Methodology for the Development of Potentially Innovative Technological Projects

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Abstract

One problem that arises at the end of engineering studies is that graduates must look for a source of income and, unfortunately, there are few employment opportunities. Based on their technological competencies, it is desirable that students develop projects that respond to real problems, so that, at the end of their studies, they could become entrepreneurs and generate jobs, or, alternatively, technology transfer could take place. Therefore, it is pertinent to have an integral methodology for the planning and development of such projects. The methodology has been developed on the Internet of Things Laboratory of the Emiliano Zapata Technological University of the State of Morelos (UTEZ), with the support of experts in entrepreneurship and innovation from other institutions in the state of Morelos, since 2016. Throughout this period, the methodology has matured through the development of prototypes aligned to strategic areas such as: Renewable Energies, Water, Health, Food, Education and Security, among others. In this way, the training of creative engineers capable of working in collaborative teams is supported. The results obtained from the participation in various competitions and innovation contests validate the methodology, obtaining several awards and recognitions at national and international level. Previously, the participations were incipient. However, the great step that is still pending is the of technology transfer.

Keywords

Collaborative teams, Technologic Universities, Motivation, Experts Evaluation

1. Introduction

A great challenge for Higher Education Institutions (HEIs) in Mexico is to ensure that the knowledge generated has an economic impact on the lives of students, as well as on the generation of employment through the creation of technology-based companies (TBCs).

It should be noted that once a product or process has been validated and protected, by Intellectual Property Rights (IPR), it is possible for it to be used as a basis for the creation of technology-based companies, or for it to be transferred. Therefore, it is important to know the last both terms.

The Technology-Based Entrepreneurship (TBE) is understood as an action oriented to commercialize and develop new products or services derived from a high level of knowledge management [1]. It is intended that the graduates of the Mechatronics degree of the Universidad

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Tecnológica Emiliano Zapata (UTEZ), in case they opt for entrepreneurship, it should be a technology-based entrepreneurship, preferably.

Technology transfer is a process that allows enterprises to get a competitive advantage in the marketplace, characterized by the transmission of knowledge generated by the university, or other instances capable of generating knowledge to an enterprise that allows it to innovate and expand its technological capabilities [2]. That is, through the appropriation of knowledge, using the knowledge learned to generate optimal solutions that reduce dependence on foreign companies and costs in technical assistance and technology acquisition [3].

On the other side, if a new technology is valuable, it is likely to be copied, reducing the potential profits of the original inventor, and potentially removing the incentive to engage in innovative activities [4]. It is therefore necessary to protect the technology through appropriate intellectual property protection to carry out the negotiation process aimed at technology transfer.

In addition, several techniques have been proposed for the creation of new products and services, with the intention of speeding up the processes, as well as fitting them to the needs of the users and the market. Some of these techniques will be described in the following section. Based on their knowledge, as well as the environment, it is possible to identify and add elements to integrate an own methodology, suitable for the Mechatronics program at UTEZ, which can be replicated in similar environments. The intention is to generate competitive prototypes, oriented to the solution of real problems, aligned to current interests, embodied in regional, national and/or international development plans, which, therefore, make them relevant and of possible interest to carry out entrepreneurship or technology transfer. It also contributes to the training of engineers capable of developing projects with these characteristics, so that they can propose solutions, develop, and implement them, with a business vision.

The environment in which this article is proposed is the subsystem of Technological Universities in Mexico, which emerged in 1991 with the purpose of offering intensive studies to students who complete their high school studies in Mexico, so that they can enter the labor market in a short time, seeking that the study programs are related to the demands of local, state and national industry [5]. The number of careers in this subsystem and the type and enrollment of each one are shown in Table 1, according to the study carried out by the General Directorate of University and Intercultural Higher Education (DGESUI) [6]. As can be seen, the areas of engineering and technology constitute 42.36%, so the proposed methodology can be very useful in the sector, starting with UTEZ.

Table 1
Technological University Careers

Areas of Knowledge	**Careers**	Enrollment
Education	0.06%	0.05%
Arts and Humanities	1.65 %	1.27 %
Social Sciences and Law	0.17 %	0.30 %
Business and Administration	25.26%	29.47%
Natural Sciences, Mathematics and Statistics	2.51 %	1.49 %
Information and Communication Technologies	14.37 %	10.97 %
Manufacturing and Construction Engineering	40.99 %	42.89 %
Agronomy and Veterinary Science	4.73 %	2.35%
Health Sciences	2.74 %	3.35 %
Services	7.53 %	7.85 %

The objective of this work is the design of a methodology for the development of potentially innovative projects at UTEZ, to increase their relevance and the possibilities that they can be the basis for entrepreneurship and/or technology transfer. This methodology seeks to support the training of students, as well as to increase the innovation potential of the projects carried out on the Internet of Things Laboratory of the Emiliano Zapata Technological University of the State of

Morelos, with the support and evaluation of experts in entrepreneurship and innovation of other institutions, as part of the activities carried out in the Integrating learning units, developed in the third, fifth and tenth semesters of the Mechatronics career.

The content of this article is as follows: In section 1, information about the challenge that origins this research and some fundaments are briefly presented, section 2 describes the theoretical framework. Section 3 shows the methodology designed. In section 4, the experimentation and results are provided. Finally, section 5 summarizes the findings and provides some concluding remarks.

2. Theoretical framework

To build a customized model for the development of the projects carried out at UTEZ, it is necessary to know the environment in which they are developed, giving priority to the problems that are identified as strategic. In addition, it is also necessary to consider the lack of motivation and the incipient participation in competitions, as well as to know some of the representative methodologies, which have demonstrated their usefulness, being adopted by several companies, and finally, to review some tools that are used in such methodologies, which can be of great utility, to strengthen this model of project generation, and which in turn is an engine of attitude change and fosters competitiveness.

2.1. Strategic goals and lines

2.1.1. Sustainable Development Objectives

The Sustainable Development Goals (SDGs), were adopted by the United Nations in 2015 as a universal call to end poverty, protect the planet and ensure that by 2030 all people enjoy peace and prosperity, create goals to be achieved with the participation of governments, the private sector, civil society, and individuals [7, 8]] (See Figure 1). Therefore, educational institutions should also be drivers of the SDGs, creating awareness and actions for it in their researchers and students.

