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Cognitive scaffolding model for project management that integrates the development of academic skills and a sustainable approach

Modelo de andamiaje cognitivo para la gestión de proyectos que integran el desarrollo de competencias académicas y el enfoque sustentable

GÓMEZ-LEMUS, Teresa de Jesús†*, PRIETO-USCANGA, Alicia, LÓPEZ-OSTRIA, María Teresa and PRIETO-USCANGA, Margarita

Tecnológico Nacional de México/ Instituto Tecnológico de Querétaro, Mexico.

ID 1st Author: *Teresa de Jesús, Gómez-Lemus* / **ORC ID:** 0000-0002-5354-4111, **CVU CONAHCYT ID:** 439435

ID 1st Co-author: *Alicia, Prieto-Uscanga* / **ORC ID:** 0000-0002-4648-9302, **CVU CONAHCYT ID:** 499973

ID 2nd Co-author: *María Teresa, López-Ostria* / **ORC ID:** 0000-0003-4135-5302, **CVU CONAHCYT ID:** 500164

ID 3rd Co-author: *Margarita, Prieto-Uscanga* / **ORC ID:** 0000-0002-2829-2100, **CVU CONAHCYT ID:** 499978

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Abstract

Objectives: With the purpose of guiding the development of research projects with a sustainable approach, in order to solve the dialectic between chaos and opportunity, posed by technological development, a cognitive scaffolding model is developed, applicable to the development of projects in any field of knowledge. This scaffolding is proposed as a sustainable model in itself, by integrating competency-based training as the main structure and as part corresponding to the social pillar or sphere; Life Cycle Analysis, indicators and other environmental issues make up the environmental pillar or sphere and the technological and commercial part make up the economic pillar or sphere. Methodology: A documentary and qualitative research is proposed for the conformation of the scaffolding model, which is validated through the application to a concrete case. Contribution: With a holistic vision that integrates sustainability and competency-based training, a technological development was achieved that integrated key determining concepts for its design, construction, operation and market vision. The model is a guide that structures the basic information in force in the global agenda, flexible, allowing the incorporation of the specific theoretical framework of the project in question.

Holistic cognitive scaffolding model, Competencies for Life, Sustainable engineering

Resumen

Objetivos: Con el propósito de orientar el desarrollo de proyectos de investigación con enfoque sustentable, que permita resolver la dialéctica entre el caos y la oportunidad, que plantea el desarrollo tecnológico se desarrolla un modelo de andamiaje cognitivo, aplicable al desarrollo de proyectos de cualquier campo del conocimiento. Este andamiaje se plantea como un modelo sustentable en sí mismo, al integrar la formación por competencias como estructura principal y como parte correspondiente al pilar o esfera de lo social; el Análisis de Ciclo de Vida, indicadores y otros temas medio ambientales componen el pilar o esfera de lo ambiental y la parte tecnológica y comercial conforman el pilar o esfera de lo económico. Metodología: Se plantea una investigación documental y cualitativa para la conformación del modelo de andamiaje, el cual se valida por medio de la aplicación a un caso concreto. Contribución: Con una visión holística, que integra la sustentabilidad y la formación por competencias, se logró un desarrollo tecnológico que integró conceptos clave determinantes para su diseño, construcción, funcionamiento y visión de mercado. El modelo es una guía que estructura la información básica vigente en la agenda mundial, flexible permitiendo incorporar el marco teórico específico del proyecto en cuestión.

Modelo de andamiaje cognitivo holístico, Competencias para la vida, Ingeniería sustentable

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* Correspondence to author (E-mail: teresa.gl@queretaro.tecnm.mx)
† Researcher contributing as first Author.

Introduction

In the experience of one of the members of this working group, who has been teaching the subject of Sustainable Development for at least 12 years, despite the fact that it is common to observe that what generates fear, discouragement and the perception of pointing to the technology of current goods and services as responsible for environmental deterioration in the vast majority of students, it was considered important to intervene in this dialectic of chaos and transform it into an opportunity by posing the following question: Is the development of new technologies also the way to reverse this situation?

