Article **Journal High School**
December 2023, Vol.7 No.18 32-41

Project development with STEM features

Desarrollo de proyectos con características STEM

MONTECILLO-PUENTE, Francisco Javier*†

Tecnológico Nacional de México campus Salvatierra, Instituto Tecnológico Superior de Salvatierra ITESS

ID 1st Author: *Francisco Javier, Montecillo-Puente* / **ORC ID:** 0000-0001-9540-9228, **Researcher ID Thomson:** X-2309-2018, **CVU CONAHCYT ID:** 50009

DOI: 10.35429/JHS.2023.18.7.33.41 Received July 25, 2023; Accepted December 30, 2023

Abstract

This article presents an analysis of selected projects developed at the Tecnológico Nacional de México Salvatierra (TecNM-ITESS). These projects help students to develop STEAM skills. Mechatronics and TIC's engineering programs are included in our case of study. The first part of this article, the ITESS operational framework is presented. Then, it is described Bloom's taxonomy and the PISA tests as reference tools for the development and measurement of student's capabilities. Also, education quality indicators are presented for the TecNM-ITESS and state government of Guanajuato. Indicator and STEM skills are studied to find relationships. In addition, different academic events and calls for projects that facilitate the participation of students in activities that promote STEAM skills are discussed. In a second part, some projects where students have participated are presented, the strategies used for the dissemination, identification and training of students are discussed. As well as, a sentiment analysis is presented where data has been collected from students who were involved in projects.

STEM, Learning approaches, Academic project, Educational quality

Resumen

En este artículo se presenta un análisis sobre los proyectos desarrollados en el Tecnológico Nacional de México campus Salvatierra (ITESS) para la formación de alumnos en habilidades STEAM. Por una parte, se presenta el marco operativo del ITESS y describen la taxonomía de Bloom y las pruebas de PISA como herramientas de referencia para el desarrollo y medición habilidades. También, se presentan como el TecNM y el gobierno del estado de Guanajuato en sus indicadores de calidad, estas habilidades indirectamente se incluyen. Además, diferentes eventos académicos y convocatorias que facilitan la participación de alumnos en proyectos que fomentan las habilidades STEAM son discutidas. En una segunda parte, se presentan algunos proyectos donde alumnos han tenido participación, se discuten las estrategias empleadas para la difusión, identificación y formación de alumnos. Así como, un análisis de sentimiento de los alumnos que participan en proyectos.

STEM, Técnicas de aprendizaje, Proyectos académicos, Calidad educativa

Citation: MONTECILLO-PUENTE, Francisco Javier. Project development with STEM features. Journal High School. 2023. 7-18:32-41.

* Correspondence of the Author (E-mail: famontecillo@itess.edu.mx)
† Researcher contributing as first author.

Introduction

This section discusses the definition of STEAM and an overview of the development of these skills. It also presents the Bloom taxonomy and the PISA framework for the evaluation of student performance levels. And finally, the educational quality indicators of the TecNM and the state of Guanajuato in relation to STEAM skills are presented.

STEAM

In a simplistic way STEAM is the acronym for Science, Technology, Engineering, Arts and Mathematics. STEAM in a broader sense can be defined as an educational model where STEAM knowledge areas are integrated into the teaching and learning process (Greca et al. 2021; Ortiz-Revilla et al. 2021; Aguilera and Ortiz 2021). Some of the activities reported as STEAM are: problem solving, teaching approaches that integrate two or more features; and/or teaching content with real problems containing two or more features. The incorporation of the term A, aims to include the arts and creativity in the development of academic activities, (Marín-Marín et al., 2020).

There are different models proposed for teachers to effectively implement this educational approach, (Greca et al., 2021). A method for teaching-learning sequencing with STEAM characteristics considers the epistemological, psychological and didactic axes. In this approach, research-based design (IBD) is used and assessable learning standards (ALE) are defined. In order to plan the activities, the subjects, the contents to be addressed, the ALE, the objective and the situations to be resolved are defined. In its implementation, an iterative process is followed to improve the prototype to be developed and the teachers serve as a guide in the execution of the activities. This method is presented for basic education level.