Figure 1: Sustainable Development Goals [7, 8].

2.1.2. Strategic lines

Singularity University, located next to the NASA Research Center, unlike others, emerged as a complement to traditional universities to promote entrepreneurship, innovation, and technology. Its Entrepreneurship Program considers the problems shown in Figure 2 as a call to leverage technology for social impact. Its mission is to educate, empower & inspire leaders to apply exponential technologies to addressing humanity's grand challenges [9].

Figure 2: Strategic lines of Singulary University's Entrepreneurship Program [9].

2.2. Representative Project Management Methodologies

2.2.1. DesignPedia two rhombus model

Based on the double rhombus model [10], an iterative process composed of four development phases was built, which is not linear, since sometimes is necessary to move in an agile way in the identification and construction of ideas and concepts (See Figure 3). Each phase of work constitutes the entry to the next step. It is possible to go backwards or forwards depending on the results achieved [10].

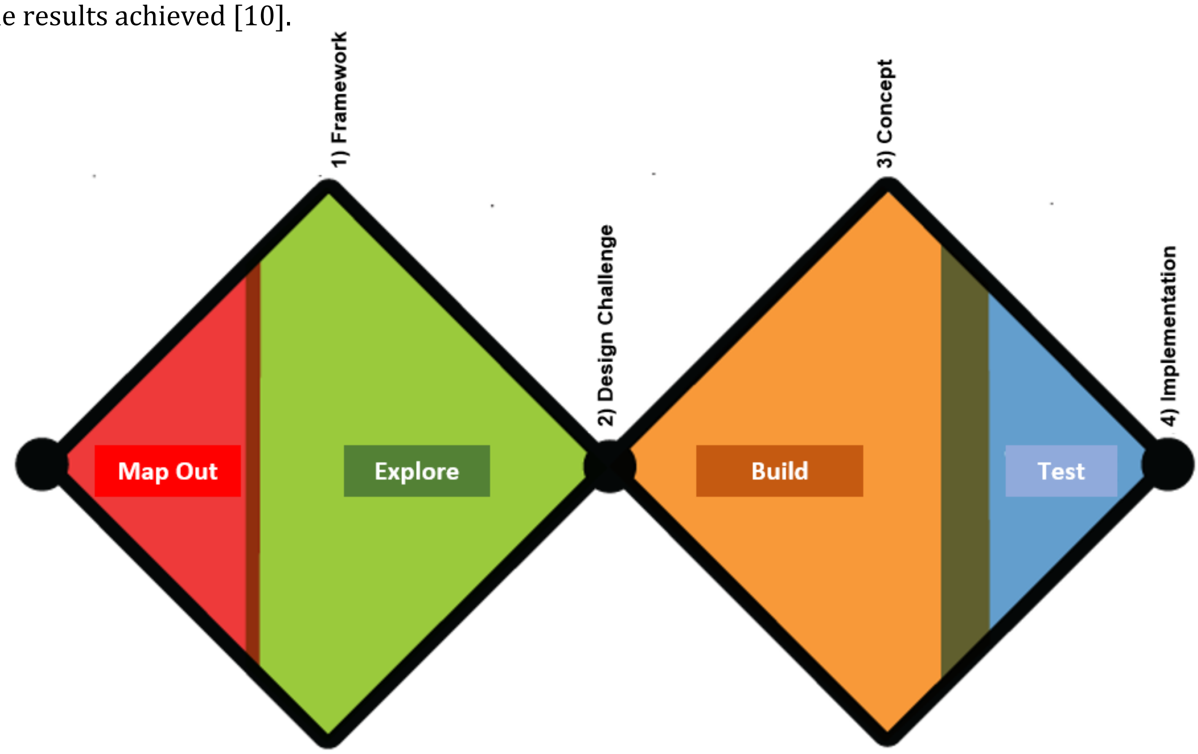

Figure 3: DesignPedia Methodology [10].

The phases of the Designpedia methodology are:

a) **Mapping:** The work context is delimited in relation to what is known, what is unknown and yet to be known, as well as the scope and objectives. Not only should solutions be sought, but also answers should be given to why it is being done, for what and whom [10].

b) **Explore:** Qualitative research tools are used to understand and delimit the challenge or problem to be solved, by understanding the context and the individuals involved. In most cases, the aim is to empathize with the person facing the problem or the need to be solved. Preliminary information is available about what is being done, what is possible, and what is not possible [10].

c) **Construct:** Once a correct framework has been defined, solutions are devised and developed. Various models for idea generation are shown in [9]. The prototype, or materialized idea, can be a drawing, a model, or a cardboard box, which allows defining and transmitting ideas quickly, creating a communication and discussion link [10].

d) **Testing:** In this stage, feedback is obtained from the target audience, to understand what works and what does not, by taking calculated risks. The objective is to test certain functionalities at an early stage without the need to have the final product to modify or adapt it. In early-stage developments, more qualitative and personal interview models are chosen, while in mature phases, the aim is to reach the largest possible number of users, considering experienced people who are very familiar with the subject matter and those who are not [10].

2.2.2. Lean Startup

This methodology was provided by Eric Ries in his book "The Lean Startup". It is a very useful method for starting a business, product, or service [11], widely adopted by companies that create and launch products [12]. The fundamental activity of a startup is to convert ideas into products, measure how consumers respond and learn when to pivot or persevere, facing under conditions of extreme uncertainty [13]. The lean startup method aims to iterate business ideas, helping entrepreneurs make an early decision about their feasibility [14]. It is about creating a product that the customer needs and is willing to pay for, using the minimum number of resources. A problem of many failed entrepreneurs is that they create a business plan, get the financing, develop the product, but only get feedback from customers after launching it to the market [15]. Figure 4 shows the main stages of this methodology:

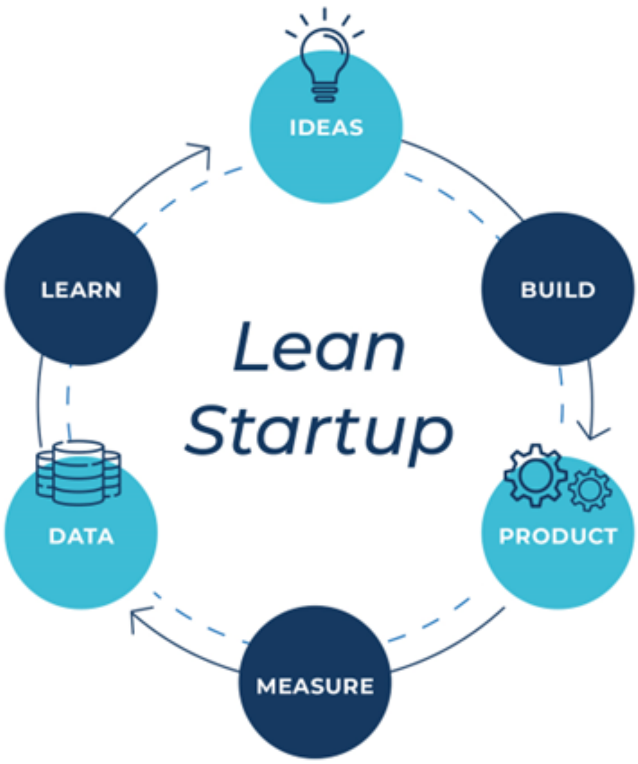

Figure 4: Lean Startup Methodology [13, 15].

- **Build:** This stage involves the launch of a product or service even when there is insufficient data to create a product tailored to the customer's needs. The ideal is to create a Minimum Valuable Product (MVP), which should be a version with the minimum functionalities to collect the maximum amount of learning validated by customers [15].
- **Measure:** The second stage is the most challenging and consists of measuring how consumers respond, i.e., whether real progress is being made, and providing sufficient information to influence strategic planning and make appropriate decisions [13, 15].
- **Learning:** Know whether the business is viable and, if so, continue to persevere or, if not, pivot, i.e., substantially readjust ideas that are not working [13, 15].

Once the hypotheses and assumptions have been established, the entrepreneur validates them with the customers through the PMV, which allows to know from a small investment if the idea being developed is accepted in the market. If it can be shown that it responds to the customer's desire, its functionalities will be increased and, on the contrary, if the product does not fit the market, a new approach to the business or product will have to be given. The essence of this methodology is to learn in a short time, with a minimum investment of resources [15].

2.2.3. Design Thinking

It is considered a method to solve problems in a practical and creative way. Unlike open brainstorming, a solution to the problem must be generated at the end [16]. Design thinking is a process to innovate in products, processes, or services, it is not linear, since it constantly moves forward and backward, it is iterative, in which it goes backward again and again. At the end of the phases, a prototype is created, and it is possible to go through the Design Thinking process again. It is a way to solve problems while decreasing risks and increasing the chances of success. It starts by focusing on human needs, that is, on people, and from them, observes, creates prototypes, and tests them. It connects knowledge from various disciplines to generate a humanly desirable, technically feasible and economically profitable solution through a creative strategy [17] (see Figure 5) [18].

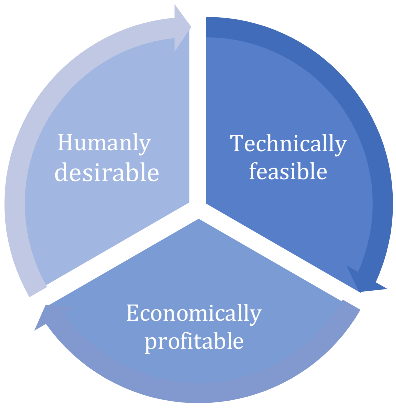

Figure 5: Aspects considered by Design Thinking [18].

The creator of this technique, Tim Brown employs the sensibilities and methods of designers to match people's needs with what is technologically feasible and what a viable business strategy can turn into customer value and market opportunity [18]. It is a process that encourages the participation of employees, customers, suppliers, and professionals from different disciplines. This methodology consists of several stages that each designer groups in a different way, but in essence they are understand, observe, define, ideate, prototype, test, implement and learn. In each of these phases, problems can be defined, questions can be asked, and solutions can be proposed (see Figure 6).

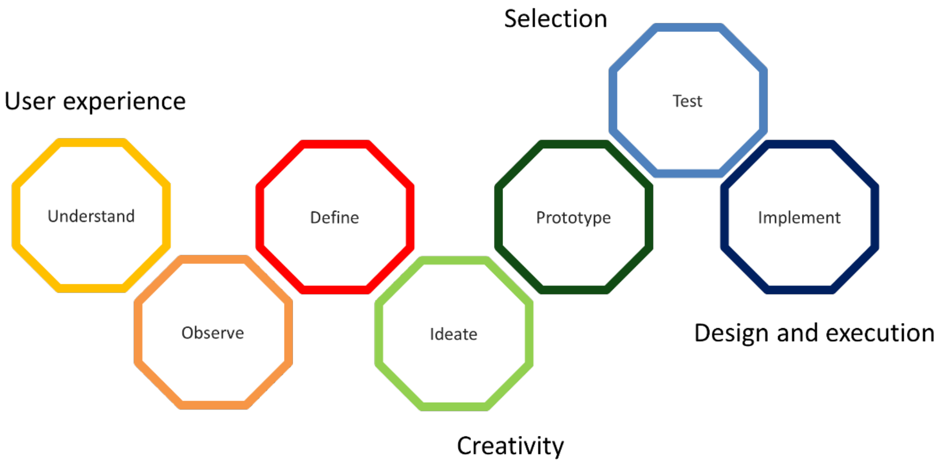

Figure 6: Stages of the Design Thinking Process. Adapted from [18].

