A JOURNAL BY SISSA MEDIALAB

PRACTICE INSIGHTS

Scaffolding in science mediation: a superhero-based educational initiative to explore how mediators support students' knowledge appropriation

Florence Vigneron, Cecile de Hosson and Muriel Guedj

Abstract

This practice insight examines how science mediators facilitate students' appropriation of scientific knowledge. It focuses on the Science of Superheroes initiative, which is an informal education curriculum activity designed to engage middle school students in exploring environmental challenges through the creation of a superhero. Using Bruner's scaffolding framework, we analyze how mediators' interventions shift between scaffolding functions, depending on the task. While the appropriation of scientific knowledge is supported by questioning and information-sharing strategies, the creative phase sees an increase in proposal-based scaffolding, which struggles to counterbalance students' reliance on magical thinking. This cognitive tension highlights the challenges of integrating scientific knowledge into a fictional narrative. Our findings highlight the need for science mediators to refine their questioning techniques, foster greater self-regulation among students, and enhance their ability to meaningfully incorporate scientific concepts into their superhero designs. Our study contributes to ongoing discussions on the professionalization of science mediation and offers new insights for mediator training.

Keywords

Popularization of science and technology; Science education

Received: 3rd April 2025
Accepted: 24th September 2025
Published: 11th December 2025

1 ▪ Introduction

In recent years, an increasing number of science mediation[1] initiatives have been implemented in the school context. Although these initiatives, which can be classified as informal education, are structured around learning environments, they remain distinct from conventional formal education, mainly due to the involvement of external science mediators rather than school-affiliated science teachers. Formal education is characterized by structured learning processes delivered within institutional settings, following standardized curricula, assessments, and pedagogical objectives [OECD, 2018]. In the context of science education, this corresponds to classroom-based instruction, where scientific knowledge is transmitted through a predefined academic framework [Osborne & Dillon, 2008]. Science outreach initiatives in schools fall under the heading of informal education, as they occupy an intermediate space between formal and informal learning [Johnson & Majewska, 2022]. While informal education does not focus exclusively on learning objectives, it does incorporate them into a more flexible approach.

Informal education takes place outside compulsory education and has objectives that intersect with intentional teaching and learning processes. Unlike formal education, it is not systematically assessed or credentialed, although it may complement formal curricula in contexts such as museums, science centers, or extracurricular workshops. Moreover, it offers participatory learning opportunities and promotes group activities that encourage dynamic and interdisciplinary engagement with scientific knowledge [Stocklmayer et al., 2010; Colardyn & Bjornavold, 2004].

Within the French context, informal science education relies on a diverse network of professionals, including institutional and non-profit actors who collaborate to make scientific knowledge accessible to a broad audience. Key players in the field include Centers for Scientific, Technical, and Industrial Culture (*Centres de culture scientifique, technique et industrielle*), science and technology outreach associations, together with educational and cultural institutions. However, defining the role of science mediators remains complex, as responsibilities and job descriptions vary depending on the institutional context. Rasse [2014] highlights this ambiguity, noting that while some scientists perceive mediators as mere "knowledge transmitters" [E., 1994; Chaumier & Mairesse, 2013], others see them as "agents of social change" [Hurstel, 1975]. Further complicating the definition, Chaumier and Mairesse [2013] emphasize that the profession takes on different forms depending on the structures in which science mediators operate.

Additionally, it is important to consider how the professionalization of science mediators has evolved. Recent data from the French ReMédiS 2023 survey reveals that 90% of science mediators hold a master's degree or higher (mainly, but not exclusively, in science), with 30% holding a PhD [ReMédiS, 2023], reflecting the increasing specialization and disciplinary expertise in the field [Richard & Chevalier, 2023]. However, while a solid understanding of scientific knowledge is essential, it is not necessarily sufficient to fulfill the role of a science mediator, just as strong scientific knowledge alone is not enough to be an effective science teacher. Furthermore, according to the ReMédiS report, many science mediators are calling

1. In this paper, we use the English translation "science mediation" of the French expression *médiation scientifique* to refer to science dissemination initiatives. The actors who engage in these mediations, and who are responsible for the dissemination of scientific knowledge, are referred to as "science mediators".

for specialized training tailored to their profession. Despite this concern, there is a lack of such training, at least in France.

In this context, we hypothesize that a better understanding of the dynamics of science mediation activities could provide valuable insights to inform discussions on the training needs of future science mediators. For example, training programs could focus on how to formulate and communicate scientific knowledge in ways that are both accessible and intellectually rigorous, suited to diverse audiences, and adapted to diverse contexts and constraints. The case study presented here is founded on this hypothesis. The aim is to characterize the choices made by science mediators within the framework of the informal *Science of Superheroes* initiative, developed by the non-profit organization *Instant Science*.[2] The term *choices* refers to choices related to scientific knowledge. Specifically, this practice insight explores the following overarching research question: How do science mediators support the integration of scientific knowledge within the *Science of Superheroes* initiative? This question is approached through two complementary angles:

a) What scaffolding functions are mobilized by mediators at different stages of the activity, and how do these functions align with the nature of the tasks?

b) What traces of these scaffolding interventions can be observed in students' final productions, as indirect indicators of their appropriation of scientific knowledge?

This second line of inquiry is based on the assumption that student productions can reflect, albeit partially and indirectly, how scientific knowledge has been appropriated and mobilized in the creative dimension of the task.