However, one of the questions about the STEAM approach is that it lacks an instrument to determine which academic activity is STEAM (Aguilera and Ortiz-Revilla et al., 2021). In this sense, for the evaluation of characteristic A (Arts) of an activity, one proposal is to identify: the degree of creativity, the context, the individual's ability to demonstrate creativity and the final product.

STEAM skills formation

Bloom's taxonomy seeks to define the stages of learning development in students, while the PISA test seeks to measure students' level of learning. Bloom's taxonomy of cognitive skills has six levels: remembering, understanding, applying, analysing, evaluating and creating (del Moral, 2012). This taxonomy sets a benchmark for defining teaching-learning processes. In terms of skills assessment frameworks, the PISA (Programme for International Student Assessment) test focuses on assessing the competencies of 15-year-old students in the areas of reading, mathematics and science. The S (Science) and M (Mathematics) components are assessed prior to higher education. In each area, performance levels of as indicated in Table 1 are assessed. This test shows the individual assessment of the S: science and M: mathematics characteristics.

Performance level Mathematics	Performance level Science
Level 5. Develop and work with models for complex situations.	Identify, explain and apply scientific knowledge and knowledge about science in complex life circumstances.
Level 4. Work with explicit models in complex situations.	Level 5. Identify scientific components of many complex life situations and apply scientific concepts.
Level 3. Execute clearly described procedures.	Level 4. Engage explicit phenomena to make inferences about the parallel of science or technology.
Level 2. Interpret and recognise contexts with direct inferences.	Level 3. Clearly identify scientific problems described in a variety of contexts.
Level 1. Answer questions with familiar contexts where all information is present and the question is clear.	Level 2. Able to offer possible explanations known to them or draw conclusions based on simple investigations.
Below Level 1. Not able to perform the most elementary mathematical tasks.	Level 1. Have very limited scientific knowledge which can only be applied to a few situations they are familiar with.

Table 1 Performance levels in PISA tests, contains two characteristics (SM)

ECORFAN® All rights reserved.

Regarding higher education, the Ibero-American Association of Engineering Education Institutions (ASIBEI) and the National Association of Engineering Schools and Faculties (ANFEI) agree on the development of technological competences, social, political and attitudinal competences (ASIBEI, 2016; ANFEI, 2016). Table 2 shows the list of competences for engineering. From this, two educational strategies can be observed: the development of student learning under academic projects and the ability to communicate.

Technological competences	Social, political and attitudinal competences
Identify, formulate and solve engineering problems.	Performing effectively in work teams.
Conceive, design and develop engineering projects.	Communicate effectively.
Manage, plan, execute and control engineering projects.	Act ethically, with professional responsibility and social commitment, considering the economic, social and environmental impact of their activity in their local and global context.
Effectively use the techniques and tools applied in engineering.	Learn continuously and autonomously.
Contribute to the generation of technological developments and/or innovations.	Act with an entrepreneurial spirit.

Table 2 List of competences for engineering students

Following on from the previous point, the EDUSIMSTEAM project, (Aydos, 2023; Australia, 2019), lists a set of pedagogical practices for implementing STEAM education. These practices include: traditional direct instruction, teaching with experiments, problem/project-based approach, inquiry-based approach, collaborative learning, peer teaching, flipped classroom, personalised learning, integrated learning, differentiated instruction, summative assessment, formative assessment and self-assessment. In addition, this project takes as references the principles defined by The Australian Government Department of Education for the successful implementation of these practices. These principles are:

- PSTEAM1 use inquiry-based learning,
- PSTEAM2 solve real problems,
- PSTEAM3 teach integrated STEAM learning,
- PSTEAM4 empower and resource teachers,
- PSTEAM5 create school-business-community collaborations,
- PSTEAM6 use technology as an enabler of knowledge, differentiate teaching,
- PSTEAM7 linking education to 21st century learning (critical thinking, creativity, communication, collaboration).