Its stages are:

a) **Understand.** It is about deeply understanding what the people for whom the final product is intended do. It is essential to meet with some end users and pay attention to them. The appropriate team is formed to solve the problem, identifying the area of knowledge [17]. It is recommended that it be made up of experts from different areas to provide solutions from different approaches. The objective is to solve something in a positive way, integrating a product or service that provides exceptional value for the customer, which could not be achieved individually [18].

b) **Observe.** Empathy is generated with the user and his environment, based on his observation and the circumstances surrounding the product. Human needs are the starting point. It is observed what the consumer does and not only what he/she says [17]. Different interviews and empathy maps are conducted with potential buyers of the product or service [18]. To connect with customers, it is necessary to understand how they are in their daily lives [19].

c) **Define.** All possible alternative solutions to the problem are considered, from the most obvious to the most adventurous, without taking any of them for granted. The problem must be structured and defined to clarify and focus the challenge. Subsequently, it is necessary to communicate the project using various tools such as: mind maps, conceptual maps, mood boards or story telling [18].

d) **Ideate.** Once the design brief is clear and the data are available, the concepts that can solve the problem under analysis are evaluated. Ideation generates many possible solutions to the project. The focus must be kept on the problem to be solved, without judging too early. At the end of this phase, it is necessary to express the thought with visual tools such as photos, sketches, diagrams, moving notes. Brainstorming is a very useful technique for this stage, as it is a way to generate many ideas, to take advantage of collective thinking [17, 18].

e) **Prototype.** It consists of building the product or service as quickly as possible by making sketches, mock-ups, foam models, 3D prints, among others [14], and even rebuilding again [17]. In [19] the importance of Design Thinking in the educational field is mentioned, in which the prototype becomes the protagonist.

In [19], Ignacio López Forniés emphasizes the need for a creative leader to move spirits and minds and motivate personnel to solve problems.

2.3. Representative tools

2.3.1. Customer Journey Map (CJM)

This strategic tool is the description of the user journey by representing the different touch points that characterize their interaction with a product, service, or company. An example is shown in Figure 7. The CJM writes the narrative of what customers do, what they think and feel when they are approaching a brand. It is a visual representation of what it would mean to be a real customer and indicates to brands where they give clarity or what direction they can offer in terms of the experience when acquiring their products or services. Unfortunately, it is partially unknown in Mexico [20]. This method is fundamental to all experience design and strategy and will become a necessary skill for designers and managers working on a brand [21].

In [22] it is recommended to use the power of synthesis for the elaboration, to place emphasis on the flow of information and of the physical devices used. In addition. It is indicated that it may be necessary to repeat for several days to gather a balanced perspective.

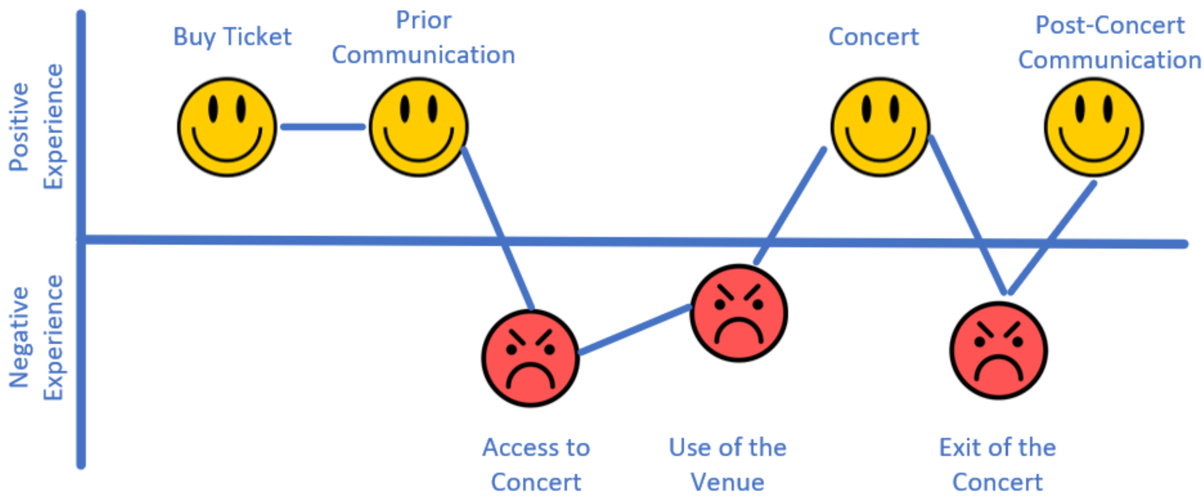

Figure 7: Customer Journey Map [10].

2.3.2. Empathy Map

This tool seeks to collect the user's point of view regarding a need or problem, product, or service. Once the empathy map is generated (Figure 8), the aim is to capture the way of being and acting by answering the following questions:

- o What does he/she say and what does he/she think? Opinions and facts that he/she communicates and those that go through his/her mind.
- o What does he/she do and what does he/she feel? Actions and behavior he/she develops, feelings and emotions.
- o What does he/she see and what does he/she hear? Things and events that the user appreciates or facts and data that are reported.

This is to empathically know the scenario in which the client develops, according to the analyzed need. Once the user or client is delimited, according to the researched, a deeper reflection on their needs, emotions and attitudes is carried out (See Figure 8).

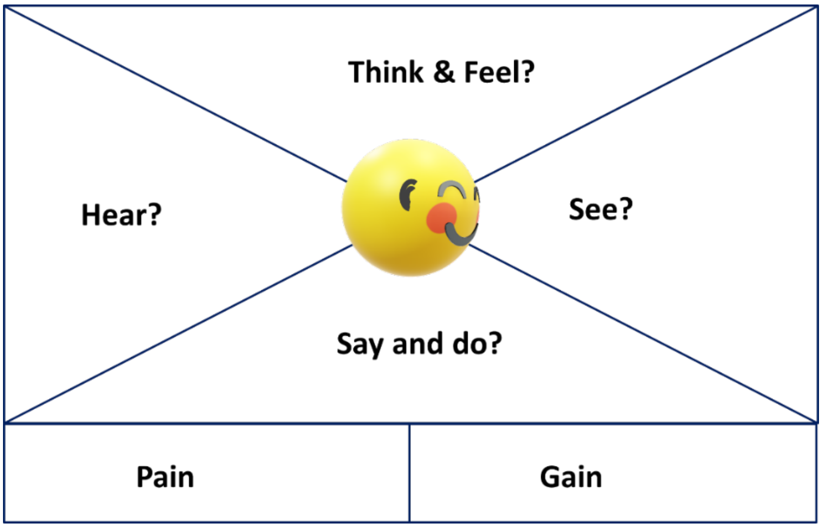

Figure 8: Empathy Map. Adapted from [23].