We begin with a detailed presentation of the *Science of Superheroes* initiative. Next, we outline key findings from previous research in science education and communication focused on science mediation activities and, more broadly, initiatives aimed at disseminating scientific knowledge. This review establishes the theoretical background that frames our study and clarifies our research questions. Then, we present our methodology for collecting and analyzing empirical data, before discussing our key findings drawn from two examples. Our analysis highlights both the successes and challenges of the initiative and helps to understand their underlying causes. Finally, we propose avenues for improving this mediation effort, from both a training perspective and in terms of scientific knowledge dissemination.

Our study presents a significant methodological challenge: identifying appropriate tools to capture the epistemic dimension of science mediation, i.e., aspects related to scientific knowledge that help reflect on the nature of science. Consequently, another key objective is to provide the community of researchers in science education and communication with a methodological framework for investigating knowledge dissemination initiatives in informal contexts.

2 ▪ The *Science of Superheroes* project

The *Science of Superheroes* project is an informal science education initiative by *Instant Science*, part of the French Artistic and Cultural Education Pathways program (Le parcours d'éducation artistique et culturelle). Designed for middle school students, the project aims to

2. https://www.instantscience.fr/.

engage them in scientific and environmental issues through the creative process of designing superheroes. Topics covered include plastic pollution, oil spills, bee colony collapse, light pollution, air pollution, drought, and wildfire. These complex issues share several characteristics: they have global repercussions and affect both ecosystems and human populations; they pose serious threats to human health and biodiversity; and they are largely anthropogenic, stemming from industrial, agricultural, and urban activities. By exposing students to these challenges, the project aims to develop their scientific literacy and encourage them to take an active role in discussions about the relationship between science and society.

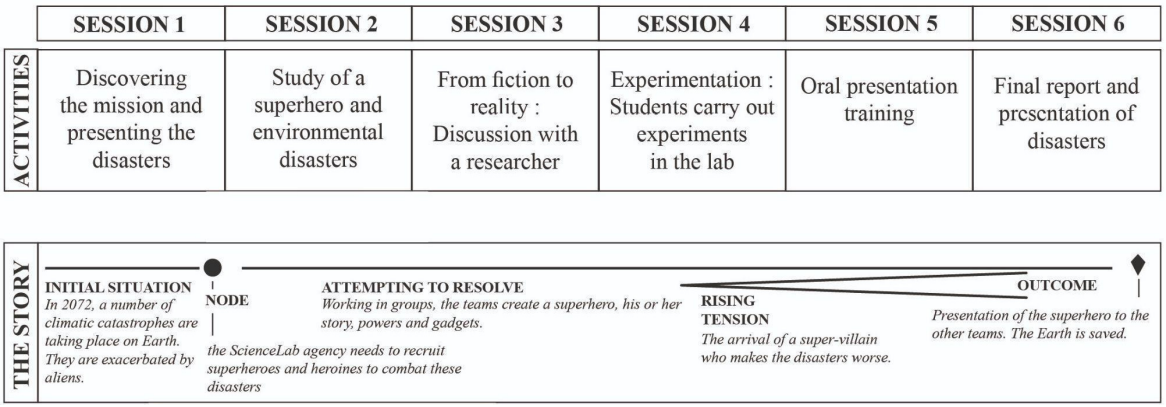


Figure 1. Overall structure of the mediation program showing details of the six sessions.

The initiative consists of six, two-hour sessions conducted during regular school hours (Figure 1). During these sessions, students work in groups of four, and each group is tasked with developing one or more strategies to mitigate the impact of an environmental disaster. Their first objective is to familiarize themselves with the selected disaster and understand both its scientific and environmental implications. This process is supported by two science mediators (Session 1) and enriched by a guest lecture from a researcher specialized in the relevant scientific domain (an entomologist specialized in bees, an ethologist, a materials scientist, and a meteorologist). The purpose of these interventions is to enhance the scientific depth of the project, while exposing students to real-world scientific inquiry (Session 3).

Each group is then asked to conceptualize a superhero, whose attributes and characteristics serve as mechanisms to counteract the ecological consequences of the disaster. This creative phase is guided by the mediators, who ensure that the superhero's story, traits, and abilities integrate scientific knowledge related to the disaster, and/or strategies for mitigating its effects (Sessions 2 and 4). In Session 5, the group prepares a public presentation, which they deliver in the final session (Session 6). Figure 2 illustrates a typical recorded session.

3 ▪ State-of-the-art: linking educational and communication research with informal science education

While there is an extensive body of science education research that has analyzed how knowledge is framed, transmitted, and appropriated by learners in formal school contexts, fewer studies have investigated knowledge dissemination in science mediation initiatives or, more broadly, in public science engagement discourses [Guenther & Joubert, 2017]. This gap

Figure 2. Overview of the mediation structure. Credit: Florence Vigneron.

is particularly striking given that informal science mediators have expressed the need for research that could inform and refine their practices [ReMédiS, 2023]. One of the main challenges is the lack of a methodological framework for the study of informal education. This challenge is accentuated by the absence of standardized assessment tools for evaluating learning outcomes.

In a comprehensive review, Davies et al. [2021] explore how national contexts and media formats shape science communication practices, particularly on social media platforms. The latter authors note that since the 1980s, science communication has evolved into a professional practice, an educational program, and a multidisciplinary research domain [Gascoigne et al., 2010]. Further evidence of this expansion is found in a Special Issue of the *Journal of Science Communication* [Fischer et al., 2024], which emphasizes the importance of developing collaborations between practitioners and researchers working in the field. As the issues to be addressed become increasingly complex (environmental questions, biodiversity, health, energy, etc.), these collaborations are considered essential in order to ground science mediation in solid theoretical foundations and empirical evidence.