In these STEAM principles some of the technological competences proposed by ASIBEI and ANFEI: solving engineering problems can be related to PSTEAM2, effective use of techniques and tools to PSTEAM6; and social competences to PSTEAM7.

Following this line of identifying STEAM projects or activities, (Connor et al., 2015), four engineering-level case studies are evaluated according to pedagogical characteristics: problem-based, project-based, inquiry-based and discovery learning. These characteristics and the field of application define whether the project is STEAM. In these case studies, a student-centred and active learning approach is used for project development. Also, it is established that there is confusion in applying these approaches and that it may be caused by a self-centred discipline of those involved. This refers to a lack of preparedness to deal with interdisciplinary education on the part of students and academics. In this sense, the provisions of the EDUSIMSTEAM project can be used as a guide to overcome this difficulty.

TecNM and consideration of STEAM skills

The Instituto Tecnológico Superior de Salvatierra (ITESS) is a decentralised campus of the TecNM located in Salvatierra in the state of Guanajuato that is aligned to the quality indicators of the State. Within the guiding development plans under which it is governed, the development of STEAM skills is not explicitly stated.

ECORFAN® All rights reserved.

However, according to the vision, objective and indicators, these can be identified. In terms of government, the Guanajuato State Plan 2040 sets out two points related to STEAM training as a vision (iplaneg, 2023):

- Excellence in upper secondary and higher education in the areas of science, technology and innovation. At this point, the ST (Science, Technology) characteristics are present.

- We have highly qualified human capital and the development of new technologies and innovation in production is promoted. At this point, there is the T (Technology) characteristic aimed at students.

Regarding ITESS, it has the Institutional Innovation and Development Programme 2019-2024 (PIID), aligned to the State quality indicators. Some of the thematic axes related to STEAM are: academic programmes for digital transformation in higher education, professional certifications, start-ups and spin-off companies that participate in value chains, linking with companies to produce innovation products and technological development, (PIID-ITESS, 2019).

From here it is noted that the following principles suggested by EDUSIMSTEAM, (Aydos, 2023; Australia, 2019), are present: PSTEAM2 problem solving and PSTEAM5 school-business-community collaboration, as well as the T (Technology) characteristic. In this same sense, for entry to the TecNM in the programmes of Information and Communication Technologies and Mechatronics Engineering, an entry profile is sought for students with the following qualities: knowledge of the physical-mathematical area, self-learning ability, basic level of English, analysis and synthesis of practical problems, study habits and methods, willingness to work in a team, interest in applying technology and research methods, as well as basic operation of a computer. STEM characteristics are present, as well as the problem solving principle, PSTEAM2.

The TecNM within its development plan, in terms of educational quality, has as indicators the participation of students in research, entrepreneurship and innovation projects, Table 3. This table presents the STEAM characteristic and the EDUSIMSTEAM principle that is applied to achieve it. PSTEAM4, the teacher can access resources by applying to calls for projects where the themes are in line with his or her area. The PSTEAM3 principle, which refers to applying STEAM practices, was not identified. However, the TecNM suggests as a learning activity the development of integrative projects, here is an opportunity for teachers to include STEAM practices and principles.

Line of action TecNM	Indicator	Feature STAEM
2.2 Increase attention to demand.	2.2.4 Undergraduate terminal efficiency rate .	E
4.1 Promote the training of highly specialised human capital to generate research and technological development, innovation and entrepreneurship.	4.1.5 Number of undergraduate students participating in research projects .	STEM PSTEAM1 PSTEAM2 PSTEAM4 PSTEAM5 PSTEAM6
5.1 Optimise institutional linkage mechanisms.	5.1.6 Students with occupational certificates .	E PSTEAM1
5.3 Development of entrepreneurial talent and the creation of technology-based companies.	5.3.3 Students participating in entrepreneurship models .	E PSTEAM1, PSTEAM5.

