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FROM THEORY TO ACTION

The collective adventure of science recreation clubs

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Science recreation, as a means of science outreach, has gained a lot of momentum over the last decades. Its greatest strength arises from the interactive essence that fosters rewarding experiences for the participants. However, this modality has lacked formal analysis to establish its fundamental characteristics and opportunities for advancement. The present work integrates the experience of more than 30 years in the development of science recreation activities with important analytical contributions, of the last years, to build a cutting-edge perspective of the field. To go further, it is articulated with the importance of the systematic work of clubs that achieve a deeper impact on the public. All this is rounded off addressing the case of the Children's Science Club, in Zacatecas, Mexico, to share learning and results of three decades of experience.

Keywords: **science recreation**, **science clubs**, **non-formal science education**, **children in science**, **science workshops**.

INTRODUCTION: THE IMPORTANCE OF PLEASURE IN SCIENCE OUTREACH

In a world where technology is constantly advancing and science plays a fundamental role in our lives, it is crucial to arouse interest and scientific curiosity in children and young people. However, the specialized language used by researchers can often make science intimidating, or even inaccessible, to those without specialized training in the field (Estrada, 2002). In addition to the complexity of jargon, school science sometimes is too restrictive: leading to «an attenuated presentation of science –one that is less authentic as well as less motivating» (Braund & Reiss, 2006).

«Science recreation activities appeal to people's innate curiosity and avoid mere memorizing of abstract concepts»

Here science recreation emerges as a powerful tool, within the range of public communication of science (Garcia-Guerrero et al., 2022), to open the doors of scientific knowledge in an accessible and entertaining way. Active participation, observation, experimentation and critical reasoning are encouraged to awaken passion for science. In this sense, important elements of the AEIOU model of the reactions sought with science communication activities are adopted (Burns et al., 2003): 1) *awareness*: make people aware that there is a scientific topic that they can learn about; 2) *enjoyment*: promote pleasurable experiences that motivate participants to engage in the process (and others like it); 3) *interest*: motivate people to find out more about the topic; 4) *opinion*: provide elements for people to form their own criteria in the issue at hand, and 5) *understanding*: ensure that participants grasp the topic in a relevant way with their reality.

The degree of progress in each point may vary, depending on the conditions of the public, but it is worth noting the importance given to pleasure as a

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motor for participation and learning; a coincidence between the AEIOU model and science recreation. In contrast to traditional teaching methods, these resources appeal to people's innate curiosity and avoid mere memorizing of abstract concepts.

In this article, we will explore the fundamentals of science recreation activities. Next, the value of the systematic work of science clubs will be addressed: first from a broad perspective and then with the experience of the Children's Science Club, in Zacatecas, Mexico. Ultimately, we will seek to provide elements to recognize how science recreation sparks a passion for scientific knowledge, to cultivate new generations of curious and creative citizens.

FUNDAMENTALS OF SCIENCE RECREATION

Modern science recreation activities have a practical trajectory of more than four decades with activities such as workshops, demonstrations and games (García-Guerrero & Lewenstein, 2022). However, only recently has their work been systematically studied. The concept of science recreation in a basic way is associated with the double meaning of recreation: as fun and as the social construction of a scientific concept in a non-specialized context (García-Molina, 2011; Lewenstein, 2013).

This conception provides a good starting point, but it is linked to other means of science outreach that also have an emphasis on fun. The advancement of science recreation requires a more solid conceptual base to build the paradigms, in the sense of Kuhn (1971), which serve as the basis for a practical and reflective professional community.

Gabrielson (2015) highlights the importance of putting hands into action, in experimental dynamics, carefully observing what happens; this leads to an experiential link with natural phenomena and scientific issues, in an authentic and personal way. And it is not about isolated participation, efforts are made to form groups –guided by a facilitator–, which explore natural phenomena in games in which people assume the role of scientific researchers (García-Guerrero, 2022).