Symmetrically, the editorial of the JCOM special issue "Connecting Science Communication Research and Practice" [Fischer et al., 2024] highlights the importance of research focused on mediation contexts. This perspective is supported by other studies exploring the complexity of mediation practices [Davis et al., 2018; Han & Stenhouse, 2014; Brossard, 2013; Scheufele, 2022]. As observed by Trench [2017], increased interest in science communication, and the availability of funding has led to the expansion of the professional community. However, Anjos et al. [2021] caution that science mediators may lack access to

current research due to time constraints and the limited availability of academic publications, a concern echoed by the French *L'École de la Médiation*[3] and the ReMédiS study on science mediators' professional profiles [Richard & Chevalier, 2023].

Museum-based research has also contributed to understanding science communication through the lens of scientific knowledge and visitor interactions. The work of Achiam and Marandino [2013] explores theoretical frameworks for improving museum-based science communication, drawing on concepts from science didactics and cognitive sciences. Their study, *A Framework for Understanding the Conditions of Science Representation and Dissemination in Museums* (2014), applies the didactic co-determination framework [Chevallard, 1991] to the design of science exhibitions, and provides valuable theoretical insights into how museums mediate scientific knowledge.

Taken together, these studies highlight the interdisciplinary and evolving nature of science communication research, and the need for tailored methodologies that can bridge educational science, communication research, and informal science education [Johnson & Majewska, 2022]. Our study is positioned in this underexplored research space. The aim is to contribute to the development of methodologies that can capture the diversity of science mediation practices and ultimately address both academic and professional needs in the field. We are specifically interested in the superhero as a medium for the restitution of scientific knowledge within an informal education initiative.

4 ▪ Theoretical framework and research questions

Our analysis focuses on science mediators. In particular, how their interventions facilitate (or hinder) students' appropriation of scientific knowledge related to environmental disasters, and its integration into the creation of a superhero. We draw upon Bruner's concept of scaffolding [Bruner, 1974] as it emphasizes the role of an instructor or facilitator. Here, the science mediator structures learning experiences that aim to gradually make students more autonomous, which support them in completing a difficult task and limit barriers to acquiring new competencies.

The mediators who participate in the *Science of Superheroes* initiative provide different levels of guidance, ranging from introducing scientific concepts and facilitating discussions (Sessions 1 and 3), to actively shaping the creative processes (Sessions 2, 3, and 4). The guidance they provide is aligned with the scaffolding framework. Specifically, they continuously adjust their interventions as students' understanding evolves, thereby ensuring that the scientific knowledge embedded in the superhero narrative remains both accurate and meaningful. By applying this framework, we seek to examine how mediators' choices and strategies influence the appropriation and transformation of scientific knowledge and identify key elements of effective mediation.

Bruner describes scaffolding as the process of reducing the degrees of freedom in task execution so that the child can focus on mastering the difficult skill they are acquiring [Bruner, 1978]. Scaffolding refers to the temporary support provided by a teacher, peer, or educator to help a learner complete a task that is beyond their current level of competence. Support is gradually withdrawn as the learner gains proficiency, promoting autonomous knowledge acquisition. Bruner identifies the following six, key functions:

3. https://www.estim-mediation.fr/.

Task commitment — Engaging the learner's interest

Difficulty reduction — Simplifying the task by breaking it into manageable steps.

Maintaining orientation — Helping learners stay focused on the task's objectives.

Highlighting critical features — Drawing attention to key aspects of the task.

Frustration control — Providing support to minimize frustration and errors.

Demonstration — Showing the learner how to perform specific components of the task.

Against this background, the present paper focuses on the following research question: How do the scaffolding functions implemented by mediators in the *Science of Superheroes* initiative support students' appropriation and transformation of scientific knowledge?

5 ▪ Data collection and analysis

5.1 ▪ *Data collection*

Our case study is based on the observation of the *Science of Superheroes* workshops conducted within the regular school timetable, in two lower secondary schools in southern France. Six sessions were held in standard classrooms and involved entire mixed-ability classes. Although the activity was external to the official curriculum, in the sense that it was not part of a formal science education program, it was fully integrated into school hours and received institutional approval. We therefore characterize it as informal education conducted in a formal setting. As mentioned above, the project was led by the association *Instant Science*, whose mediators facilitated the workshop. In addition, a researcher specialized in the relevant environmental topic participated in one of the sessions, providing a short talk and interacting with students. This involvement was made possible through a dedicated partnership between the schools and the association.

The workshops analyzed in this study were facilitated by two female science mediators. One holds a Master's degree in natural sciences, and the other a Master's in science communication. Both have received short-term training in science mediation (approximately 20 hours each) and are employed full-time by the association *Instant Science*. At the time of the study, one had been involved in the program for three years, and the other for one year. In addition to leading the sessions, both mediators participated in the co-design of the workshop.

Data were collected from the following sources (Figure 3):

- Session preparation documentation created by the science mediators.
- Audio and video recordings of the six sessions, with the explicit agreement of all participants (students, mediators, and scientists).
- Verbatim transcripts of excerpts from the recordings.

Lavalier microphones were used to record interactions between science mediators and students. These recordings were anonymized and transcribed with Transana software [Woods, 2019].

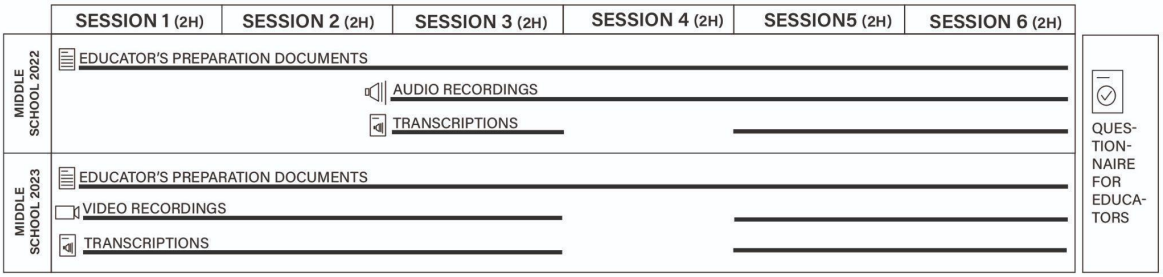


Figure 3. Classification and chronology of data collection in 2022 and 2023.