Table 3 *Table of indicators with impact on STEAM skills development*

TecNM campus Salvatierra

The case study of this article focuses on an analysis of student participation in academic events that require or develop STEAM skills within the TecNM campus Salvatierra. In the absence of an instrument that correctly assesses the STEAM level, the strategies and principles defined in the EDUSIMSTEAM project (Aydos, 2023; Australia, 2019) are considered. This study focuses on the educational programmes of Mechatronics Engineering and Information and Communication Technologies (ICT) that after pandemic have collaborated in the development of projects.

ISSN-2523-0336
ECORFAN® All rights reserved.

December 2023, Vol.7 No.18 32-41

Events and academic programmes for STEAM skills development

The TecNM within its guideline marks the participation in academic events, integrative projects and integral degrees. An integrative project involves the development of a project that includes several subjects, different semesters and different disciplines. Regarding innovation, the TecNM has the INNOVATEC event where the objective is to develop technology-based projects (innovatec, 2023). A second academic event is the Coding Cup programming competition where teams participate and the problems involve mathematics and computer science, (codingcup, 2023). A third event is the TecNM Summer of Scientific Research, which aims to integrate TecNM undergraduate students into the work of scientific research and technological development (cenidet, 2023). The DELFIN programme, which is of an international nature, seeks to bring students closer to scientific work (DELFIN, 2023). There is also a call for the development of projects with TecNM funding and an internal call for ITESS research projects where teachers can incorporate students (dpii, 2023). As far as the state government is concerned, there are different programmes and calls for proposals. IDEA Guanajuato is a space created to promote the economic and social development of the state through innovation, entrepreneurship, science and technology, (idea, 023). Also, the Secretary of Education of Guanajuato in 2020 with the Internationalisation programme in Casa SEG for the development of projects. Likewise, the Institute for the Development and Attention to Youth of the State of Guanajuato (JUVENTUDESGTO) also has a programme of "support for mobility" for the development of competences, (juventudes, 2023).

There are other events organised by private companies where students can participate to develop their STEAM skills. In terms of competitions, there are: the ICPC programming competition and the PLC programming competition Bushido organised by SMC Mexico, a leading automation company, created in 2021, (smc, 2021).

There is also the NASA Space Challenge, now in its 12th edition, where they will solve challenges, show their teamwork and coordination skills, and seek impactful solutions that address the needs of space, the environment, space exploration and the world, (space, 2023). INROADS occupational certifications in collaboration with google, for the development of competencies in ICT, project management, user experience and data analytics, (inroads, 2023). Table 4 presents a summary of activities that students have shown interest in and that are directly related to the contents of the mechatronics and ICT programmes. The activities proposed by the TecNM, government and private initiative are contemplated.

Event	STEAM feature of the event	Participating teams/projects	Students	Alumnae
INNOVATEC TECNM (anual)	STEM	Local stage 5 teams of 4 members.	15	5
TecNM Summer of Science (annual)	STEAM	4 projects, 3 students per project.	8	4
Coding Cup TecNM (annual)	TEM	National stage: 4 teams of 3 pupils,	8	4
Youth Mobility (annual)	STEM	1 project of 4 students	2	2
Internationalisation at Casa SEG (once a year)	STEM	1 project of 4 students.	2	2
SMC BUSHIDO PLC competition (annual)	TE	4 teams of 3 people.	8	4
NASA Space Challenge	STEM	1 team of 6 pupils	4	2
Hackaton idea GTO (annual)	TEM	1 team of 3 students	2	1
ICPC International Collegiate Programming Contest (annual)	TEM	1 team of 3 pupils	2	1
TecNM research project funded (annual)	STEM	1 project with 3 pupils	1	3
Internal research project (annual)	STEM	3 projects involving 6 students	3	3

Table 4 *Participation in STEAM events and capacities, the event can be annual or a single call, this in the years 2022 and 2023 (post-pandemic).*

From this table it can be seen that the characteristic Science appears 7 times, Technology 11 times, Engineering 11 times, Arts 1 time and Mathematics 10 times. In these projects or academic events 86 students have participated in an event with a STEAM characteristic, and in terms of demographics there are 55 males and 31 females. It is important to mention that the programmes or calls for proposals depend on government and company programmes, so they are not permanent. Therefore, teachers and students must be constantly monitoring the different calls for applications that have an impact on the quality indicators of the institution.