The subject of Sustainable Development, which is taught in all the study programmes offered by the Tecnológico Nacional de México, is a propitious field for exposing and analysing with students the different problems related to the climate crisis, the overexploitation of resources, the damage to ecosystems, the effects on human health, economic crises and social problems.

The starting point is to consider that the task of the teacher is to raise the problem, but also to offer the tools of knowledge and provisions that strengthen students to contribute to the construction of bridges that connect the chaos with the opportunity to offer possible solutions, reorienting the focus of technology, with a holistic vision and conscious, responsible, respectful and benevolent participation towards people and the environment. The added value of this proposal is to integrate in one image the purposes of Education by Competences and Sustainable Development with the addition of some tools for continuous improvement.

This article presents a cognitive scaffolding model for the management of sustainable research projects, which is structured mainly by integrating the four pillars for education in the 21st century, proposed in the Delors Report presented to UNESCO in 1996, also considered as fundamental learning or competences for a person's life, as well as the concepts of Sustainable Development and the 2030 Agenda.

The central hypothesis is that the Scaffolding Model offers a roadmap that influences student awareness in order to rethink the objectives of technological developments towards projects that address current social, economic and environmental challenges and contribute to Sustainable Development.

For the purposes of this article, a brief theoretical framework will be described to provide a guide to the concepts proposed in the model; in their real application, these concepts must be studied in depth by each student for their project and expanded in order to understand them better.

Also for its didactics in this article, the scaffolding model will be explained based on the application to a case of technological development carried out by a postgraduate student, CONAHCyT scholarship holder, arguing the qualitative analysis that was applied.

Finally, the results and conclusions obtained will be discussed.

Conceptual framework

Delors Report

The main structure of the scaffolding is based on the Delors Report presented to the UN by the International Commission on Education for the 21st Century in 1996, entitled "The Four Pillars of Education"; Knowing How to Understand, Knowing How to Do, Knowing How to Live Together and Knowing How to Be. However, the task of education is to know how to transmit to the individual the freedom to be continuously swimming in information that is constantly changing, being alert to currents that can threaten and damage existence in different areas, as well as to provide the guidance and tools necessary to analyse it and implement the knowledge acquired in individual and collective projects that promote general well-being, with the best intention that these competences serve the individual throughout his or her life [1].

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Competences

The competence-based approach underpins the educational model proposed by the Tecnológico Nacional de México, identifying those of BEING, associated with the development of soft skills, which require internal work of motivation for a subsequent drive towards materialisation. Those of UNDERSTANDING, which contribute to the acquisition and generation of knowledge about the phenomena of the environment. Those of DOING, as those that translate that knowledge into facts, and that of LIVING, related to the interaction with others, typical of a life in society.

Brundtland Report and Agenda 2030

For any type of project, it is considered necessary to know the Our Common Future Report or also known as the Brundtland Report presented to the UN in 1987, in which the Commission that studied and elaborated the report integrated social, economic and environmental development into the concept of Sustainable Development, defining it as that which "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" [2].

The Brundtland Report sets out the intention, but it is through the 2030 Agenda that the 17 goals and 169 targets of Sustainable Development can be specifically placed [3].

Circular Economy

Some countries that have already made progress in the approach of projects considered as sustainable, have shared their experience and implementation, one of which is being widely accepted and used in Europe and Latin America, is the "Circular Economy" approach, the principles of this approach are mainly to avoid the extraction of resources and raw materials by reusing those already in circulation and to promote the use of renewable energies [4].

Life Cycle Assessment

Life Cycle Analysis is an important topic to understand that the responsibility of offering a product in the market is not only the commitment to sell, the perspective is from where the resources that the product will require are obtained and even what will happen to it, once it reaches its obsolescence [5] and [6].

Continuous improvement tools.

The Deming Cycle contains the stages that must be considered every time you want to start a project or improve it, that is why it is also known as the Spiral of Continuous Improvement, the stages are: Plan, Do, Check, Act or PDCA: Plan, Do, Check, Act [7].

Lean Manufacturing is a method of work organisation, well known in industry, that seeks to continuously improve and eliminate any type of waste or action that does not add to the process, optimising costs and time. In fact, the concept is applicable even to other goods or services, as it is closely linked to the Circular Economy [8].