Table 1. Correspondence between scaffolding functions [Bruner, 1978] and semantic markers [Marzin-Janvier, 2015].

Scaffolding Function [Bruner, 1978]	**Semantic Markers of Scaffolding Strategies [Marzin-Janvier, 2015]**
Task commitment	Questioning, Agreement
Difficulty reduction	Exemplification, Introduction of information, Reformulation, Proposal
Maintaining orientation	Rule reminders
Highlighting critical features	Exemplification, Proposal, Rule reminders
Frustration control	Support, Rule reminders
Demonstration	Proposal, Exemplification

5.2 ▪ *Data analysis*

Our analysis relies on transcriptions of the six mediation sessions. Our analytical framework aligns each of Bruner's six scaffolding functions [Bruner, 1978] with semantic markers from Marzin-Janvier's [2015] classification. The aim is to identify discursive strategies through which each scaffolding function is enacted in the mediators' discourse (see Table 1). We also seek to identify students' reactions to these strategies, in terms of the appropriation and inclusion of scientific knowledge.

In practical terms, *task commitment* is reflected in the ways mediators engage students and sustain their interest in the project. This is achieved through questioning strategies designed to stimulate curiosity and involvement. *Difficulty reduction*, which consists in breaking down complex tasks into manageable steps, is primarily enacted through the introduction of information, proposal, reformulation and exemplification. *Maintaining orientation* ensures that students remain focused on the objectives of the activity. It is achieved through the rule reminders strategy that refers to verbal interventions in which the mediator explicitly restates the rules, constraints, or expectations of the task, often to redirect students' proposals toward greater scientific consistency. Similarly, *highlighting critical features* helps scaffold students' creative choices, and ensure that their superheroes embody relevant scientific mechanisms that address the selected environmental challenges. It relies on exemplification, proposal, and rule reminders. *Frustration control* aims to maintain students' motivation and confidence and is enacted through rule reminders and support strategies. Finally, *demonstration* is enacted through exemplification and proposal.

Transana tracks scaffolding strategies over time and quantifies their frequency during specific tasks. In each step of our iterative analysis, we select the most relevant scaffolding strategies (relative to the specificities of each class) and observe interactions during all six sessions. Once these scaffolding strategies are identified, we measure their frequency and examine their impact on students' commitment to engage in scientific concepts. This approach allows us to explore the relationship between task design and scaffolding strategies, and pinpoint moments where the mediators' interventions play a crucial role.

We illustrate our analytical approach with an excerpt from a session transcript, supported by images that capture the mediators' and students' gestures and spatial position. In this activity, students participate in a brainstorming exercise to generate associations related to their assigned environmental challenge. The following exchange takes place in a group working on the *bee colony collapse* scenario:

> *Mediator:* Now, I don't know if you remember, but earlier the entomologist told us about an extremely interesting bee-fighting technique. And given that you have a trio of superheroes… → **proposal**
>
> *Entomologist:* Yes
>
> *Mediator:* Does that give you any ideas? → **questioning**
>
> *Student 2:* Ah.
>
> *Mediator:* What were they? What do bees do with Asian hornets? → **questioning/ reformulation**
>
> *Student 1:* like this *(moves his hands very fast)*
>
> *Entomologist:* You're getting there… → **agreement**
>
> *Mediator:* I don't know, does that make sense to you? → **questioning** Good → **support**, so you have your fighting technique, inspired by Asian bees. → **proposal**

In this short extract from a dialogue involving a mediator, an entomologist, and two students, we observe four scaffolding strategies: proposal, questioning, agreement, and support. The interaction highlights how scientific input is reactivated and integrated into the students' fictional project through a combination of prompts and encouragement.

We identify and categorize each scaffolding strategy, for each transcript. Then, for each session, we count the number of scaffoldings in each category. The aim is to evaluate which scaffolding strategies are more prevalent, as a function of the task given to the group. In this paper, we focus on two phases of the project: students' exploration of the environmental disaster (scientific task, Session 1); and the design of superpowers, and the development of the superhero narrative (creative task, Sessions 2 and 4). These phases are explored for two groups: one focused on bee colony collapse, and the other on the tsunami of plastic. By analyzing pivotal moments, we seek to uncover the interactional dynamics at play, their role in students' engagement with scientific challenges, and their incorporation into their superhero designs.

6 ▪ Findings

Figure 4 shows the distribution of scaffolding strategies used by mediators during two key stages of the workshop: the appropriation of the environmental disaster (on the left), and the construction of the superhero (on the right), both based on the "collapse of bee colonies" scenario. A number of differences emerge between these two phases. While the questioning strategy remains dominant and stable across both, we observe a notable decrease in the use of agreement and introduction of information in the superhero construction phase. This indicates that mediators did not withdraw their support but rather reoriented it by relying more heavily on questioning to maintain students' cognitive engagement.

Interestingly, this shift is not synonymous with reduced scaffolding. On the contrary, two new strategies appear, rule reminders and exemplification, which were not observed during the initial phase. This suggests a reconfiguration of the mediators' scaffolding: they move from supporting the comprehension of scientific and environmental issues through validation and input, to maintaining an epistemic framing of the creative process through more indirect means. In this second phase, mediators seem to promote students' autonomy while also ensuring that the fictional elements of their superheroes remain anchored in scientific reasoning. These observations support the idea of a flexible scaffolding model, adjusted to the evolving cognitive and creative demands of the task.