Recently Recreación en Cadena, the Mexican Network of Science Recreation, promoted the creation of a «Manifesto» that establishes a more specific vision of the field (Garcia-Guerrero et al., 2022). After conducting a survey among its members, with several rounds of discussion and analysis, this network defined science recreation as the set of activities for the public communication of science that seek to develop exciting experiences, assigning a leading

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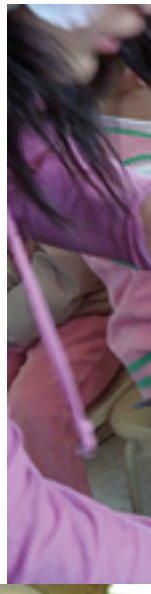
Above, participants of the Children's Science Club in 2009 witness a demonstration of what happens when you throw water into a burning liquid. The image shows three kids (black t-shirt on the left, white t-shirt and dark green hoodie on the right) that now are university students and collaborate as volunteers with the Quark Group.

«The possibility of moving freely and the use of easily available materials provide great versatility to science recreation activities»

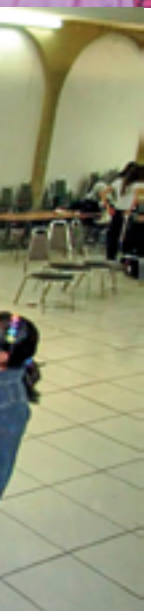


Under these lines, a former participant of the Children's Science Club develops an activity about the importance of skepticism with children of Jerez, Zacatecas, in 2010.

Grupo Quark

role to the participants. They are based on two essential axes: 1) Synchronous development of activities, with a direct and immediate interaction between mediators and participants. The interactions that are sought are: physical, intellectual, and emotional. In the first case, to build meaningful experiences, participants use different senses to obtain information directly from the phenomena addressed or from models that represent them. The second case implies a dialogue that allows mediators to identify the context of the people involved, helping establish a didactic strategy that adapts to their conditions. Finally, the last component calls for the use of narrative, dynamic, and creative resources to get people emotionally involved in the activity.

Grupo Quark



Above, children at a kindergarden in Zacatecas play in a recreational activity that uses a plasma ball to address the fourth state of matter. The facilitator is a former participant of the Children's Science Club, a law student that kept contact with science through the Quark Group (Picture taken in 2017).

«Putting hands into action leads to an experiential link with natural phenomena and scientific issues, in an authentic and personal way»

2) Construction of new interpretations of phenomena, concepts, controversies and scientific challenges, through pertinent reworkings for the public.

Three large distinctive elements appear: the emphasis on the participants as the central axis of the process, the temporal synchrony in the dynamics, and the interaction that involves people in an integral way. The contribution of Recreacion en Cadena offers a clear perspective of the essence of science recreation and, at the same time, elaborates a taxonomy of the different dynamics that includes workshops, demonstrations, talks, games and theater plays.

This range allows science recreation activities to venture into different settings (schools, museums, festivals and public spaces) to meet a wide variety of goals, depending on the context in which they work. The possibility of moving freely and the use of easily available materials provide great versatility to the activities, turning science recreation groups into a kind of guerilla for science outreach (García-Guerrero & Lewenstein, 2022).

THE SIGNIFICANCE IN THE CLUBS

Science recreation activities often manage to arouse interest, or even passion, for science and technology in the participants. This makes us wonder if there are spaces where the public can participate regularly in this type of activity. Burns et al. (2003) point out that «it is not just about producing attractive science events, many results of science communication have a personal and long-term nature». An isolated experience hardly results in a closer relationship with science, it is necessary to encourage constant encounters for it to flourish.

