# IMPACTO DE LA METODOLOGÍA STEM MAKER EN LA ENSEÑANZA DE APLICACIONES HARDWARE

## IMPACT OF THE STEM MAKER METHODOLOGY IN THE TEACHING OF HARDWARE APPLICATIONS

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Año 10 No. 30
Recibido: 17/septiembre/2023
Aprobado: 15/abril/2024
Publicado: 30/mayo/2024

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RD-ICUAP Año 10, No. 30, 2024, pp. 87 - 98 ISSN 2448-5829

## Resumen

En el ambiente educativo existe un constante cambio en los diversos elementos que intervienen en los procesos de enseñanza-aprendizaje. Uno de los elementos fundamentales es la metodología de enseñanza. Una de las metodologías de enseñanza emergentes actualmente en la metodología STEM que se presenta como un enfoque multidisciplinario de la enseñanza, el cual está integrado por cuatro áreas de estudio que constituyen el significado de sus siglas: Ciencia, Tecnología, Ingeniería y Matemáticas. La metodología STEM se ha visto complementada con la irrupción del movimiento Maker y la filosofía DIY (Do It Yourself), lo que está provocando el desarrollo de nuevas metodologías, enfoques y recursos educativos que se basan en principios como la creación, la colaboración y el aprendizaje Maker. En este trabajo se analizó el impacto de la aplicación de la metodología STEM Maker en un taller desarrollado en la Benemérita Universidad Autónoma de Puebla con una mayoría de estudiantes de secundaria y preparatoria. Los resultados muestran que la metodología STEM Maker favoreció el proceso de enseñanza-aprendizaje en más del 75% de los asistentes. Algunos otros efectos positivos los han llevado a diversos ambientes académicos como ferias de ciencias, reconocimiento en áreas STEM y el desarrollo de habilidades para la implementación de proyectos que respondan a las necesidades del contexto particular de cada uno de los participantes.


Palabras clave: STEM, metodología de enseñanza-aprendizaje, desarrollo de hardware y movimiento Maker.


## Abstract

In the educational environment there is a constant change in the various elements involved in the teaching-learning processes. One of the fundamental elements is the teaching methodology. One of the currently emerging teaching methodologies in the STEM methodology that is presented as a multidisciplinary approach to teaching, which is integrated by four areas of study that constitute the meaning of its acronyms: Science, Technology, Engineering and Mathematics. The STEM methodology has been complemented by the emergence of the maker movement and the DIY (Do It Yourself) philosophy, which is causing the development of new methodologies, approaches and educational resources that are based on principles such as creation, collaboration and learning Maker. In this paper, the impact of the application of the STEM Maker methodology was analyzed in a workshop developed at the Benemérita Universidad Autónoma de Puebla with a majority of high school and professional school students. The results show that the STEM Maker methodology favored the teaching-learning process in more than 75% of the attendees. Some other positive effects have led them to various academic environments such as science fairs, recognition in STEM areas and the development of skills for the implementation of projects that meet the needs of the particular context of each participant.


Keywords: STEM, teaching-learning methodology, hardware development, and Maker movement.

RD-ICUAP Año 10, No. 30, 2024, pp. 87 - 98 ISSN 2448-5829

## Introduction

Currently, in the global world context, technological changes such as the internet of things, artificial intelligence, new forms of Big data processing, robotics, the shared economy or crowdsourcing are becoming more common. Studying and using Science (Ambrož et al., 2023; Andrade, 2021; Arteaga-Marín, 2022; Benkler, 2006), Technology (Bevan et al., 2014; Burrows et al., 2018; Chen et al., 2020), Engineering (Domínguez & Mocencahua, 2016; Esquer & Fernández, 2021; García-Fuentes et al., 2023), and Mathematics (Garduño, & Reyes, 2022; Grout, 2017; Gutiérrez & Jaramillo, 2022) in an interdisciplinary and transdisciplinary way, preserving the richness and uniqueness of each field of study, enriching and expanding them, is closely related to innovation, because when expanding, convergent aspects are discovered. that were not known or formed new interactions (Hatch, 2014; Hoppenstedt, 2017; Johnston et al., 2022; Komis, 2021; LaForce 2017).

The Maker movement has its origins in the American cultural current of the "do it yourself" of the fifties, dabbling in different activities and since then forming communities around technical publications for hobbyists such as Popular Mechanics or Popular Electronics, among others (Lindberg et al., 2020; Martínez et al., 2021; Martini & Chiarella, 2017). The definition of Maker refers to "identity based on the act of creating", so that the person who repairs is a craftsman, hobbyist or inventor can be defined as such. The difference with the Makers of other generations or times is their accessibility to modern technologies and the globalized economy (Morales & Dutrénit, 2017).