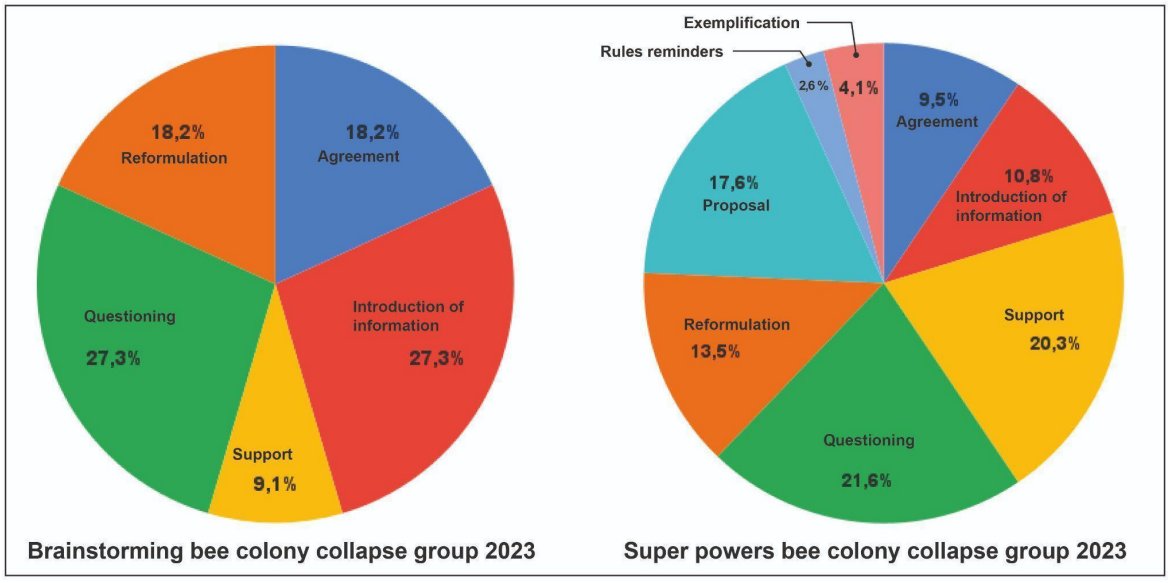


Figure 4. Comparison of scaffolding strategies used by mediators in scientific and creative tasks. The bee colony collapse group (2023).

Figure 5 presents the same analytical framework applied to a different group of students working on the "plastic tsunamis" scenario. Here, the shift in strategy between the two phases is even more pronounced. The agreement strategy, present during the initial brainstorming session, disappears entirely during the superhero construction phase. Instead, mediators rely more explicitly on rule reminders and proposals, while the proportion of questioning decreases. These shifts suggest a change in posture: mediators are no longer supporting open-ended exploration but rather guiding the group toward convergence and task completion through more directive scaffolding.

This comparison suggests that the scaffolding functions employed by mediators during the creation phase are primarily oriented toward keeping students aligned with task requirements. It also highlights the role of scaffolding in helping students manage their frustration when they struggle to meet expectations, which, in turn, requires demonstrative efforts from the mediators. In contrast, the strategies identified during the disaster appropriation phase indicate that the scaffolding interventions are mainly aimed at engaging students in understanding the scientific and environmental issues around bee colony collapse. At this stage, there appears to be no need to encourage them to remain focused on the task, as their engagement is naturally driven by the exploration of the issue.

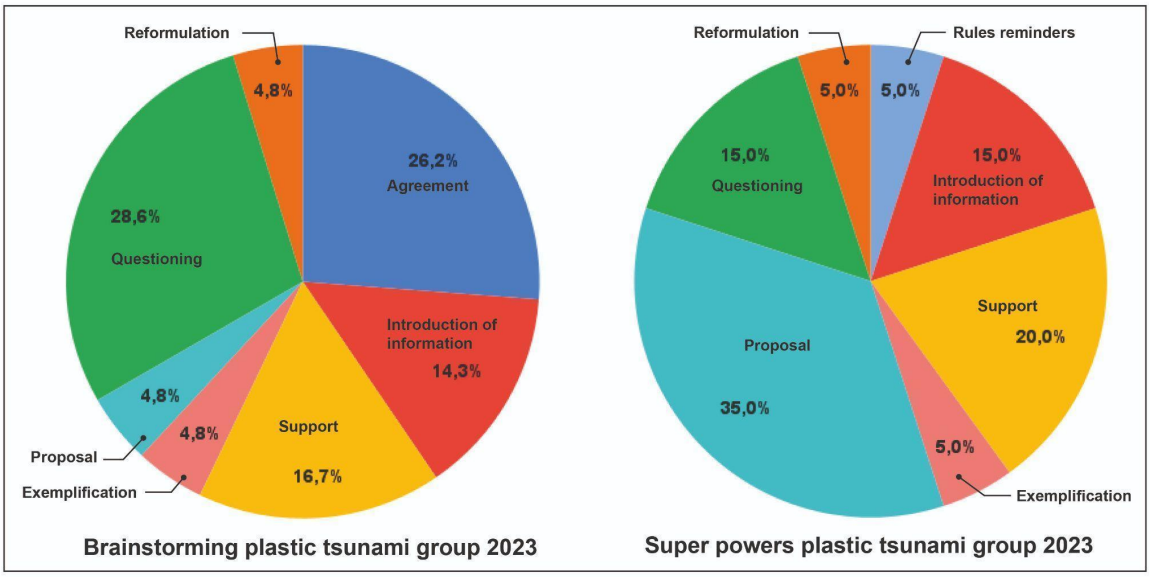


Figure 5. Comparison of scaffolding strategies used by mediators in scientific and creative tasks. The tsunami of plastic group (2023).

