation Lab (i-Lab). It is designed to help students to formulate and develop solutions to complex problems through confrontation and addressing important issues in today's world. The challenge consists of two stages: first, the teams meet in the i-Lab to plan and submit their initial proposals. After the verdict of the evaluation committee, each team receives 5,000 USD to continue their proposals. The prize of 100,000 USD is awarded to a single team. The challenges of the President's Challenge are focused on specific areas, such as educational innovation, affordable health care, energy and the environment, economic development, sustainable employment and connected cities.

For example, in the area of health, the challenge is designed to help students, postdoctoral and clinical fellows, to develop, test, validate and implement innovative solutions that could improve healthcare delivery and the lives of patients. In the area of connected cities, the challenge is to apply their creativity to find collaborative, entrepreneurial and sustainable solutions that best address urban issues related to population growth. The challenge is called "Urban Life 2030" and calls for the submission of proposals to improve the livability of cities by 2030 (Harvard Innovation Lab, 2015).

MIT Ideas Global Challenge

The program provides a space to find solutions to global problems. It invites students, faculty, alumni and partners to identify social development challenges through innovation and collaboration in communities around the world.

Through this program, participants define barriers for the welfare of communities; generate innovative solutions to these challenges; form teams to develop prototypes and proposals; share skills and resources and track their projects implementations over a year. Within this program an annual competition is held, which awards a prize of 10,000 USD to the teams with the best ideas (MIT, 2015).

Grand Challenges (Georgia Tech)

This program was established in 2012 and is part of the division of student affairs, and the leadership development and learning program. It encourages the creation of interdisciplinary teams led by students researching relevant technological and sociological problems. The program is open to all students of any Georgia Tech program. It has three main components: life, learning, and leadership.

Once a student is admitted to this institution and is accepted into the program, they live with other participants of the same project in a specific dorm. Students involved in the program share two classes and are divided into teams. In these classes, they are presented with challenges for which they have to develop problem solving skills and propose alternatives to real-world problems (Georgia Institute of Technology, 2015).

Aalborg University

The University offers a model in which elements of the Challenge Based Learning approach can be recognized. In this model, students work in teams on real and complex projects, often in collaboration with an industrial partner.

This method is also called the Aalborg Problem Based Learning model, and it is highly regarded internationally. In the Operations and Innovation Management program offered by the University, the student has the opportunity to work for four semesters with external companies and be exposed to the real problems they face. The goal is for students to develop analytical skills combined with the ability to develop creative solutions to real problems (Aalborg University, S. F.).

The University of Western Australia

The University offers the first year of the Civil Engineering Program with a Challenge Based Learning approach called Global Challenges in Engineering. Students participate in the realization of a real project in a geopolitical context and work in collaboration with NGOs.

The main issues addressed in the challenges are poverty and waste management problems. The course offers a broad overview of the engineering program. It seeks to ensure that students develop skills in areas of communication, research, teamwork, project management, cultural and gender diversity, critical thinking on environmental, legal, ethical, health and engineering safety impacts (Malmqvist et al., 2015).

Chalmers University of Technology

The institution created a laboratory called C Lab, where professors work together with students, partners and sponsors. The main players are graduate students focused on addressing sustainability challenges in areas such as sustainable urban development, energy and transport. Students are co-creators of the challenges, so they are provided with the tools to work with complex problems (Challenge Lab, 2015).

Hackathon

The Hackathon is an initiative of local, national and international companies and institutions that aims to bring together web and mobile app developers (usually college students) and put them to the test to create technological solutions to solve various society problems. It's a marathon of software development, in which, for a given time (usually 24 hours), teams create applications or other software project defined by each team (Open Data MTY, 2014).

OpenData Monterrey "Datos abiertos + hacking" is a hackathon of open data with which seeks to develop creative solutions to address social problems. In the past, this event has been hosted at Tecnológico de Monterrey, Campus Monterrey. There, the participants build apps and release and analyze data to encourage the adoption of policies of social and government transparency, in order to have a positive effect on the city The participating teams are usually multidisciplinary and consist of 2-6 candidates (MTY ACM, 2013).