Here we understand clubs as programs that bring together groups of people with a common interest, who meet regularly to carry out activities related to that interest. Science clubs promote innovative learning processes: they leave the teacher-student relationship behind to promote teamwork. They adopt and adapt learning materials and activities to create interest in science by connecting participants with positive learning experiences and meaningful social interactions (Davis et al., 2023). These clubs seek to create an atmosphere in which participants feel comfortable to explore and try new ideas; one in which they have the guide to develop their own learning (Sahin, 2013). It is a model that fits within the communities of practice theory (Wenger, 1999): groups of people who share a passion for something they do and learn to do it better as they interact on a regular basis. This allows participants to develop skills through active participation.

The class concept is left aside, to carry out processes in the form of a workshop; integrating theory and practice, approaching science as a collective adventure in which there is constant participation:

> The implementation of science recreation activities in a constant and regular manner and giving them a formal follow-up, gives us many advantages. It is no longer an isolated task but a persevering work that becomes more effective through familiarization with the participants. (García-Guerrero, 2022, p. 149).

With this knowledge of the participants, it is easier to help them take ownership of the community of practice in which they are immersed. Thus, in accordance with the ideas of Blanco (2004) and Burke and Navas Iannini (2021), we can understand science clubs as programs that show science as something that is done instead of something that is only learned. It is understood that science and technology are far from being something finished: new questions and new problems appear every day, and participants realize that they can be the ones who solve them in the future.

Here we find one of the biggest assets of science clubs: providing their members with opportunities to build an identity as science participants (Burke & Navas Iannini, 2021), as they conduct activities that are meaningful and have a purpose (Behrendt, 2017) and communicate this sense of identity. Although activities are usually planned and developed by club leaders, or facilitators, they often connect with the participants and reveal what kind of activities can help to maintain their enthusiasm in the club (Burke & Navas Iannini, 2021). It is also important to have a place where they will interact with peers who will not mock them for enjoying science, helping them cultivate the joy of investigating mystery, while having fun (Behrendt, 2017).

Clubs show great potential to develop science recreation activities with long-term impact. Small (2016) states that a science club is a natural space to develop key skills according to the Framework for 21st Century Learning: creativity and innovation, critical thinking and problem solving, as well as communication and collaboration skills. Sahin (2013) highlights after-school programs for their potential to promote student learning and develop scientific literacy. Hartley (2014) points to science clubs as important vehicles for the communication of science and related careers.

In contrast to what happens at school, science clubs have the characteristic of attendance not being compulsory (Braund & Reiss, 2006); this means they must put special work into attracting participants, but also that those involved usually have a genuine interest in the activities. Starting with such motivation these programs have the potential to inspire interest and passion for science (Behrendt, 2017). While getting participants to pursue a career in science is often cited as an important objective (Behrendt, 2017), it might be even more important to help develop citizens with a scientific culture that helps them navigate an ever-changing reality that is heavily dependent on science and technology advances.

Grupo Quark

Participants of the Children's Science Club pose with David Gross, 2004 Nobel Laureate in Physics, after an interactive question and answer session during his visit to Zacatecas on 11 November 2023.

Based on the above, we can establish that science clubs allow us to aspire to a much deeper impact of science recreation on its participants. Of course, it is always useful to go from a general vision to the analysis of a specific case, to better understand the effect of clubs on their participants.

CHILDREN'S SCIENCE CLUB: THREE DECADES OF EXPERIENCE

The Children's Science Club (CSC) started working in 1990, as part of the activities of the Science Museum of the Autonomous University of Zacatecas, in Mexico, and has become its most successful initiative (García-Guerrero et al., 2022; Villareal, 1998). To

date, the CSC has had more than 1,250 participants, establishing itself as a true hotbed of science and technology for Zacatecas: internal records show that from its ranks we can find more than 150 students of scientific careers and 94 volunteers for science outreach.

The achievements of a program like the CSC do not appear immediately; they require systematic work, in which numerous challenges are faced and, along the way, innovations must be achieved to advance effectively. In the following paragraphs, we will discuss the CSC in four major stages that show its evolution.