7 ▪ Interpretation

The differences in scaffolding strategies identified in the previous section can be explained, at least in part, by the nature of the activities assigned to the students. In Sessions 1 and 3, the tasks primarily involve interpreting scientific and environmental phenomena, such as the collapse of bee colonies or the proliferation of plastic waste. Although students are invited to take the lead in this interpretive process, their reasoning is continuously supported and structured by mediators. The scaffolding observed at this stage is marked by a recurring combination of *questioning*, *agreement*, and *introduction of information*, aimed at progressively constructing a shared understanding without requiring students to project their ideas into fictional or applied contexts. This dynamic is illustrated in the following excerpt, drawn from a group working on the bee colony collapse scenario:

> *Mediator:* What could be causing the disappearance of bees? → **questioning**. Why are they disappearing? → **questioning**
>
> *Student 1:* Uh, Asian hornets.
>
> *Mediator:* For example → **agreement**. That's a good example → **support**. Hornets that

attack bees. And they came here because humans brought them here originally, hornets didn't used to live here → **introduction of information**

Student 1: In Asia.

Mediator: Exactly → **agreement**. Do you have another explanation? Why else might bees be disappearing? → **questioning**

Student 2: Ah, because of humans.

Student 1: Because of destruction → **agreement**

Mediator: It could be deforestation → **introduction of information** absolutely → **agreement**

A similar scaffolding pattern is found in another group's discussion of the "plastic tsunamis" scenario:

Mediator: So what happens, then, if plastic ends up everywhere? → **questioning**

Student 4: Well, it causes pollution.

Mediator: Exactly → **agreement**. The fact that plastic ends up all over the place can lead to environmental pollution, especially in the oceans → **introduction of information**. Yes, for example, haven't you ever seen plastic on the beach? → **questioning**. Sometimes there are days when there's plastic on the beach, and that plastic ends up in the ocean, and it can have consequences → **introduction of information**, a negative effect on what, or on whom? → **questioning**

Student 4: Turtles.

Student 5: Marine animals.

Mediator: Marine animals, for example → **agreement**

Student 4: They confuse it, and eat it.

Mediator: Exactly… → **agreement**. So what do the turtles confuse it with? → **questioning**

Student 4: They confuse plastic with jellyfish, they think it's jellyfish.

Mediator: Yes, that's right → **agreement**. That's one of the negative consequences. And so, with ocean currents, all that plastic can end up…All that plastic gets carried to the same place and then we end up with… → **introduction of information**

Student 5: A plastic tsunami.

Mediator: A plastic tsunami → **agreement**, very good → **support**

In both cases, the mediator adopts a structured and responsive posture: guiding students through a chain of reasoning, validating their contributions, and enriching the discussion with targeted informational input. These interactions are neither rigidly directive nor purely exploratory; instead, they follow a recursive scaffolding loop (as illustrated in Figure 6), where each mediator intervention builds on the students' previous answers to deepen their understanding. This model of scaffolding supports a dynamic of sustained inquiry and progressive knowledge construction. Similar mechanisms can also be observed during the

intervention of the invited scientist, further reinforcing the consistency of this pedagogical approach.