Making things has always existed, however, the social movement, the Maker Movement, was formalized by linking contemporary technology and the basic idea of sharing in society (Niederhauser & Schrum, 2016; Nixon et al., 2021). In the case of the Maker movement, rules were created that characterize it and are described in a Hatch manifesto (Phanichraksaphong, & Tsai, 2021; Rojas et al., 2019; Villanueva & Di Stefano, 2017; Zhao et al., 2022; Zhuang et al., 2022), which suggests that these changes be carried out to the letter by oneself:

*Do:* Doing is central to what it means to be human. We must do, create and express ourselves to feel fulfilled. There's something unique about doing physical things. These things are like little pieces of us and seem to embody portions of our soul.

*Share:* Sharing with others what you have made and what you know about making is the method by which the feeling of fulfillment of a maker is achieved. You cannot do and not share.

*Give away:* There are few things more selfless and satisfying than giving away something you have made. The act of doing places a small piece of you in the object. Gifting this one to someone else is like giving someone a small part of yourself. These kinds of things are often the most precious things we own.

*Learn:* You have to learn to do. You should always try to learn more about your creation. You can become a master builder or master craftsman, but you will continue to learn, you will want to learn, and you will push yourself to learn new techniques, materials, and processes. Building a lifelong learning path ensures a rich and rewarding maker life and, above all, allows one to share.

*Equip yourself:* You must have access to the right tools for the project at hand. Invest in the tools you need to develop the creation you want to make. Authoring tools have never been cheaper, easier to use, or more powerful.

*Play:* Be playful with what you're doing, and you'll be surprised, excited, and proud of what you discover.

*Participate:* Join the Maker Movement and connect with those around you who are discovering the joy of making. Host seminars, parties, events, maker days, fairs, expos, classes, and dinners with and for other makers in your community.

RD-ICUAP Año 10, No. 30, 2024, pp. 87 - 98 ISSN 2448-5829

*Support:* This is a movement, and it requires emotional, intellectual, financial, political and institutional support. The best hope to improve the world is us, and we are responsible for making a better future.

*Change:* Embrace the change that will naturally occur as you progress through your maker adventure. Since doing is central to what it means to be human, you will become a more complete version of yourself as you do.

## Methodology

The development of the STEM Maker workshop was carried out in 16 sessions with a temporary recurrence of 1 time per week. The duration of each session was 2 hours. The integration of the total time of each session (2 hours) was governed from a division by stages as follows:

*Stage 1 (Start):* Welcome to the students and conceptual explanation of the elements and theories used for the session (30 minutes).

*Stage 2 (Development):* Procedural explanation of the practice in the implementation of Hardware and Software. Development of a practical example by the instructor integrating the concepts reviewed in stage 1 (30 minutes).

*Stage 3 (Practice):* Practical development by the students, which is integrated by the implementation of the required software and the instrumentation of the appropriate hardware.

*Stage 4 (Challenge):* Proposal of a practical development to be solved by the students, where they involve the theoretical and technical concepts that promote the development of skills in the desired learning approaches.

The diagram in Figure 1 shows the sequence blocks of the workshop stages chronologically.

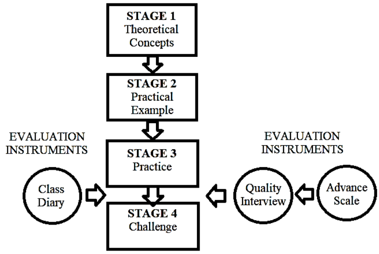


Figura 1. Sequence of a STEM Maker workshop session

## Experimental test and results

*Traffic light*

*Counter*

*Temperature Reader*

Figure 2 shows the experimental context of the traffic light implementation.

Figura 2. Implementation of the traffic light in the STEM Maker workshop

Figure 3 shows the operation of two synchronized traffic lights for a pedestrian crossing, where the delay times in the programming were synchronized and the electronic instrumentation was carried out for its correct operation.

RD-ICUAP Año 10, No. 30, 2024, pp. 87 - 98 ISSN 2448-5829

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RD-ICUAP

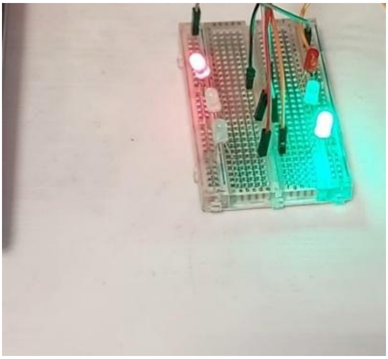


Figure 3. Result of the implementation of two synchronized semaphores

Figure 4. Implementation of the counter in the STEM Maker workshop

Figure 5 shows the operation of a two-digit counter, whose application would be used later to display the reading of a temperature sensor.