2.3.3. Focus Group

This is an interview with a small group of people conducted in a natural and unstructured manner by a moderator [10]. In [22] it is mentioned that the groups are typically composed of six to twelve homogeneous participants, although larger or smaller groups and a trained moderator whose role is to guide the discussion so that it does not stray from the topic of study have sometimes been recommended.

This technique consists of grouping several people to discuss a concept in a session lasting a maximum of two hours, where participants freely answer questions about the product or service. The objective of this activity is to activate the conversation between the parties and generate interactions to understand the different points of view. This technique is important for defining the product or service, prior to its development, to obtain information about problems, experiences, or shared desires. It can also be performed throughout the life of a product to have a control point for the adaptation of the product to customer needs [10].

2.3.4. Field Visit

In this step, a study is carried out by directly contacting the researchers, the places, and the facts to be studied. Once the different spaces of concurrence of our problem / person / object of study have been identified, the researchers go to the established place to observe in situ the users, the environment, the agents involved, among other factors. To generate a good field visit, it is necessary to start from some hypotheses or facts that we want to check: it is necessary to previously close the objective of the visit to focus on the field on those actions that interest us of our users / customers / environment.

2.3.5. Canvas Business Model

One of the main tools of the lean startup is the Canvas business model [14], which capture on a canvas the realities that every entrepreneur must articulate. It is a tool for the analysis of business ideas, which logically describes the way in which organizations create, deliver and capture value (see Figure 9) [23].

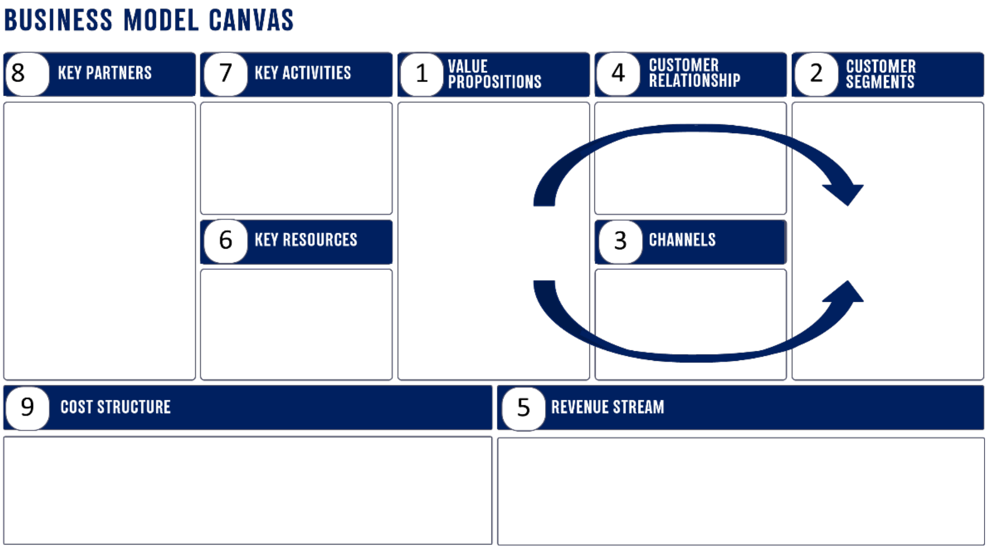

Figure 9: Stages of the Canvas Business Model. Adapted from [23].

This technique can be captured on a canvas that allows teams to quickly assess [15] and articulate their assumptions about the business idea [14]. Its nine blocks [13, 24] are shown in Figure 9. Interviews of customers and other stakeholders are done to confirm or disconfirm hypotheses [14].

2.3.6. SCAMPER

It is a convenient technique to develop creative thinking skills [25], in which the generation of ideas is favored by answering a preset list of questions [26]. Each of the questions represents as many creativity techniques as possible, so SCAMPER is considered one of the most complete tools in the process of generating ideas. Each of the letters of the acronymous SCAMPER is the first letter corresponding to a verb that triggers a series of questions that establish a certain order in the process of idea generation (See Figure 10):

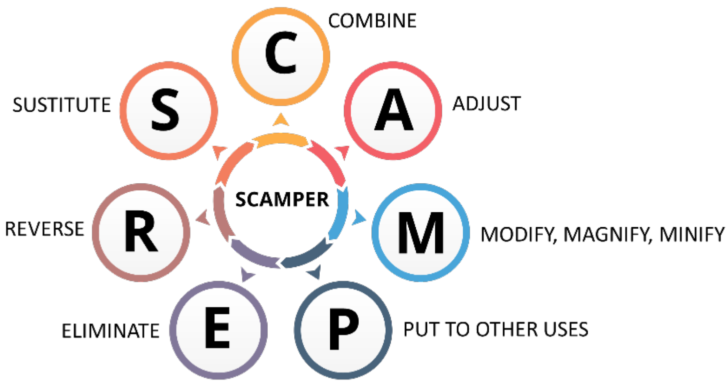

Figure 10: Stages of SCAMPER. Adapted from [26].

2.3.7. Video Marketing

This tool is very useful to capture in a multimedia file the main concept of the project, the problem, its general objective, as well as the proposed solution. Different video editing tools can be used to create these materials, but it is recommended that their duration does not exceed 3 minutes. A well-made video catches the viewer's attention.

2.3.8. Technology Readiness Level (TRL)

This tool is used to measure the technological maturity of the technology, which arose at NASA but was later generalized to be applied to any project. It is an accepted way of measuring the degree of maturity of a technology. This scale considers nine levels that extend from the basic principles of the technology to its successful testing in a real environment (see Figure 11) [27].

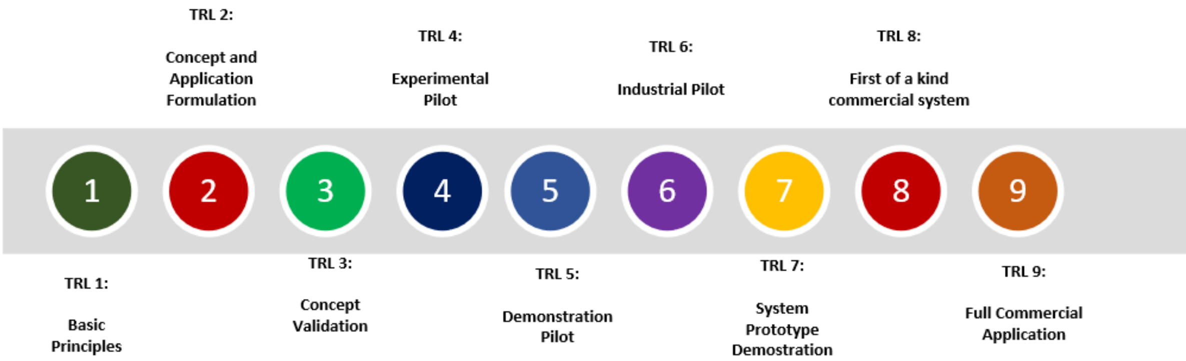

Figure 11: Technology Readiness Level [27].