First steps

The first CSC sessions were held with the idea of offering recurring recreational activities for local children. Initially, weekly sessions were held in which anyone could participate and soon after, the requirement to register was established to better monitor the participants. A small registration fee was established to help buy the materials for activities. At first, the program was run by Museum personnel: three people cared for between ten and fifteen children, aged between six and thirteen years. This first effort was essential to building a tradition: a constant venue was established where young people could go to participate in science recreation activities.

Participants were distributed in a couple of tables, there was a brief introduction on the issue to be addressed (for instance, chemical reactions), and afterwards they received the materials for the activity (a small plastic cup, baking soda and vinegar). Step by step, the Club's leaders gave instructions for what the children had to do (pour the baking soda into the cup, add the vinegar and watch what happens when they react). Finally, the process ended with an explanation of the phenomena at hand (a chemical reaction produces new substances, different from the original; in this case baking soda and vinegar transformed into carbon dioxide [a gas], water [a liquid] and sodium acetate [solid]). This kind of dynamic was repeated for three or four activities each session.

In 1995 the Museum promoted the creation of an outreach group made up of young volunteers. All eight members of this group were high school students and, coincidentally, one of them was a former CSC participant. Initially they worked with school groups, but at the beginning of 1996 the enthusiasm of its members led them to take charge of the CSC.

The new leaders refreshed the CSC, giving it more dynamism and organizing the sessions thematically. Previously, each week there were activities from different areas of science, which did not necessarily connect with each other. For example, you could put together a session about pressure starting with one activity addressing the concept of pressure as a force distributed into an area; a second one were you show how atmospheric pressure can stop water from falling from a glass turned upside down, with the help of a sheet of paper; a third activity could use a model of the lungs to see how we breathe; finally, participants put together a couple of suction cups to see how hard it is to defeat atmospheric pressure to get them separated. Each activity included ideas that would support the discussion in the next one. The new approach sought to give a certain coherence to the topics covered, so that the workshops would reinforce each other.

A new approach

At the beginning of 2001, the group of volunteers could not continue in charge of the CSC, so it was necessary to find someone to assume this responsibility. To that end, in September of that year a new outreach group was formed: Quark. In addition to giving continuity to the activities of the CSC, a symbiotic relationship with the Science Museum was established; leading to an impact on more than 150,000 people in science recreation activities in schools and special events.

Within the CSC, the permanence of its participants for several years was noted and the possibility of jumping to collaborate as voluntary science communicators began to be planned. Just as in the sports environment there are scouts that look for

outstanding abilities, the same is sought with the children of the CSC. Those who are most interested and committed are given the tools to collaborate in outreach. Since 2004, when the first successful jump was made, the 94 people who have moved to Quark have enriched the group with their work and perspective from «the other side».

Consolidation

The challenge of having a high rate of return in the CSC participants lies in permanently renewing the contents. With Quark, the annual programs have a general theme and each session a particular subtheme. Thus, each session can address a topic from different angles that give a broader picture.

In 2023, the CSC worked with the «Mitos Desmitificados» ('Demystified Myths') program to address issues that children have heard from people close to them, or seen in tv, movies or social media, thinking they are true (while being false) or the other way around. Sessions include themes as «I see it but don't believe it», «Vaccines», «Food myths», «Explosives» and «Superheroes». As an example of this last case, there were activities to show that gamma rays do not give people super powers and instead are really dangerous; that if Flash runs too fast, he would burn himself down because of friction; explore how Spiderman´s ability to adhere to walls might work, or what kind of properties Thor´s hammer would need in order to cause lightnings.

On average, six different workshops are held every Saturday, with a total of over 150 activities per year. Because of this work, there is a wide and growing catalog of activities. To leave evidence of them, and allow them to be replicated in other contexts, from its early years Quark developed systematizations with all the information on materials, questions, theory, methods, and explanations to carry out the workshops. As this work gained maturity, in 2011 the series of books «Para jugar con la ciencia» ('To play with science') was born, which to date has six books published and one more in the editorial process.