Characteristics of STEAM students at TecNM ITESS

Relevant questions about the number of STEAM-trained students at ITESS and the opportunity to incorporate more are:

- Why do students participate?
- What is their feeling about participating?

ECORFAN® All rights reserved.

December 2023, Vol.7 No.18 32-41

- What are the qualities of the students who participate?

- Why do students not participate?

To answer these questions, students were asked to answer these questions. To answer, they were asked to indicate 4 qualities, causes or reasons according to the question. Sixty-two students responded, their answers were grouped into similar terms and categories were created. Figure 1 shows the percentages of responses from students who have participated in projects. It is observed that the first three qualities for participating in projects are: responsible, disciplined and respectful. As an observation, technical and capacity skills are in the fourth position. As for the feeling that these have a positive connotation, the top three are: happiness, satisfaction and excitement.

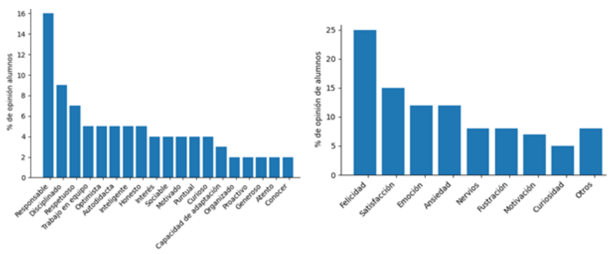

Figure 1 *Responses from students participating in events. Left: qualities. Right: feeling*

Regarding students who do not participate, the main reasons are lack of time, lack of skills and lack of interest, see Figure 2. This opens the door to create and evaluate strategies that fit in with classroom activities and encourage participation in STEAM academic activities.

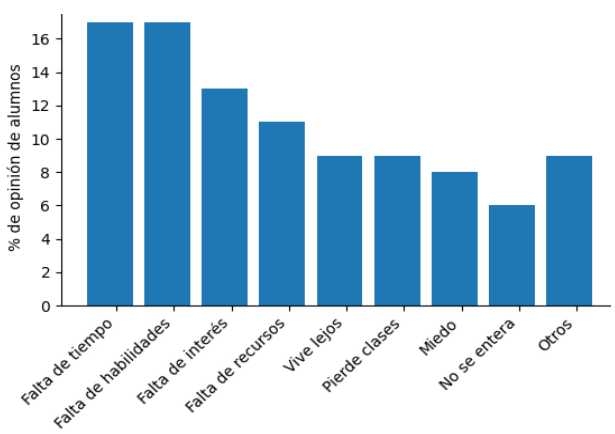

Figure 2 Reasons why students do not participate in projects

Student participation in STEAM projects

In this section we analyse some of the projects where there was student participation based on STEAM characteristics and principles. We present the development of an application for teaching English using augmented reality, the development of a video game for teaching numbers and letters, the development of a greenhouse for cacti, an automatic hydroponic system, an interface for water treatment and a database for disease detection using pytorch.

STEM projects with student participation

The project classification of fungal diseases of foliage based on Deep Learning in the TecNM 2022 call, where 3 students participated and the characteristics are STEM. The students worked with image capture systems, pytorch for neural networks and infection of plants with fungi, Figure 3. In addition, the students created a database to identify the developmental stages of foliage diseases with different fungi and plants.