Students from the Tecnológico de Monterrey have had an outstanding participation in these meetings. At the international hackathon organized by Facebook and held in Silicon Valley, California in November 2013, four students of the institution competed against 11 teams representing different universities worldwide. In this competition, students from the Tecnológico de Monterrey faced the challenge of developing a Facebook–connected video game for 24 hours, a development that earned them third place (Informative Portal, 2013).

Destination Imagination

Destination Imagination is an international nonprofit educational program with a presence in 48 states and 30 countries. This organization presents students with challenges in a competition setting, where they must design creative and innovative solutions. The aim of Destination Imagination (DI) is to give students the opportunity to learn and experience the creative process from imagination to innovation. More than 120 teams from different parts of Mexico, from both private schools and public schools, have participated in the competition's five categories. During the tournament, participants are encouraged to work together to come up with innovative solutions to two types of challenges: a central challenge, which they work on during DI season and a new instant challenge they must solve under a time limit.

Each challenge has certain requirements and contains a rubric for the evaluators. 60% of the team score comes from their central challenge, 25% from the instant challenge and the remaining 15% from elements selected by the team as representative thereof (Destination Imagination, 2014).

Where is this trend headed?

Challenge Based Learning has recently gained traction by incorporating innovative trends and taking advantage of a wider access and dissemination of information and communication means. Although it is a teaching-learning approach defined only recently, an evolution in consequence with current educational requirements and the characteristics of global education is expected. The following are some of the different avenues that are shaping up to be the potential future of this trend.

Just in time learning model induction

A growing trend in education today is the Just in time learning model. This trend has been driven by the development of competencies such as searching and selecting information, critical thinking and problem solving, all required in real work scenarios. With this model, the need to store information that might be useful in the future (Just in case learning) is questioned. Generally, students learn a comprehensive body of knowledge in school in the event it might be useful in their adult life. However, once they enter the workforce and are faced with a new challenge, they must learn new information because it is necessary at that exact moment to solve the problem (Cook, 2010; Sams, 2013).

The nature of the Challenge Based Learning has helped to build the Just in time learning model because the challenge shows students what they need to know to address it. On the other hand, according to Cook (2010), people should have knowledge and skills before identifying where and how to apply them. That is, a student must have a general knowledge foundation before they can recognize a situation that requires it. Also, the Just in time learning model assumes a minimum basic knowledge level to solve effectively a task.

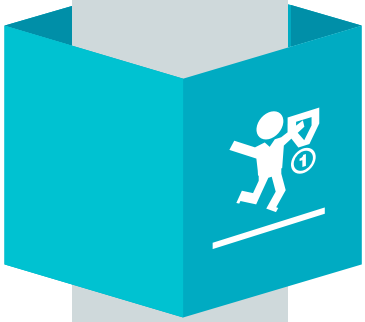
Addressing social impact issues

One of the characteristics of the implementation of challenge based projects is that it encourages students to find solutions to real problems, from conception to taking action. Since the proposed or assigned challenges are relevant to them, a channel for initiatives in which students can monitor important problems of their environment is created (Santiago, 2014). This means that the learning experience presented to students has the potential to transcend the educational dimension.

On the other hand, challenges promote addressing relevant and complex situations requiring both disciplinary and multidisciplinary strategies for their solution. Added to this, it presents a major test to the skills and knowledge of students beyond their current level (Tecnológico de Monterrey, 2015a). These elements are key to the professional development of students and provide them with tools to continue learning. Hence, problems addressed through challenges can be of great value for graduate projects of college students (Santiago, 2014).

Learning spaces and an environment focused on the student

A significant number of failures in the implementation of challenging learning experiences occur in schools that attempt to insert features of this approach in a traditional classroom environment, with rows of fixed chairs facing forward (Markham, 2014). In contrast, this approach is favored by a space that is easy to navigate, communicate in and work in groups. Therefore, the physical learning spaces play a significant role in the dynamics of addressing the challenges. Additionally, it is important that teachers are aware that their personality, attitude, expectations, openness, ability to listen and answer directly have a direct impact on the quality of the challenge. It is equally important to allow time for students to reflect on their attitudes and abilities, practice teamwork, set standards and review responsibilities.