3. Methodology proposed for development of innovative projects

After reviewing the methodologies that were found to be relevant, both those found in the literature and those learned in different innovation contests, and considering the strategic problems, the design of an integral methodology was proposed, so that it would be congruent with the Mechatronics curriculum of the UTEZ, part of the Subsystem of Technological Universities in Mexico, with the objective stated in the Introduction. That is, that its structure allows to increase the relevance and the possibilities of the developed projects, with the objective that it can be aspired to constitute the basis for entrepreneurship and/or technology transfer. At the same time this methodology seeks to support the training of students, as part of the activities carried out in the Integrating learning units of the Mechatronics degree program. Motivations was also considered as a fundamental requirement. These learning units are four-monthly, so the methodology must be agile, adapted to the duration, therefore, the phases of the methodology must be specific.

Figure 12 shows the different phases that make up this proposed methodology, based on the experience of more than 8 years of working with innovative projects with innovation potential. The blue lines show the desirable successive sequence; however, in each of them it may be necessary to go back to previous stages, which is shown with the red lines. This means that it is possible to move forward or backward, to any stage, depending on the needs.

It should be noted that the stages integrate tools, methods, and models, or are considered strategies. It also includes steps that are considered necessary, such as motivation, expert evaluation, and dissemination. It is in this last stage that participation in exhibitions and competitions is emphasized.

The stages of the proposed methodology are:

Stage 1: Motivation. Presentation of Challenges and Opportunities

It consists of two important activities that must be carried out to encourage students to carry out research projects aimed at solving strategic problems. These stages are:

- **Background on Innovative Projects.** For this activity, students are shown a series of videos on innovation projects presented in the call for the "James Dyson Award". This contest is held every year at national and international level. The objective is to reward the best designers in innovative solutions.

- **Motivation by Background.** Motivation plays a leading role in the search for and generation of innovative ideas. Students are shown current projects carried out by students who preceded them and who, with the methodology used, achieved important results during their participation in technological innovation contests and competitions.

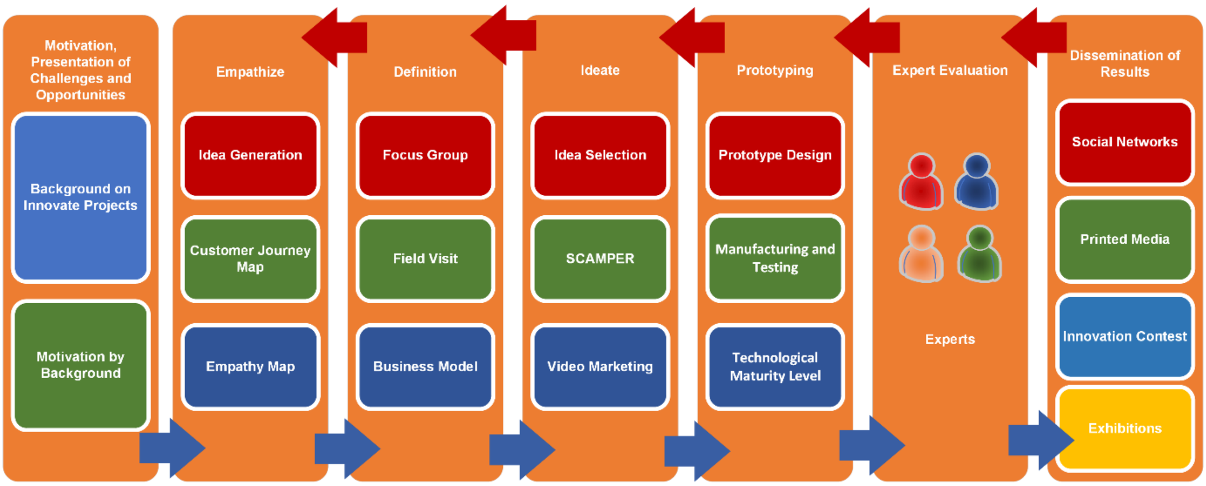

Figure 12: Stages of the proposed Methodology.

It should be noted that, previously at UTEZ, projects were developed aligned in solutions entirely for the local industry, so there was a different approach to develop projects, where the ones with the highest cost and size were considered as the bests. However, since 2016, the Centro Morelense de Innovación y Transferencia de Tecnología issued the TecnoCemiTT call inviting the community to participate with different innovative projects that solve a problem. Since then, the projects are sought to solve a problem and with a well-defined market. Since this year, all the projects carried out in the integrative subject have sought to empathize with one of the problems identified by Singularity University, as well as with the SDGs.

That is, in addition to the fact that this stage focuses on motivation, it is shown that projects oriented towards regional, national, and international priority issues have greater chances of success, by adding relevance and interest to the proposed solution.

Stage 2. Empathize

For this stage, both teachers and students detect different opportunities for innovation through the generation of ideas using the following techniques:

- **Idea Generation.** This activity constitutes the beginning of the activities that will support the definition of the possible projects to be carried out, reviewing the different actors and scenarios where impact is sought. Ideation begins based on the strategic lines defined by Singularity University and the SDGs. As a result, students or teams of students will have several ideas about the project they will develop, supported, and backed by a professor who, according to his/her experience and the projects that have been developed, will give his/her opinion on the relevance of these ideas, making ideas selection.
- **Customer Journey Map.** This tool is used to identify the positive and negative experiences of users to propose various solutions that respond to user needs in a positive way. Before proposing ideas, the current journey of our users must be identified to better understand their activities and problems.
- **Empathy Map**. With this tool it is possible to synthesize in greater depth emotional and rational aspects of the user through a canvas that captures their actions and feelings in relation to the problem addressed.