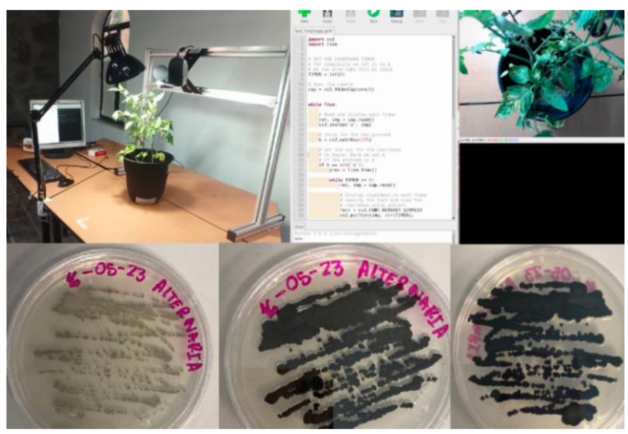

Figure 3 Images from working with students on the fungal disease project. Above: image capture for disease development level. Below: *Alternaria* fungus

As far as the scientific summer in the TecNM and Dolphin programmes is concerned, 12 students participated in three projects. The first project is the development of a mobile application to learn numbers and syllables for pre-school children, using the STEAM feature. Where audio, animations, graphic design and feature A were used. A similar project is the development of an application for teaching English using augmented reality, this project also considers STEAM features.

ECORFAN® All rights reserved.

A third project is the development of a Kuka robot simulator using the unreal video game engine, this project involves STEM, where students modelled the DH parameters of the robot, implemented the direct and inverse geometric model, loaded the robot geometry and created a basic scenario. In Figure 4, some images of these projects are illustrated. The top part shows the educational applications and the bottom part shows the kuka robot simulator.

Figure 4 Images of TecNM and Delfin Science Summer projects. Top: English with AR, Middle: video game for children. Bottom: Kuka robot simulator.

Innovation and mobility projects, one for agricultural applications and a stay at the University of Bristol. The first, the development of an automated greenhouse for the cultivation of cacti. In this project the students modelled and designed the greenhouse to control variables such as pH, conductivity, humidity, temperature, fertilisers and fungicides. The second was an automatic hydroponic system for growing lettuce in urban environments. It controls ph, conductivity, dosage of nutrients A and B, as well as the control of the irrigation cycle. The mobility project was developed at the University of Bristol and consisted of applying clustering algorithms for image classification to locate locations on maps using k-means, Gaussian mixtures and hierarchical clustering. This was also with STEM features, as well as involving foreign language skills. Illustrative images of these projects are shown in Figure 5. At the top is the greenhouse and at the bottom are the clustering algorithms.

Applying the STEAM characteristics and EDUSIMSTEAM principles, (Aydos, 2023; Australia, 2019), to each project generates the following Table 5. The experiences of the teachers involved are the ones who determined the STEAM principles or characteristics applied. From this table it can be seen that characteristic A (arts) is present in only one of the projects. The video game project for children was supported by a graphic designer and in the case of music, principles of composition and harmonisation were considered.

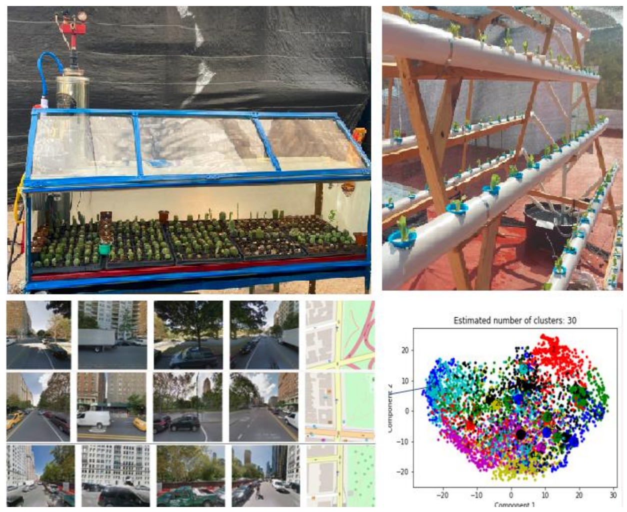

Figure 5 Images of the innovation and mobility projects. Above: greenhouse, hydroponic system. Below: clustering