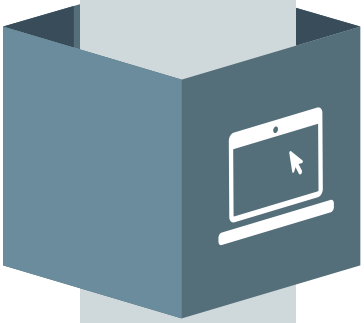


Flexible learning and educational technology

Educational trends driven by technology, such as the flipped classroom, hybrid learning, and online courses, encourage educators to rethink when and how students learn. Technology platforms have also evolved to expand and revolutionize the workplace, and Challenge Based Learning can easily integrate into Computer Based Instruction. These trends and resources have the potential to transform traditional education.

At the same time, some teachers are exploring the value of less structured learning during the regular school day. Different strategies used in the design or implementation of a solution to a challenge, such as designating a time free of schoolwork, give students more opportunities to discover and develop their interests (Boss, 2014).

The role of teachers is evolving, as students have more control and responsibility for their own learning. In this integration, Challenge Based Learning has the advantage of offering greater flexibility to the student to identify, communicate and analyze information at the various stages of solving the challenge. For example, students can get advice or feedback from experts in the fields related to the challenge, asynchronously and from different geographical locations.



Teacher collaboration networks

One of the areas in which this trend has an impact is in an increase in the means of educational cooperation, assistance and exchange of experiences. With the globalization of the media and access to social networks of interaction, there is no reason for a teacher to feel isolated during the implementation process of Challenge Based Learning. This also applies even if the teacher is the only one within the institution getting started with this educational approach (Boss, 2014).

It's not unusual to find an increasing emergence of communities of colleagues sharing interests and open to collaborate in both disciplinary and multidisciplinary projects, within and outside their institutions. Once the teacher becomes a learner interconnected with a community of teachers, he or she becomes an example of how to take advantage of digital tools and work done in collaboration with others (Boss, 2014).

A critical look

Challenge based learning is known for its potential to demonstrate the link between learning and real problems of the environment, and how students can contribute to their solution. However, it also faces various questions given its recent definition, implementation practice and other associated difficulties.

▲ Complex unstructured problems

The challenges students will face in their professional and work environments demand skills that transcend a traditional academic setting (World Economic Forum, 2015). However, students usually aren't accustomed to being exposed to real and unstructured problems requiring non-pre-defined solutions. In the context of Challenge Based Learning, it is important to note that, at the beginning of a challenge, the information should be presented to students in an organized manner that allows them to gradually deepen their learning and does not distract them from the objective with too much information (Shuptrine, 2013). While it is true that the formulation of the problem must be global, it is crucial not to forget the importance of teaching them efficient processes to work with real and relevant scenarios that could enable the implementation of concrete and meaningful solutions.

▲ Exclusive emphasis on inductive experiences

One of the most common concerns regarding the implementation of Challenge Based Learning is that the approach could downplay the principles and theories explaining the workings of certain phenomena and focus instead on the results of the event. Although the intention of challenge based educational programs is to achieve empirical results, students who fail to understand the underlying fundamentals of the facts also lack the ability to identify important practical relations between the studied phenomena (Abrahams and Millar, 2008). When working with challenges it is important to design activities that would enable students to describe, explain and validate the operation of the observed knowledge.

▲ Is a single strategy for the entire curriculum the most convenient for students?

Regardless of which teaching method is chosen, it has to be appropriate for students, the topic or subject taught, the characteristics of the content, the context and the teacher who implements it. Not only teachers have different strengths, skills, and methodological preferences, but students also respond better to a diversity of teaching approaches. Therefore, it is important that teachers are trained in different teaching resources, in order to benefit from the variety of choices currently available. The more knowledge of these methods the teacher has, the better he or she will be prepared to use the most suitable strategy at the right time.