Stage 3. Definition

Students or teams of students are expected to define the idea they will develop based on the data and results obtained from the previous stage. The tools used to define the idea are:

- **Focus Group.** With this tool, information should be obtained about the problem addressed and the idea that will be developed to solve it, identifying their shared experiences or desires.
- **Field Visit.** Once the different spaces of concurrence of our problem/person/object of study have been identified, the students go to the established place to observe in situ the users, the environment, the agents involved, among other factors. Previously, the hypothesis or facts that are sought to be verified and clearly identify the objective of the realization is established.
- **Business model.** It is designed for a quick evaluation of the idea being proposed. By having the respective commercial proposal and identifying the elements required to comply with each of the segments, a complete picture is obtained, both technical and financial, which seeks to reduce uncertainty and risk during its execution.

Stage 4. Ideate

Once they have defined the ideas, considering their relevance and potential, they must select the one with which they identify. To do this, a consultation is carried out with the teacher who, based on his/her experience, will be able to select and determine which is the best idea with which to work in the other stages. The following tools are used at this stage:

- SCAMPER. The SCAMPER questionnaire is carried out to define characteristics of the project in a simple way through a series of questions agreed upon as a team or individually.
- Video Marketing. This deliverable gives a lot of presence to the project in the different contests, contests and presentations that are held. In addition, in some of them it is explicitly requested.

Stage 5. Prototyping

Teams are given a maximum of five weeks to have a MVP. At this stage, the following should be available:

- **Prototype Design.** For this activity, a sketch, a 3D print, or a design made in a computer-aided design program is provided. This is an important activity to be able to visualize the product in a physical form and perform the next activity.
- **Manufacturing and Testing**. This activity is of utmost importance for all projects. It is the one that defines its qualification in the field of integrator, but beyond that, having the prototype will make the project venture into different contests, competitions, or project presentations. To do this, a time of 4 weeks is allocated in which the materials and supplies must be obtained to be able to make the prototype. To conclude this activity, projects should be presented to different innovation specialists to obtain feedback.
- **Technological Maturity Level**. This tool helps us to measure the technological maturity of the projects developed, which will be an indicator in the review and evaluation by experts.

According to [21], in the success of the prototypes with greater fidelity presented in competitions, the tests and observations carried out in situ have been key, which has allowed us to know the situations and conditions in which they will operate, clarifying the doubts of the designers and taking actions to correct the necessary details.

Stage 6. Expert Evaluation

Projects should be presented to a committee of innovative experts to obtain different points of view and feedback to fine-tune details of the prototype. This exercise is relevant, since having different external opinions feeds the project, based on the recommendations and the identification of the best practices to be implemented. This is another differentiating phase of the proposed methodology, as it allows for a much broader and more competitive vision.

Stage 7. Dissemination of Results

Finally, at this stage all projects can be published in various media, to show the developments that are being made by the Academic Division of Industrial Mechanics. For this, print media, through local newspapers and in the youth news section are used, as well as institutional social networks, such as Facebook and Twitter.

4. Results and experimentation

Some of the projects in which this methodology was applied, as well as the results obtained in different national or international technological innovation competitions, are shown in Table 2, where the different projects that participated from 2018 to 2022 in technological innovation competitions are observed. These projects are described below.

4.1. Hawa

In 2019 and as a result of this methodology, a second place was obtained at the national level for the project called "Hawa", which sought to reduce the amount of water wasted in toilets and sinks, being able to use this device in public spaces (See Figure 13).

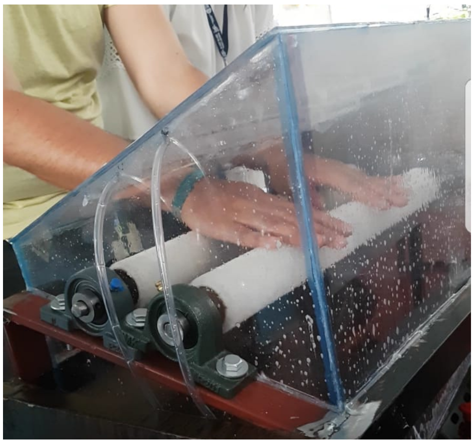

Figure 13: Hawa project.

4.2. AMILI Robot

The problem that gave rise to this project focuses on people who work in the fields and who are exposed to pesticides that are used to fumigate crop fields, which can undermine their health. The objective of this assistance and service robot is to carry out the fumigation activity in a safer way for the people working in the field. In principle, the robot works in two modes: radio control and autonomously, the first being the predominant option of operation, since so far experience is still being developed in the field of autonomous vehicles to make trips without instructions from an operator. Figure 14 shows the AMILI Robot project in its final stages. AMILI participated in different tournaments such as: the Robotics and Advanced Technologies Tournament (TRYTA) of the National Polytechnic Institute, where it won first place in the Ecotech category in 2019.

Figure 14: AMILI Robot.

4.3. Smart Dispenser

One of the problems encountered during the COVID-19 pandemic was the use of various devices to carry out prevention functions in public spaces. In addition, the lack of personnel and culture to carry out the corresponding temperature checks and the use of face masks (Figure 15). That is why the idea of carrying out this project arose with the aim of designing an intelligent electromechanical device capable of supplying antibacterial gel to people for the promotion and application of preventive hygiene measures with the use of Computational Intelligence tools and Embedded Systems.

Figure 15: Smart Dispenser.

This project was prototyped again in 2021. It had initially been carried out in 2020, but its tests were not carried out due to the pandemic conditions. In 2021 it was decided to redesign this prototype and validate it in the different technological innovation contests and competitions. In Figure 16 the first prototypes of this project, made by a student in the internship stage, is shown.