Proyect	STEAM feature of the event	STEAM Principle, [22,23].
Cactaceae greenhouse: AutoSrpout	S: natural sciences T: sensors, actuators, microcontrollers E: CAD modelling and design M: fertiliser and fungicide dosing. Control of variables.	PSTEAM1, PSTEAM2, PSTEAM4, PSTEAM5, PSTEAM6, PSTEAM7
Hydroponic system for growing lettuce.	S: natural sciences T: sensors, actuators, microcontrollers E: CAD modelling and design. Control of irrigation cycles. M: A and B fertiliser dosing.	PSTEAM1, PSTEAM2, PSTEAM6, PSTEAM7
Evaluation of clustering methods to describe images on maps.	S: computer science T: video cameras, GPS E: data analysis, algorithms M: clustering models	PSTEAM1, PSTEAM2, PSTEAM4, PSTEAM6, PSTEAM7
	ST: computer systems. T: telecommunications, augmented reality. E: software development M: 3D space	PSTEAM1, PSTEAM2, PSTEAM6
Augmented reality applied to learning in pre-school education.	S: computer systems. T: smart phones A: music, visual art E: software development M: 3D space, animations.	PSTEAM1, PSETAM2, PSTEAM6.

Table 5 STEAM projects, principles and characteristics

ECORFAN® All rights reserved.

Strategies for training students with STEAM skills

In this section the strategies to encourage the participation of students in academic events that develop STEAM skills within ITESS are presented. In the institute there are different mechanisms that allow motivating students, such as: granting credits, social service, extracurricular activities, professional residencies, integral degree, transport and food scholarships. Some of the strategies that have been implemented to encourage student participation are the following:

- National or international mobility is an attraction where students can travel within the country or abroad.

- State calls for applications generally have economic incentives, so it is also an attractive option for students.

- Transport or food scholarships.

- Extra-curricular credits, release from social service, and graduation for thesis projects.

- Extra points in related subjects.

- Experience in project development and STEAM skills training.

- Testimonials from students in their job placement.

- Institutional recognition.

- Consideration of these students in occupational certifications.

- Testimonials about their experience in participating in events by participating students.

- Individual and/or group motivation to improve their skills.

However, within the indicators of the TecNM campus Salvatierra, there is a goal for the ICT and mechatronics programmes as follows: 30 students participating in research projects, 20 students participating in entrepreneurship events and 10 students with occupational certifications.

If we group them annually into a fictitious STEAM indicator, the target would be 60 students participating. Table 6 below shows student participation in 2022 and 2023: In 2023, 28 students participated in 2023 and in 2022 only 25, indicating that less than half of the desired indicator is achieved.

Year	Event	Participants
2023	TecNM Summer 2023	12
	Innovatec TecNM regional 2023	4
	TecNM Research projects 2023	3
	Research internal project ITESS 2023	3
	Coding Cup TecNM 2023	6
2022	Summer TecnNM 2022	8
	Innovatec TecNM regional 2022	4
	Research internal project ITESS 2022	3
	Coding Cup TecNM 2022	6
	Evaluation of clustering algorithms in maps and images	4

Table 6 Table of events 2022 and 2023, after the pandemic

Acknowledgements

The Tecnológico Nacional de México campus Salvatierra is thanked for the development of this work.

Conclusions

The TecNM and the ITESS within its development plan are aligned to the State and National objectives, so indicators are created to evaluate the quality of the programmes. An analysis of the indicators related to STEAM characteristics is presented. Explicitly they are not considered, but according to the STEAM characteristics and principles in the indicators, types of academic activities and state objectives they are implicit. An analysis of the projects in which students participated and an analysis of the different academic events where ITESS students have participated, mainly the engineering programmes in mechatronics and ICTs, was carried out. Also, some of the strategies used to involve students in projects and/or academic activities were presented, as well as their limitations. The skills of the students participating in these projects were also discussed. The result was responsibility as the main quality of the participants and happiness as an emotion. From the academic side, and specifically tutorials, an analysis or strategies for time management and skills development should be carried out, as these are the two reasons why more students participate in STEAM projects.