▲ The lack of a solid instructional framework highlights the need for more research

Challenge Based Learning is an approach that has shown encouraging results regarding performance, motivation, competency development and significant contributions of social impact. Recently various pilot studies have been conducted to investigate and understand the different aspects of the school ecosystem that could influence the success of this approach (Apple, 2015). However, Challenge Based Learning is a relatively new approach, which has yet to provide a framework that would allow the design of effective learning experiences. Therefore, educational research must render an account of the maturity and consolidation of this approach to teaching-learning, in order to make decisions on its profitability and scalability in higher education.

▲ Time, space and resources availability of organizations and institutions

In the implementation of Challenge Based Learning, challenges need not be fictitious, since there are plenty of real problematic situations that deserve creative solutions. Domestic and foreign companies

in the public and private sectors, consultancies, government institutions, NGOs, among others, can provide conducive spaces for students to apply their knowledge and skills while developing new competencies. However, one of the greatest challenges this approach will face is related to the demand for resources in these organizations. Challenges designers will have to facilitate spaces where students can work on their projects outside the classroom as well as seek support from evaluators, jurors, critics and experts in the relevant field, to provide students with an enriching and meaningful learning experience.

Challenges

Challenge Based Learning faces its own difficulties, with some of the most relevant being:

▲ Unfamiliar educational approach

Despite being based on other more mature approaches like Project Based Learning and Problem Based Learning, the concept itself of Challenge Based Learning is relatively new with very few comparative research studies, and few replicable studies to date (Giorgio and Brophy, 2001; Hift, 2013; Malmqvist et al., 2015).

▲ Design of effective challenging learning experiences

Further research is needed on how to develop learning experiences and their effects on the academic performance of the students, as well as investigate the design of appropriate learning spaces for the implementation of this approach (Malmqvist et al., 2015).

▲ Innovative and appropriate evaluation methods

Traditional evaluation methods usually are inadequate to assess the learning gained by using this approach. Teachers that have implemented Challenge Based Learning expressed the need for more extensive training on assessment strategies for challenging learning experiences, particularly for the development of evaluation rubrics and the implementation of this approach (Hargis, Cavanaugh and Marin, 2013).

▲ Less class time

There is less class time when the Challenge Based Learning approach is implemented, just as with any other active learning strategy (Roselli and Brophy, 2006). That is why it's so important for the teacher to establish the right balance between what the students find on their own, guidance and feedback, and the teachers' direct instruction.