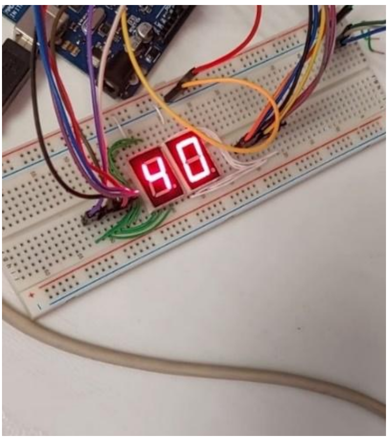


Figura 3. Impacto económico de las MIPYMEs en México (INEGI, 2021).

Finally, Figure 6 illustrates the instrumentation of the temperature reader, which is integrated by an LM35 sensor and the temperature value is displayed on two 7-segment displays. In the experimental test, a lighter was used to visualize the temperature increase.

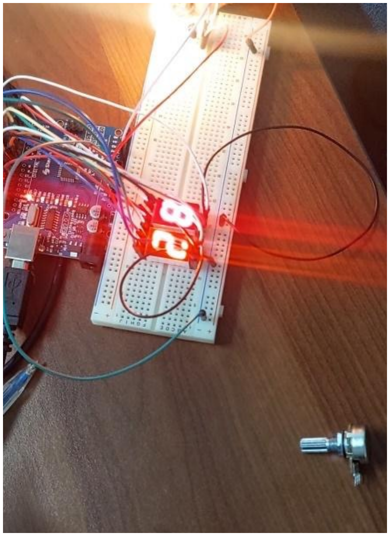


Figure 6. Result of the implementation of a temperature reader

The results obtained from the data collected are shown in the graph of figure 7. Where it can be seen that approximately 70% of the attendees at the STEM Maker workshop developed skills in hardware satisfactorily.

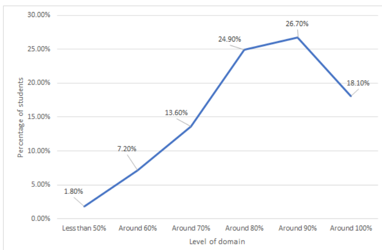
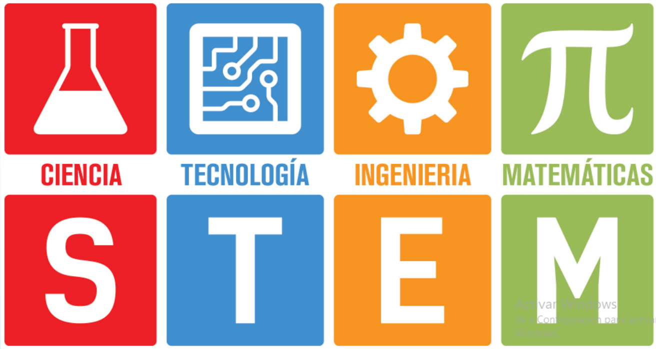



Figure 7. Percentage of development of skills in the implementation of Hardware by the participants of the STEM Maker workshop

## Conclusions

The implementation of the hardware applications developed in the STEM Maker workshop involved new concepts for the attendees, however, one of the advantages of applying the STEM Maker methodology is that by performing the practices physically, the attendees were able to better understand the application of the theoretical part when experimenting with the interconnection of physical components, programming logic, among other aspects. Another advantage that was reflected in the application of this methodology was the integration of the working group, since the exchange of ideas and collaboration between different members of the group was encouraged. Finally, as future work, it is intended to direct this workshop to teachers, with the purpose of promoting competences in the STEM areas and they can carry it out in their classroom contexts in their respective institutions.




https://www.stemhub.nv.gov/latinos-en-stem

ISSN 2448-5829
Año 10, No. 30, 2024, pp. 87 - 98
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## Declaración de no Conflicto de intereses

Los autores declaran que no existe conflicto de interés alguno.

## Declaración de privacidad

Los datos de este artículo, así como los detalles técnicos para la realización del experimento, se pueden compartir a solicitud directa con el autor de correspondencia.

Los datos personales facilitados por los autores a RD-ICUAP se usarán exclusivamente para los fines declarados por la misma, no estando disponibles para ningún otro propósito ni proporcionados a terceros.

## Agradecimientos

Los autores agradecen a la Facultad de Ciencias de la Computación y a la Facultad de Ciencias de la Electrónica de la Benemérita Universidad Autónoma de Puebla.

RD-ICUAP Año 10, No. 30, 2024, pp. 87 - 98 ISSN 2448-5829

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