ECORFAN® All rights reserved.

On the teaching side, it is suggested that the work assigned contemplates the STEAM practices and principles established in the EDUSIMTSTEAM project. This is to have a point of reference, as each teacher can develop their own activities to apply these principles. As mentioned in the literature, there is no frame of reference that indicates or evaluates what a STEAM activity is. In our study we consider a STEAM event or project when it has some of the characteristics and applies some of the principles set out in EDUSIMSTEAM. However, there is no framework or instrument that measures whether a project is considered STEAM.

References

Greca I.M., Ortiz-Revilla J. y Arriassecq. I. (2021). "Diseño y evaluación de una secuencia de enseñanza-aprendizaje STEAM para Educación Primaria."Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 18.1.

Ortiz-Revilla, J., Sanz-Camarero, R., Greca, I. M. (2021). "Una mirada crítica a los modelos teóricos sobre educación STEAM integrada." Revista Iberoamericana de Educación, 87.2.

Aguilera, D. and Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: a systematic literature review. Education Sciences, 11.7.

del Moral Santaella, Cristina. (2012). “Conocimiento didáctico general para el diseño y desarrollo de experiencias de aprendizaje significativas en la formación del profesorado.” Profesorado. Revista de Currículum y Formación de Profesorado, 16.2.

OCDE. El programa PISA de la OCDE Qué es y para qué sirve. https://www.oecd.org/pisa/39730818.pdf

ASIBEI. (2016).CONSEJO FEDERAL DE DECANOS DE INGENIERÍA DE ARGENTINA CONFEDI, R. Giordano Lerena. Competencias y perfil del ingeniero iberoamericano, formación de profesores y desarrollo tecnológico e innovación (Documentos Plan Estratégico ASIBEI).

ANFEI. (2016). Expereiencias Institucionales en la Educación por Competencias en Ingenieria.

iplaneg (2023). https://iplaneg.guanajuato.gob.mx/ped2040/.

PIID-ITESS. (2019). https://itess.edu.mx/pdfdiib.html.

innovatec. (2023). https://innova.tecnm.mx/documentos/Convocatoria-InnovaTecNM-fd97d.pdf

cenidet. (2023). https://veranocientifico.cenidet.tecnm.mx/content/convocatorias/ConvocatoriaCongreso2023.pdf

space.(2023). https://www.spaceappschallenge.org/2023/locations/santiago-de-queretaro/

icpc. (2023). https://icpc.global/

idea. (2023) https://idea.guanajuato.gob.mx/conocenos

smc. (2021). https://smc.com.mx/wp-content/uploads/2021/08/bases_.pdf

codingcup.(2023). https://www.codingcup.org/
juventudes. (2023) https://juventudesgto.guanajuato.gob.mx

delfin. (2023). https://programadelfin.org.mx/

dpii. (2023) https://proyectos.dpii.tecnm.mx/

Marín-Marín., J.A., Moreno-Guerrero, A.J., Dúo-Terrón P. and López-Belmonte, J. (2021) STEAM in education: a bibliometric analysis of performance and co-words in Web of Science. International Journal of STEM Education, 8.41 https://doi.org/10.1186/s40594-021-00296-x

Connor A.M, Karmokar S. and Whittington, C. (2015). From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education. International Journal of Engineering Pedagogy (iJEP), 5.2.

Aydos, C. (2023). STEAM Strategies for Best Practices. EDUSIMSTEAM project, Ministry of National Education / Directorate General of Innovation and Educational Technologies.

Australia. (2019). Australian Goverment Department of Education. Best Practice Guide:

ECORFAN® All rights reserved.

December 2023, Vol.7 No.18 32-41

Elements of successful school-industry STEM partnerships.

inroads. (2023). https://becas.inroads.org.mx/.

ISSN-2523-0336
ECORFAN® All rights reserved.