▲ Teacher preparation

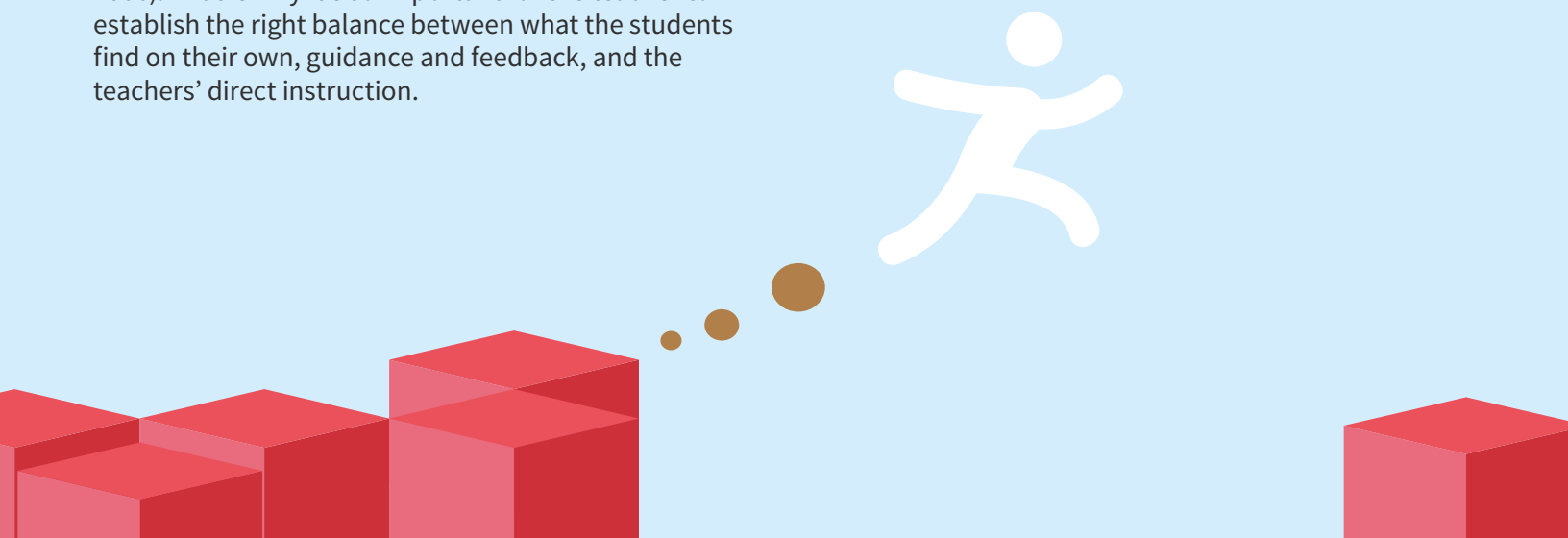
Among their new roles, teachers have to present students with big enough challenges for them to learn new ideas and acquire new tools to solve them, but close enough to them so they find relevancy on finding a solution (Johnson and Adams, 2011). It is expected of the teacher to document themselves on the design of activities that promote the development of disciplinary and transversal competencies in students, ensuring productive and challenging participation. And to integrate these designs with the course objectives.

▲ Management of tolerance to frustration, uncertainty and resilience development

When working on the solutions to the challenges, participants could achieve unfavorable or unexpected results; however, it is important to remember that unsuccessful solutions and implementations are potential sources of experiences and learning that contribute to the development of training skills. It's also important to incorporate metacognitive activities that support the analysis and reflection of learning experiences regardless of the results.

▲ Interdisciplinary work

This model presents new demands to teachers, because to address broad or complex problems it is often necessary to create interdisciplinary student teams. Therefore, this requires working together with other teachers from the same or different area, in order to provide accurate feedback and guide students throughout the entire problem-solving process.



Recommended actions for teachers

Next are a few recommendations for **teachers**, prepared by the Observatory of Educational Innovation to enhance the implementation of Challenge Based Learning.

Address challenges close to the reality of the students to incite their interest and motivation.

Make sure there is a strong relationship between content, course objectives and the competencies you seek to develop in students through the challenges.

Design challenges that require students to make decisions and make judgments based on facts and logical information to back up their decisions and reasoning.

Clearly define what students are expected to do during the challenge, create evaluation tools and explain how students will be evaluated.

Allow students to participate in the definition of the challenge or determine the direction of the research and solution proposal.

Help students to divide the challenge in reasonable segments.

Resist the temptation to rush the process or to give the students the solution.

Match the challenge with the available resources and time to enhance its scope and feasibility, and to ensure students have the opportunity to act on their solutions.