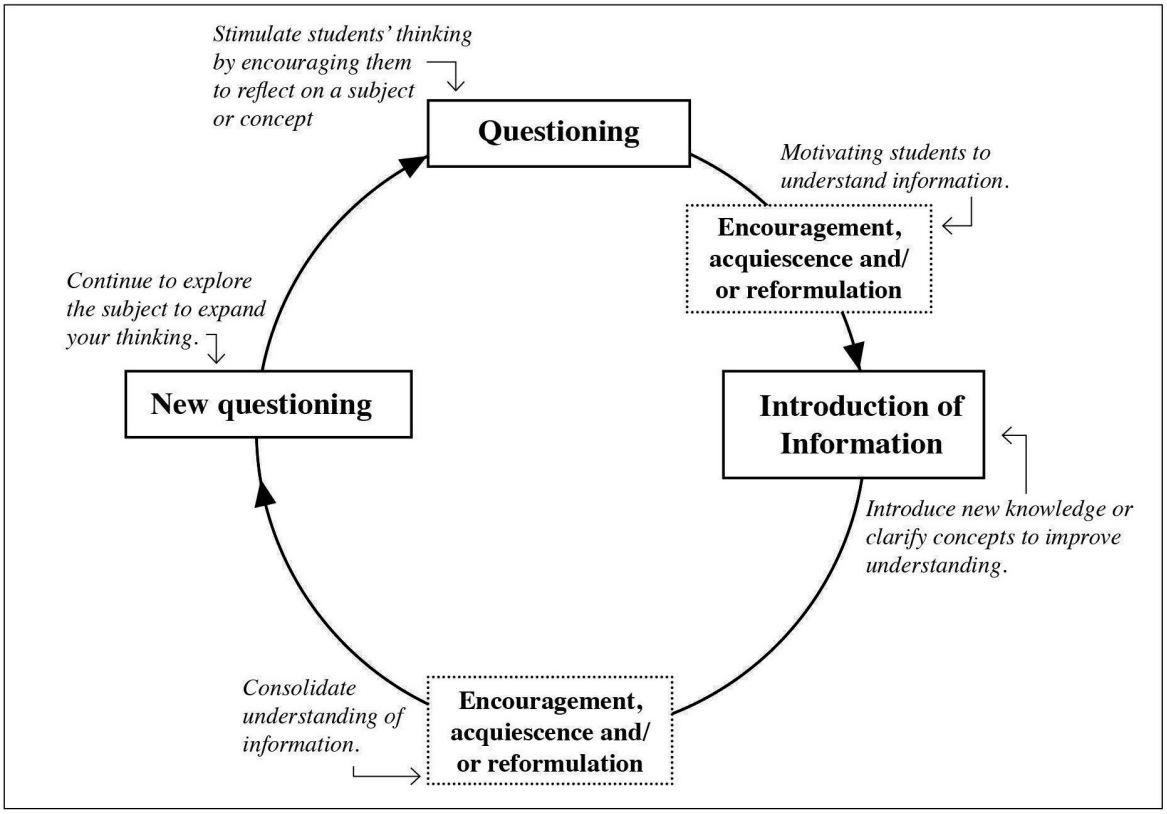


Figure 6. Recursive cycle of scaffolding observed during the ownership phase of the *Science of Superheroes* mediated activity. Credit: Florence Vigneron.

A different scaffolding dynamic emerges in the second phase of the activity, which focuses on creative production, in particular, the development of a superhero intended to address the environmental issue previously explored. Unlike the brainstorming phase, which primarily mobilized *questioning*, *agreement*, and *information input* to support scientific reasoning, this creative stage is marked by a reconfiguration of scaffolding strategies. Mediators continue to support students, but the nature of their interventions changes significantly: *proposals* become much more frequent, often accompanied by *exemplifications*, *support*, and *rule reminders*. These interventions aim to help students maintain the internal coherence of their narrative while preserving links with the scientific material previously discussed. This shift is visible, for instance, in the following excerpt, where students describe the characteristics of their superhero designed to combat bee colony collapse:

> *Student 1:* So, in real life, she's in high school, she's studying architecture (…)
>
> *Mediator:* Why is she studying architecture? → **questioning** How could becoming an architect be useful to her? → **questioning**
>
> *Student 3:* Uh…
>
> *Mediator:* Actually, it could also help with the bees… → **proposal**
>
> *Student 2:* Yeah, for biodiversity, buildings have trees inside them (…)

Mediator: We talked about architecture studies when the scientist came. Many buildings are inspired by nature… → **introduction of information** for example, in terms of air circulation, to better protect the people inside → **exemplification**. So you can use that to support your argument. → **proposal**

Student 1: We could say she wants to be an architect later to create, um… eco-fri… um…

Mediator: Eco-friendly, yes! — agreement That's exactly what I'm asking you to do → **rule reminder**. For each step, you need to be able to explain the choices you've made → **rule reminder**. Your decisions are excellent → **support**, you just need to explain them, okay? Okay? → **rule reminder**

A quite similar pattern is found in the group working on the "plastic tsunamis" scenario. Here too, the mediators mostly rely on *proposals* and *support* to help students elaborate a scientifically grounded, yet imaginative, solution:

Mediator: So once your hero has vacuumed up the plastic, what does he do with it? → **questioning** Couldn't he transform the plastic into something useful? → **questioning + proposal**

Student 4: Actually, since we're in Algeria, we wanted to transform the plastic and then give it to poor people…

Mediator: Ok. → **agreement**

Student 4: So then Mediator 2 told us we could make energy…

Mediator: For example → **support**, energy is what powers electricity, it's what allows us to produce things… → **proposal**

Student 4: That's what I said, and then she said we should make something that doesn't pollute.

Mediator: Oh yeah, that's important, definitely → **support**. It could be renewable energy. → **proposal**

Student 5: What's that?

Mediator: Renewable energy is energy that doesn't pollute, exactly → **introduction of information**. For example, with wind turbines or solar panels, we produce renewable energy. We use something natural, like wind or sunlight, and we transform it into energy that we can use. → **exemplification**

Student 5: So basically, what we'll do is use plastic to turn it into energy… how?

Mediator: Into renewable energy. → **agreement**

Student 5: Renewable, and then we'll give it to poor people, to provide them with electricity, gas…

Mediator: I think that's a really good idea. → **support**

These excerpts show that, in this phase, scaffolding becomes more orienting and adaptive. Mediators aim to foster narrative plausibility while supporting students' ownership of their creative ideas. The use of *proposals* is particularly notable, allowing mediators to offer

suggestions without taking over the creative process, while *rule reminders* serve to maintain the task's epistemic framing.

However, across all groups, this phase also sees the emergence of a recurring difficulty: the tendency to rely on magical solutions. These are narrative shortcuts that bypass scientific constraints in favor of immediate, omnipotent effects. One clear example appears in the group working on the bees scenario, when students describe a pesticide-neutralizing gadget:

> *Mediator:* Okay, so for the third function, you proposed that it removes chemicals and replaces them with a healing agent → **reformulating**. How does it work? → **questioning**
>
> *Student 1:* Well…
>
> *Student 2:* It's a button, you just press it.

Here, scaffolding appears to have limited immediate impact on the integration of scientific knowledge. Students simplify complex issues, such as pesticide degradation or energy conversion, into instant, effortless outcomes. Other examples include ultra-powerful vacuum devices that eliminate all plastic waste from the oceans in a single gesture. Despite the mediators' efforts to adapt their scaffolding, by multiplying proposals, emphasizing scientific plausibility, and frequently reminding students of the rules of the game, these "magical solutions" often persist. They suggest that fictional creativity may sometimes resist epistemic constraints, highlighting the challenge of maintaining scientific coherence within imaginative storytelling.

