

10 years of Math hands-on activities in Mexico

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Introduction

Mexico is a diverse country in contexts and conditions, in consequence, there are many difficulties for achieving science communication goals. There is almost no science culture, especially in Mathematics. Science communicators in Mexico often lack knowledge and improvise without professional study programs.

In the absence of criteria or methodologies, many errors caused by inexperience are repeated, and sometimes the public even gets the opposite effects to what is sought, which contributes to the reinforcing of stereotypes and negative ideas towards Science.

Mexican Science communicators work in many cases through trial and error and use imported products or communication strategies that are not contextualized for the diversity of Mexican audiences nor consider local conditions. In addition, it is considered that Sci-comm does not require experience and that it should be carried out in a voluntary way. Meanwhile, entertainment products that mispend resources but have no scientific content are also common and very popular.

Against this backdrop, the communication of Mathematics in a country with little scientific culture presents additional challenges, such as:

- the fact that the discipline deals more with objects arising from the imagination than with concrete things, the mechanistic biases of the school curriculum
- the multiple misconceptions that Mexicans have about this area of knowledge, in which stereotypes are repeated and erroneous ideas and predispositions to anxiety and other negative feelings are reinforced.
- the belief that Mathematicians already have the necessary tools to communicate Science, or that a Communicator no longer requires Mathematics knowledge; only a few realize that interdisciplinarity is needed to be a good Science communicator.

Most of the outreach products found in Mexico are aimed at audiences who like or are interested in Science. Since 2010, two of the public institutions that carry out mathematical research in the

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country (UNAM and CIMAT) have sought to carry out Math hands-on activities intended for different audiences, specifically, those who did not like Math or those who had a very poor approach to the discipline.

Although both groups have traced their paths independently, they came to gather experiences by working with diverse environments and audiences, which led to finding similar results, solutions, and evidence that should be taken into account when sharing Mathematics.

The aim of this paper is to clarify how direct communication activities can contribute to transforming some misconceptions about Mathematics.

On the socio-emotional dimension of hands-on activities

Along with 10 years of experience in communicating Mathematics throughout Mexico and in various contexts, we have managed to identify a pattern regarding the perception that Mexican society has about Mathematics: “they are difficult”, “they only are numbers”, “they are procedures that must be learned by heart” and so on. This kind of notions are linked to emotions and attitudes towards the discipline that are considered as negative: “I fear them”, “I do not like them”, “they bore me”, “they overwhelm me and generate anxiety”, “they confuse me”, “I feel incapable”, “they make me angry”, among others.

We identified that the first obstacles to overcome in order to implement hands-on activities with a diverse audience are their own misconceptions and emotions towards Mathematics. In our experience, to achieve success in math communication, it is necessary to take into account the emotional barrier that stops Mexican society from enjoying solving mathematical challenges.

It is possible to focus on the various emotions that someone experiences when participating in hands-on activities. These emotions could be self-regulatory or the facilitator could help regulate so that the person concerned has a positive overall experience based mainly on curiosity and puzzlement (Goldin, 2000).

One of our purposes as Mathematics communicators, working mainly with hands-on activities, is to achieve that, when experiencing key moments of frustration, participants manage to develop or strengthen strategies that allow them to overcome or increase their threshold to failure, as well as their ability to persist in adverse situations.

In general terms, this achievement strengthens their socio-emotional tools to maintain motivation, lose fear, and work their anxiety towards Mathematics. It is also a chance to experience the intellectual/cognitive satisfaction that Mathematics offers through hands-on activities.

Based on our experience, the interest in Science, and particularly in Mathematics, can be triggered by the creation of environments that generate emotions and positive attitudes towards the discipline. In order to generate environments where it is possible to detonate aha! moments that can awake the interest in mathematics, the design and implementation of hands-on activities must consider the affective and cognitive dimensions globally.

On design

When designing Math hands-on activities, the first thing you need to do is to characterize the public, so that it is possible to identify previous restrictions and conditions you will work with. This will allow you to define specific goals, such as socio-emotional or cognitive ones.

The design must be dynamic for adjusting it whenever is needed while activities are implemented. You also need to carry out a retrospective analysis of the results so that you can refine and improve their impact on the public on iterative cycles as far as possible.

Throughout our experience, we have identified three main aspects that could be considered when designing hands-on activities: *cognitive design*, *socio-emotional design*, and *conditions and constraints*.

On the importance of the facilitator

The way in which the science communicator interacts with the participants is something that must be considered in Math hands-on activities. It is desirable to create an environment in which participants can freely express their interest, frustration, surprise and other emotions or thoughts that activities generate within them.

Based on the experience and feedback of our work, we have enlisted a series of characteristics or basic skills that could help define the ideal profile of a hands-on Mathematics communicator. These skills have been divided into three categories according to their type: skills of *socio-emotional perception*, skills of *contribution to the process of dialogue*, and skills of *execution*.

It is necessary to consider that these skills could describe the ideal profile of a facilitator of hands-on Mathematics activities. It will not always be possible to meet each and every one of the mentioned characteristics; however, it could be a guide to help evaluate the facilitator's performance and identify improvement possibilities.

On evaluation

In the design of activities, an evaluation strategy should be made according to the established goals, the resources available, and whether or not time is available for more or less in-depth analysis.

In hands-on activities, it is possible to evaluate three major components according to the focus of interest:

- the efficiency of activities to achieve the aims and/or goals for both cognitive and affective dimensions
- the performance of facilitators
- the impact of activities on the public

Regardless of the type of evaluation to be carried out or the tools and methodologies chosen, the characterization of the public is something that must be done on each occasion: it provides elements of socio-demographic variables to develop the corresponding analysis and, in many cases, they direct the analysis of the results in certain directions.

Final thoughts

In the course of this work, some reflections and recommendations have been presented on the conduct of hands-on mathematical activities. These reflections have been built over 10 years of experience doing communication of Mathematics in Mexico, by the initiatives of the Institute of Mathematics of the UNAM and the Research Center in Mathematics. In spite of the above-mentioned problems related to the lack of professionalization, the great diversity of socio-cultural contexts, and the lack of favorable conditions for Sci-comm, it has been possible to identify key elements to consider when communicating Mathematics through hands-on activities in the Mexican context.

The negative perception about Mathematics present in the Mexican population has an origin in the affective domain, which is directly related to feelings, emotions, beliefs, attitudes, values, and appreciations that Mathematics can generate in people. This approach implies that both the design and implementation of hands-on activities require a strong affective dimension to be included in their development and evaluation, since the aims and goals of the activities will include cognitive and affective aspects.

In this paper we attempt to provide an overview of the elements that could be considered when designing and implementing hands-on Math activities, so it is possible to achieve the incorporation of criteria that take the affective dimension into account. With this, it is hoped to generate a significant change in perceptions and attitudes towards Mathematics, which could lead to a greater acceptance of Mathematics and a genuine interest in engaging in the world of Science.

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