5 s Classify, Organise, Clean, Standardise and Keep Improving, are the Spanish translation of Seiri, Seiton, Seiso, Seiketsu, Shitsuke, are actions to be performed, it is a tool within Lean Manufacturing, whose mission is to optimise the work environment to promote continuous improvement and quality improvement, since working in a clean, orderly environment, avoids wasted time, travel and accidents in addition to motivating the mood increasing productivity and satisfaction [9].

Theoretical framework of the specific project

Of course, depending on the type of project in question, it will be necessary to obtain the relevant information. The topics suggested so far form the basic scaffolding for putting together a project with the characteristics required for a sustainable project today, and nurture the competences of knowing in order to understand.

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Development

Figure 1, graphically expresses the scaffolding or the proposed methodology, integrating different knowledge and valuable tools in the field of engineering, management and human development, which have been developed by very different authors, from very different fields of knowledge and moments in human history. The competences to be developed proposed in the Delors Report are expressed in the perimeter ring, and in the inner space of the scheme, the questions or topics for reflection on the respective competence to be achieved. In the centre of the scheme, the project in question for each student Of course, depending on the type of project in question, it will be necessary to obtain the relevant information.

Figure 1 Scaffolding model for sustainable project management
Source: own elaboration

The model is explained below, together with a case in which it was applied. The project is related to the spaces where sorghum is stored, where rodents are present, which is not desirable since it contaminates the product that is used for animal and human food and additionally the economic losses that its disposal implies because it does not meet the conditions for consumption.

This project was developed by a student from Cd. Victoria Tamaulipas, as an option to obtain a master's degree in engineering, in the programme offered by the Tecnológico Nacional de México, Instituto Tecnológico de Querétaro, who already knew about this problem in his home town and even had the support of farmers to develop a solution, which kept him focused, committed and motivated to carry out the research project.

Competence development

Competences for BEING

The proposed model starts at the development of these competences and ends at the same place, i.e. at the beginning of the project the student and the teacher are according to the initial information in one way and at the end of the study it is very likely or desirable that they will have changed. At the start of the project it is important to recognise that there is a motivation to carry it out, with the vision of serving society, which does not, however, preclude an economic gain from the work.

Competences for UNDERSTANDING

To acquire this competence, each student proceeds to search and find the information suggested in the conceptual framework of this article, related to sustainability and adding others according to the topic of the specific project, analysing, synthesising and finding the integration of the concepts for the development of the project.

The proposal of this scaffolding model arises from the concern to rethink technology and make it a great ally. In the field of technology education it is important to reflect on the technology and science applied in the production of goods and services and also on its probable collateral damage to the economy, the environment and society, for which Life Cycle Analysis helps. This analysis considers the technological development from considering the raw material to be used in it, through the manufacture, sale, transport, use and disposal of it, since usually only a short-term benefit has been considered.

Nevertheless, the Model considers it very important to incorporate soft competences for learning to live together and learning to be, as they have generally been underestimated due to the economic benefit, the success of the projects will be based on balancing individual and collective interests in the different social, economic and environmental interactions that each person carries out. However, these types of competencies seem to be divorced from technical-scientific knowledge, when in fact it would be appropriate to recognise this need.

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The optimal qualities for achieving Sustainable Development are expressed in the intersections in Figure 2: keeping the planet habitable by satisfying the needs of society requires a balance between the biocapacity of the planet and the demands of some social groups; making the interaction between economy and environment eco-efficient requires to stop thinking that the planet's resources are infinite, to learn not to waste them and to promote their recovery; achieving equity between the social and the economic sphere is possibly the most complex part because it will come from moving the heart of each individual towards a new consciousness that finds its rapture in sharing and helping the general wellbeing.