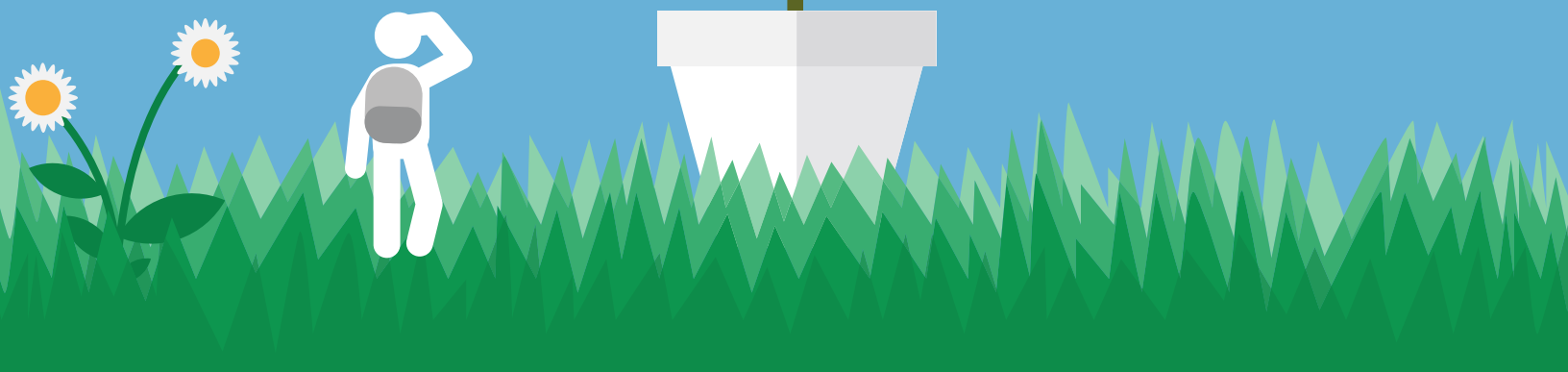
Form a team with teachers from other disciplines to enrich the students' experience.

Encourage creative thinking to guide the process, take risks and experiment.

Link the contents with the environment and external entities like companies, academic leaders, government, and other institutions.

Prepare a clear methodology for both teacher and students.

Evaluate the entire learning implementation experience, both products and processes. The evaluations may be conducted by the teachers, guests, or external agents.

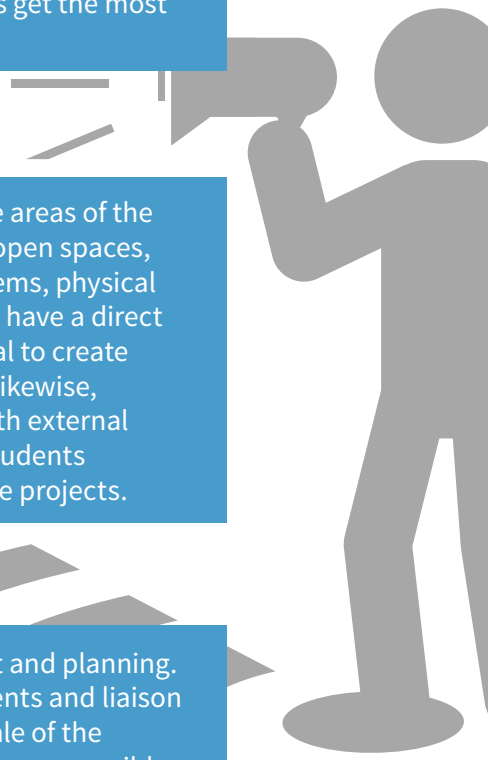


Recommended actions for leaders

The following are some recommendations for **academic leaders**, prepared by the Observatory of Educational Innovation to enhance the implementation of Challenge Based Learning.

Teacher training and preparation through workshops

It is important you take the time to answer questions about the process, share examples of implementation and related projects, help teachers understand their new role, which could be very different from what they are used to. It is recommended that students also have an opportunity to express their concerns and to collaborate in the design of challenges. These workshops should not focus only on the conceptual aspects of Challenge Based Learning, but also provide an opportunity for participants to practice the basic skills and tools they require to help their students get the most out of the experience.



Support and coordination with internal and external areas

The implementation of Challenge Based Learning requires the involvement of multiple areas of the educational institution in which it takes place. Not only the classrooms, laboratories, open spaces, but also the departments responsible for promotion, dissemination, information systems, physical facilities, support staff, external guests, among others, they all perform functions that have a direct effect on the development of learning experiences for students (Iñiguez, 2014). It is vital to create strategies to coordinate activities undertaken by the various internal areas involved. Likewise, physical, economic and administrative support is needed to facilitate relationships with external entities such as companies, government institutions, civil society, etc. Teachers and students designated as coordinators are the best source of information to know the needs of the projects.