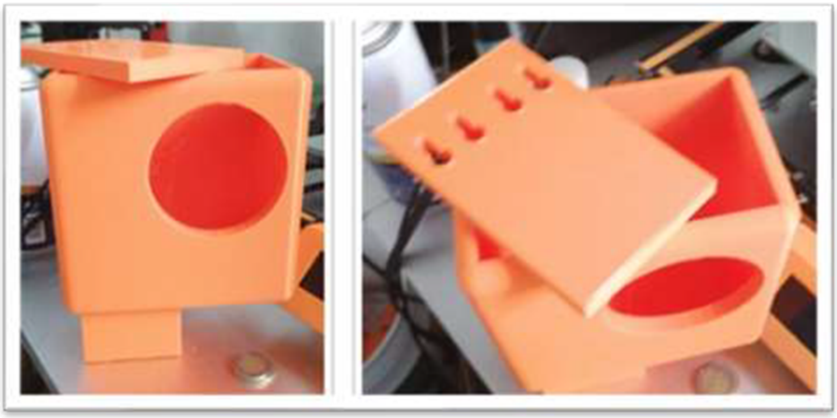

Figure 16: First prototype of the dispenser, year 2020.

For the new version, the incorporation of different functions that would enhance this project was considered, such as including a facial recognition system for the detection of face masks. Additionally, infrared sensors were incorporated to administer antibacterial gel without the need to touch the dispenser and this is a form of transmission of the virus. An App has been added to view the amount of antibacterial gel and refill it quickly. Finally, a system was added that emits a voice to give directions, as well as recommendations (See Figure 17).

Finally, this project was presented at the 2021 edition of the IEEE YESIST (Youth Endeavours for Social Innovation Using Sustainable Technology) event held virtually, in which an honorable mention was obtained for the presentation of this project.

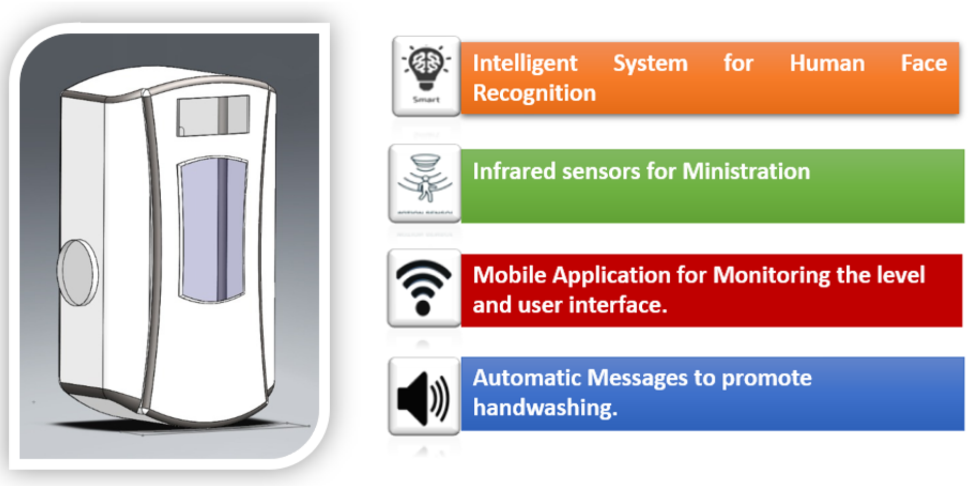

Figure 17: First prototype of the dispenser, year 2020.

4.4. IOT device to measure water quantity and quality

The problem it addresses has to do with water scarcity. Currently, many houses in Mexico suffer from lack of water or constant service cuts, which causes residents to acquire water tanks, cisterns and pumps for their continuous supply. However, one of the main problems is that, for the administration of the vital liquid, is that people cannot administer something that they cannot measure. In addition, visualizing the water level of water tanks in buildings is often dangerous for people. (See Figure 18.)

Figure 18: Location of water tanks in residential areas.

To solve the problem of water management and the danger that visualizing the water level represents for families, the idea arose of remotely measuring the quantity and quality of the water in the water tanks of the different homes, for which it is supported by sensors of level, pH, turbidity, and temperature (See Figure 19). With this project, we participated in the Youth International Science Fair 2023 that was held in Bali, Indonesia, obtaining a silver medal.
This project is still in development. Products such as research articles and a poster for presentation at student congresses related to Artificial Intelligence and Robotics have been derived.

Figure 19: Placing the device in the water tanks.

Table 2
Technological projects developed with the proposed methodology

Project	Issues / SDGs	Prize	Level
Amili: Assistance & Service Robot	Security/SDG 11	Silver Medal	International
Hawa Project	Water Care/SDG 13	Second	National
Intelligent Automatic Dispenser	Health/ DG 3	Honorable Mention	International
IOT device to measure water quantity and quality	Water Care/SDG 13	Silver Medal	International

It should be noted that, every four months there are approximately 4 groups in the integrating units, however, not all of them apply the methodology, only in those that have an impact, so that on average we work with approximately 4 or 5 teams per room, being that, of these, generally 2 projects are with the necessary competitive potential. In addition, other awards or recognitions on a smaller scale have been achieved, in addition to those shown in Table 2. Of all the cases studied, so far only one of them has generated a StartUp.

The elements of each phase have been found to be fundamental. An element of differentiation is found in the initial phase, since the motivation and leadership achieved has made the students manifest an empowerment that was not observed before. Another relevant step is the evaluation by experts, which increases the vision and improves the projects under development.

5. Conclusions

The proposed methodology has had excellent results in projects derived from the integrative learning units (or courses) either for the third, fifth or tenth semester within the Mechatronics career. The places obtained in different national and international competitions show the relevance of the alignment of the projects with the different strategic lines selected, such as: Renewable Energies, Water Care, Poverty, Food, Security, Environment and Health. The motivation achieved, thanks to the results of the methodology and the leadership at the state level, makes the students show a remarkable empowerment, which strengthens their graduation profile. Another notable element of differentiation of the proposed methodology is the evaluation of experts since it allows to improve some characteristics and/or conditions and to have a much broader and more competitive vision. It should be noted that the stages integrate tools, methods, and models, or are considered strategies. In the dissemination stage, the participation in exhibitions and competitions is encouraged. As future work, it is expected that this methodology can be applied in other careers within the same UTEZ, such as: Maintenance, Industrial Processes and Nanotechnology. It should be noted that, for reasons of space, a case study is not included, so it is planned to show it in another article. On the other hand, there is still a lot of work to be done, since it is necessary to promote the culture of high-impact entrepreneurship, which is not generally managed in public institutions, and it is necessary to develop the vision of creating scalable ventures.

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