Digital transition

As it was the case around the world, the covid-19 pandemic was a milestone for Quark and the CSC. There was a transition to digital media, with the unprecedented challenge of doing remote science recreation activities, to start the second semester of 2020 with an online version of the CSC.

What do you take away from your participation in the Zacatecas Children's Science Club?

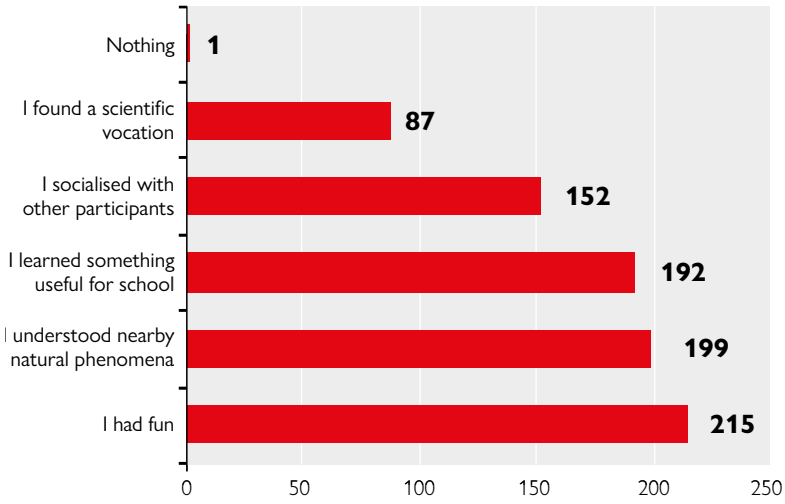


Figure 1. Respondents expressed they found several benefits from their participation in the Children's Science Club. The main one was having fun in the activities, which was probably an important factor for the continuity in their participation.

SOURCE: García-Guerrero et al. (2019)

After your experience in the Children's Science Club, would you like to get involved in science outreach projects?

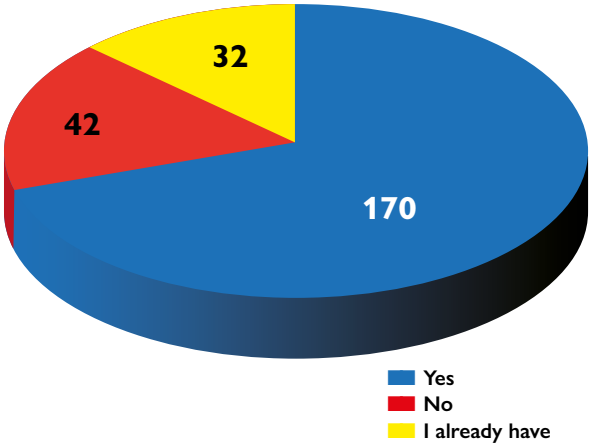


Figure 2. One important point of emphasis of the work in the Children's Science Club is motivating participants to establish an ongoing relationship with science, one that might lead to becoming agents of science communication activities. An important portion of respondents show interest in doing this.

SOURCE: García-Guerrero et al. (2019)

The parents of the participants received a list of material that they had ready for Saturday, when the children connected to a videoconference to develop the activities alongside the group. For one session, participants were asked to have a straw, a bowl filled with water, and dish soap, in order to form a cluster of bubbles that served as a representation of galaxy clusters in the universe. Throughout the activity, participants talked about structures in space from planets, planetary systems, galaxies, and so on. With this kind of dynamics, an attempt was made to maintain the aforementioned three levels of interaction.

The initial base of participants was local, but little by little foreign children joined until they became the majority (with the presence of up to 13 states of the country). Given this, at the end of the isolation and with the return of face-to-face activities, the decision was made to keep the online version of the club.