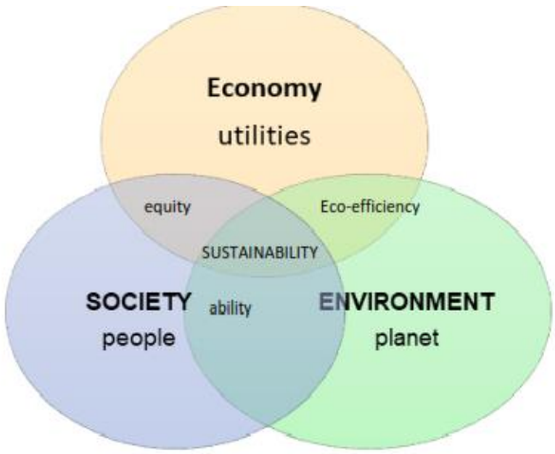

Figure 2 Balance between the spheres or scenarios of Sustainable Development
Source: [3]

In the case of the electronic rodent repelling device project, the student had already considered the technological development of a device to prevent the presence of rodents in sorghum warehouses, but the investigation of the conceptual framework served to visualise the scope and qualities of the device.

A brief analysis from a Sustainable Development perspective considering economic, social and environmental factors is explained below.

Analysis:

- Applying the sustainability approach from the social sphere, we reflected on the consequences of the presence of mice in these warehouses; damage to health due to contamination by faeces and urine.
- From the economic sphere, the economic losses due to the loss of contaminated grain were observed, and it was also found that the problem is not exclusive to warehouses, nor to sorghum in particular, which positions the project with a wide market share.
- Looking at the problem from the environmental sphere it was considered that mice are part of the food chain of other species, therefore it was decided to scare them away and not exterminate them.

Summary:

Although there are already devices on the market for this purpose, the student and the people who needed to solve the problem had already tried them and determined that they did not have the required signal range and results; the proposal from the Sustainable Development approach was:

- From the economic sphere, a patent search was carried out to review what legally exists in the market and not to incur in controversies. Also, in the construction of the prototype, a simple design was sought and the use of parts that offered greater durability was sought, as well as the selection of companies supplying inputs that were committed to sustainability (if this information was available).
- In the environmental sphere, as already mentioned, the premise was not to exterminate them and not to have noise pollution due to the device emitting a continuous signal, for this reason, the technology that was developed was so that the device would recognise the rodents and after recognition, the device would emit the signal that would scare them away, additionally it was added that it would work with photovoltaic cells, which makes it versatile for use regardless of whether or not electricity is available and avoids the emission of greenhouse gases caused by the consumption of electricity.
- The contribution in the social sphere is to provide a solution that keeps rodents away from the product that will be consumed by animals and humans.

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- The time and research resources applied to the project, as observed in the analysis, can have a wide yield and field of application, considering the multiple places where this technology can be applied.

Under these design premises, it was considered to include in the theoretical framework, the knowledge of neural networks, which is the basis for the device to recognise the specific presence of rodents.

In relation to the 2030 Agenda, Figure 3, several goals were addressed; 3 Health and well-being, 7 Affordable and clean energy, 8 Decent work and economic growth, 9 Industry, innovation and infrastructure, 12 Responsible production and consumption and 15 Life of terrestrial ecosystems.

Figure 3 SDGs: Sustainable Development Goals
Source [3]

Aligned to the Circular Economy, opportunities to reuse, repair, remanufacture and recycle were considered; applying in the project a simple and easy to repair design and implementation of photovoltaic cells for the operation of the device [10].

Competences to DO and continuous improvement tools

For the development of these competences it is suggested to start:

- Being clear on the objectives of the project, on what you want to do and achieve, on the action plan (first part of the Deming cycle), on the support required from others and how to contribute.

- Aligning your excitement about the project, expressing verbally and clearly structured what you expect from the project, in less than five minutes.

- Working to a plan and schedule of work.

- Incorporate useful engineering tools such as Deming Cycle, Lean Manufacturing and 5 s, which are used in industry, and as the person becomes familiar with them, they permeate the person and they apply them in other activities of daily life, Figure 4.