Time and resource management

Critical issues related to available resources can be prevented with good management and planning. Appropriate time should be given to teachers to design and manage special requirements and liaison activities. A useful strategy is to assign periods in the calendar in proportion to the scale of the challenge. It is advisable to schedule follow-up meetings with teachers and to appoint a responsible person to the area, with the aim of providing support to problems that could arise during the planning and management of resources.

Collegial disciplinary or multidisciplinary work

It is important to encourage and facilitate collaborative work. Teachers are enthusiastic about the opportunity to work directly with their colleagues, not only to design the challenge but also to implement it. Collaboration with other education professionals is invaluable when it comes to sharing ideas and resources, to help each other with recommendations, especially in awkward or difficult situations. In turn, this practice of collegial work helps students make connections between disciplines. By extending the challenge to a multidisciplinary level, students are encouraged to look at solutions and strategies that connect more than one disciplinary area.

Frequently Asked Questions

Challenge Based Learning has been used with encouraging results in different disciplinary areas and at different educational levels. However, various concerns, questions or myths keep surrounding its implementation. Here we discuss some of the most common issues that arise when this approach is put into practice, accompanied by explanations and alternatives from experience in previous implementations.

Will students learn the material they need to know?

Teachers who have implemented Challenge Based Learning have found that the process itself promotes mastery of the content. Towards the end of the study, many teachers observed that students had mastered the study material beyond their expectations. Teachers can start using standardized content and then proceed to connect it to 21st-century skills through the process. Don't forget that the design of the solution and its implementation require space for conducting research, discussing information, implement the knowledge and receive timely feedback.

Some students are not very participative, how can we engage them with this approach?

Studies have found that even students who tend to lose interest in school find themselves motivated and interested in addressing challenges (Apple, 2015;. Johnson et al. 2009). This is attractive because it connects schoolwork to real life and it is structured very differently from what many students are used to doing. In your work as a teacher you can present the process, especially the challenge, in a real context, in a way that motivates and engages students.

If the teacher doesn't teach the content, how will students learn it?

This question is based on the fallacy that students don't learn anything unless the teacher tells them what to learn. This presupposes that students should be taught content so that they can succeed at the next level. Research shows the inadequacy of this argument: active and interactive learning multiplies learning for students (Kim Sharma, Land and Furlong 2013; Tandogan and Orhan, 2007; Tay, 2015). It is through inquiry, application, demonstration, communication and metacognition that students gain new knowledge and skills.

Can Challenge Based Learning be implemented in a short academic period?

Yes. A challenge can be implemented in as much or little time as you see fit. Above all, make sure that the challenge is designed to be solved in the time available. In turn, certain stages of the process need to be coordinated. For example, while some students continue to work in groups to develop questions, investigating, proposing solutions and creating products, the implementation of the challenge can be carried out by other students. You can also explore ways in which students can continue to work on the challenge outside the classroom.

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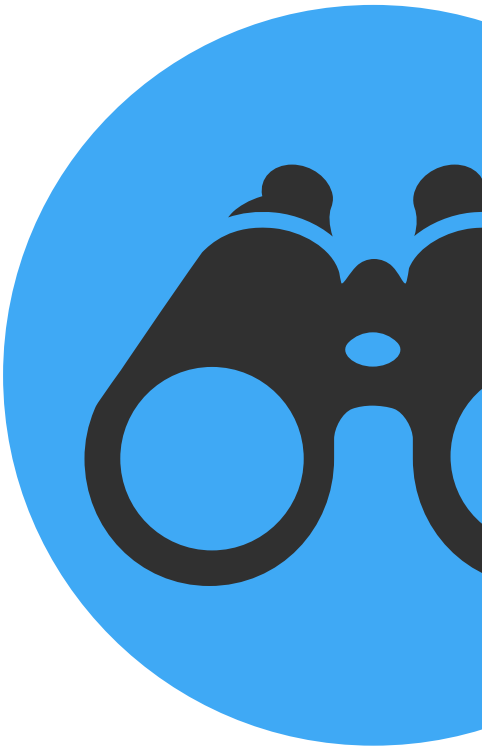

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