A BIT OF RESULTS

In three decades of work, the CSC has established itself as a benchmark for initiatives of its kind, which can be backed up with data. The great advantage is that there is a record of the participants who have gone through the program since Quark took over. With this information as a basis, in 2018 a follow-up study was carried out on the children and young people who were part of the CSC between 2002 and 2016 (García-Guerrero et al., 2019).

«Science clubs create interest in science by connecting participants with positive learning experiences and meaningful social interactions»

With responses from 244 subjects, 34.3 % of the total of 711 participants, evidence was found of an important characteristic of the CSC: the high rate of return. A total of 77.5 % of the people who responded participated in the program for more than a year and 36.5 % had a stay of more than 2 and a half years. Next, it is worth asking what the participants obtained from the activities and Figure 1 shows the answer to this approach. In this case, the participants were able to select all the options they considered true. Thus, 88 % of the study participants had fun with the activities, 82 % understood phenomena around them, 78 % learned things that were useful to them at school and 35 % found a scientific vocation. It should be noted that only one person stated that they had not obtained anything positive from the CSC.

Finally, it was sought to probe the interest of the participants in joining science outreach initiatives. In Figure 2, we appreciate that 13 % of the subjects have already participated in the development of some event of science communication; 70 % are interested in doing it; and only 17 % would not like to. This is a positive indicator of the foundation being built by the CSC, with children growing up wanting to be a part of outreach projects.

CONCLUSIONS: FROM SCIENCE CLUBS TO SCIENCE CAREERS

The CSC is a program dedicated to making science and technology a relevant part of the lives of its participants, using elements of science recreation to stimulate their participation in an active, curious, reflective, and critical way. Through its 33 years of existence it has managed to grow into a successful program, that could be briefly characterized through the eight key components of club management proposed by Davis et al. (2023):

1. Vision: Develop regular activities to help children and youngsters to enjoy and understand science in a safe community of practice.

2. Resourcing and funding: The main source of funding are the registration fees paid by the parents of participants, but the CSC has a scholarship program that ensures that no one is left out because of not being able to afford the fee.

3. Club structure: Participants are distributed into age groups that take turns to participate in the different activities of each session.

4. Facilitation: Science recreation activities for the CSC are designed, prepared, and developed by the volunteer members of the Quark Group.

5. Sustainability: The commitment of the Science Museum , the Quark Group facilitators, parents and participants, has allowed the CSC to keep growing over the last three decades. Currently, the club has 100 registered participants with an average attendance of 83 per session.

6. Professional development: The CSC provides the opportunity for older and committed participants to jump into the Quark Group, that provides training and permanent development for them to turn into volunteer facilitators. Also, Quark receives members from different backgrounds (high school and university students, mostly).

7. Safety: The wellbeing of CSC participants is the first priority of the program's organizers, that is why – in addition to people developing activities –, every

session there is a team of volunteers dedicated to registering the arrival of the children and youngsters, helping have additional caution whenever an activity requires a hazardous material, monitoring if someone feels ill or uncomfortable, and, finally, registering when participants leave.

8. Communication: Parents are the biggest supporters and allies of the CSC, that is why a fluid communication with them is of great importance.

The monitoring of children and young people has allowed the program to establish a community of practice that does not end with their participation in the CSC, but rather opens the doors to a path in science outreach and even to scientific-technological careers.

In this way, a virtuous circle is achieved in which the outreach work itself –over the years– allows the training of new generations of committed science communicators who will take science recreation much further qualitatively and quantitatively. More studies are still needed to achieve a deeper analysis of factors such as the motivation that generates the commitment of the participants, the background that encourages them to come to the CSC and the potential offered by the creation of new clubs in different settings. For now, we hope this discussion will serve as a catalyst for more Science recreation initiatives in clubs and the research that helps strengthen them.

«The Children Science Club of Zacatecas is a program dedicated to making science and technology a relevant part of the lives of its participants»

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