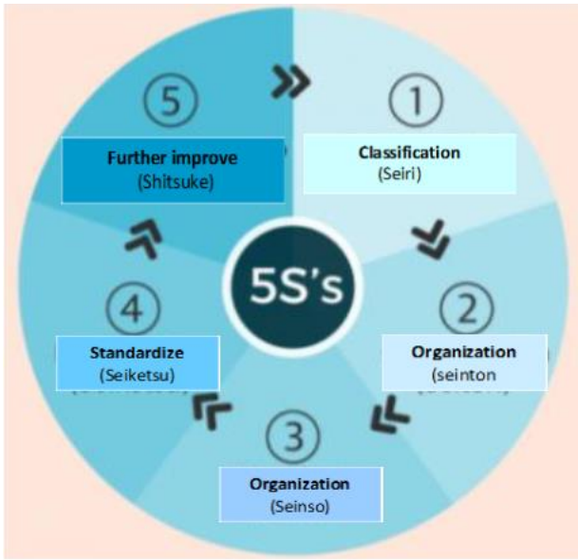

Figure 4 Tool 5 s
Source [8]

In relation to the project in question, applying the Deming cycle tool: Plan, Do, Check and Act, a work programme was planned from the start, taking into account the goals for the construction of a prototype.

Often the availability of resources for the materialisation of projects is complicated, scarce and not timely, under these premises, it is clear that it is necessary to learn to work with Lean Manufacturing, eliminating waste and optimising costs, whatever the project in question.

Competences for LIVING TOGETHER

The proposed scaffolding sets out the objectives and reflections that favour the development of knowledge and know-how in order to acquire knowledge of the technical and economic aspects of projects.

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However, in order to understand and implement in parallel the competences that could be the missing ingredients for the development of technology in the future, the model proposes incorporating reflections in relation to ethical values, as these are the ones that can change the course of current goods, services and production systems and that the power to apply them lies in the hands of each individual consumer or producer.

Projects, however good they may be, depend very much on the mastery of applying soft skills and sustainable results depend on ethical values and knowledge. At each stage during project development, performance refers back to Universal Values, from the position in which each person is involved, the model considers that in the background Among the problems in all the scenarios of Sustainable Development is the lack of application of universal values, which have confused and diverted humanity, putting material gains before the gains that sublimate the human spirit.

Results

The cognitive scaffolding model proposed in this work is a methodological proposal with instruments to address the development of technological projects, with design parameters based on the economic, social and environmental conditions surrounding the project, with innovation and quality [11], incorporating central aspects in the training of students: sustainability and development of competences. In addition, it also allows the incorporation of continuous improvement tools that organise the generation and execution of projects, without falling into rigidity, allowing its application in different types of projects.

In the reference project, developed by a postgraduate student supported by a CONCYT grant for his master's studies, the technology used was for the recognition of mice, for the emission of signals and, additionally, it was added that it should work with photovoltaic cells. In the construction of the prototype, its life cycle was analysed and a simple design was sought, using parts that offered greater durability, as well as selecting suppliers in the production line that were friendly to sustainability (if this information was available) [12]. Figure 5 shows a worksheet prepared by the student, showing the aspects analysed.

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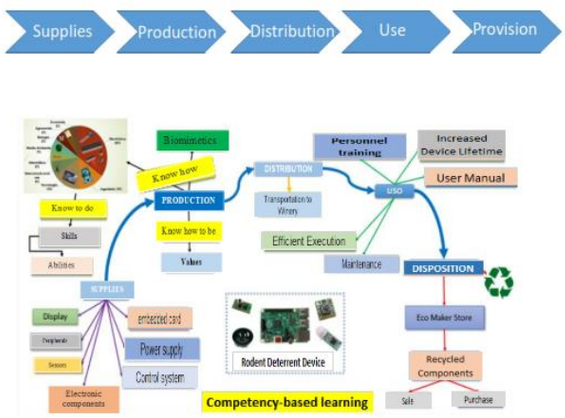

Figure 5 Project analysis worksheet
Source [12]

Figure 6 shows the developed device. The project was awarded a prize at an engineering expo.

Figure 7 Dispositivo desarrollado
Source: [12]

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Conclusions and future work

The projects are important, but even more important is the training of professionals with criteria of sustainability, ethics and quality, to make technology a viable way to solve some of the activities of human beings without collateral damage.

As an area of opportunity we have, that not always the same student who develops the technology, is interested in carrying out the commercialisation of their projects, so this offers the opportunity to integrate other types of projects under the same approach of sustainability but oriented to form a value chain around the projects that are generated in these environments, since also in many of the events such as the expo-engineering, the intellectual property of the same is put at risk.

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