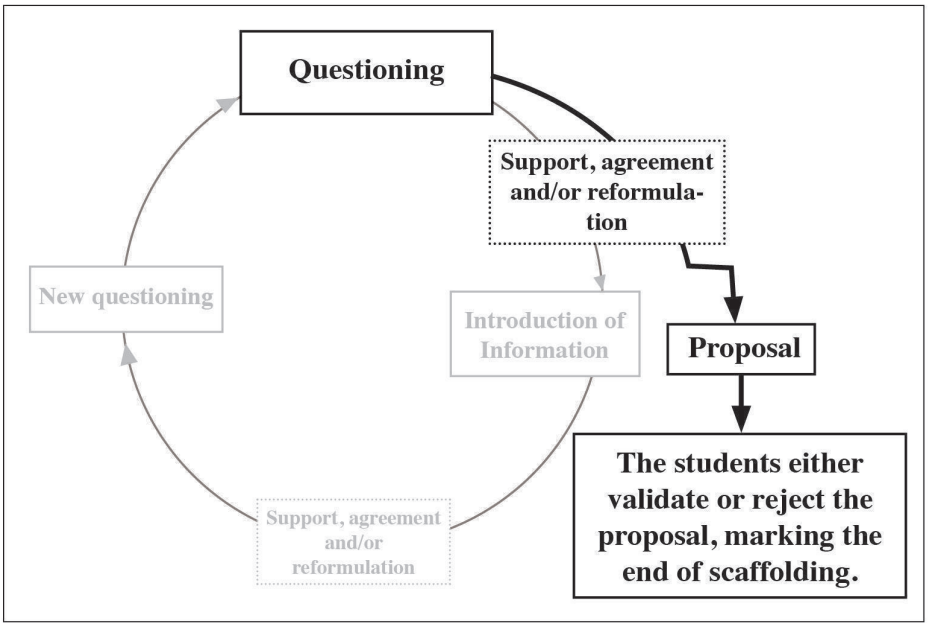


Figure 7. Interruption of the cycle by propositional scaffolding in the *Science of Superheroes* mediation initiative. Credit: Florence Vigneron.

Our analysis highlights the ability to adapt scaffolding strategies to task objectives. While scientific discussions rely on a questioning-feedback cycle, creative activities require mediators to propose connections between scientific knowledge and fictional elements, to

deepen students' conceptual understanding in their superhero designs. In creative tasks, although mediators adjust their scaffolding to help students integrate scientific knowledge into their fictional storytelling, it is ineffective. It is as if creative and fictional dimensions overwhelm the scientific dimension (see figure 7).

One possible interpretation of this difference lies in the intrinsic characteristics of the superhero figure. As noted above, initially, students tend to resort to the most radical solution, simply eliminating the cause of the disaster. In doing so, they do not rely on scientific reasoning but instead invoke the superpowers of their superheroes. This tendency, which is directly linked to the inherent nature of the superhero figure, diverts students from the intended learning objectives. This, in turn, can explain the shift in scaffolding strategies used by mediators, as they seek to prevent the superhero creation process becoming a dead end.

In fact, the superhero figure appears to activate a cognitive process similar to what Piaget [1926] describes as magical thinking. *Magical thinking* can be defined as the tendency to rely on intuition rather than rational analysis [Subbotsky, 2010; Gardair, 2014]. The concept is aligned with dual-process theories of cognition, particularly the two-system model proposed by Kahneman [2012]. According to this framework, System 1 is fast, intuitive, and automatic, while System 2 is analytical, effortful, and engaged in scientific reasoning. We follow Gardair [2014], who conceptualizes magical thinking as a key component of System 1, favoring simple, intuitive solutions over complex, evidence-based reasoning. Developmental psychology also provides insights into the role of magical thinking. In adults, it manifests as a preference for pragmatic, rapid solutions, often leading to a simplification, or distortion of reality to meet immediate needs. In the superhero creation process, magical thinking is activated as students construct their characters' abilities, often bypassing scientific constraints in favor of instantaneous, all-powerful solutions.

These findings allow us to address our first research question — What scaffolding functions are mobilized by mediators at different stages of the activity, and how do these functions align with the nature of the tasks? The scaffolding functions mobilized by mediators vary according to the phase of the activity. In the initial stages, focused on students' appropriation of scientific content, mediators primarily support conceptual clarification through questioning and informational input. In contrast, the superhero creation phase introduces a tension between scientific consistency and narrative engagement. Faced with students' growing investment in the fictional dimension, mediators adapt their strategies, relying more on proposals, exemplification, and rule reminders, to help anchor creative ideas in scientific reasoning. This shift reflects an effort to maintain epistemic continuity in a context where the fictional frame can easily take precedence over disciplinary knowledge.

To address our second research question — What traces of these scaffolding interventions can be observed in students' final productions, as indirect indicators of their appropriation of scientific knowledge? We examined the content of the posters produced by students in Session 6 of the workshop. Each poster included a drawing of the superhero, a short description of their origin story, and a presentation of their powers. For the two groups considered in this article, these productions are presented in Figures 8 and 9.

In both cases, the posters reveal traces of scientific content initially discussed during the workshop and provide insight into how students appropriated and mobilized this knowledge (see also Al Khatib and Gacogne [2018], on the concept of appropriation in mediation practices). For instance, the character BeeMan, created to address the collapse of bee

Origin: BeeMan's family was forced to leave their planet due to the disappearance of bees. This ecological disaster led to the collapse of plant life and a resulting famine, which forced them into exile. Once on Earth, BeeMan realizes that a similar catastrophe is looming. He receives his powers from the Aztec god Quetzalcoatl and gains the ability to transform into a bee.
Superpowers: super vision to detect hornet nests. Control over bees, allowing him to gather them together to generate heat and make hornets, his enemies, explode.

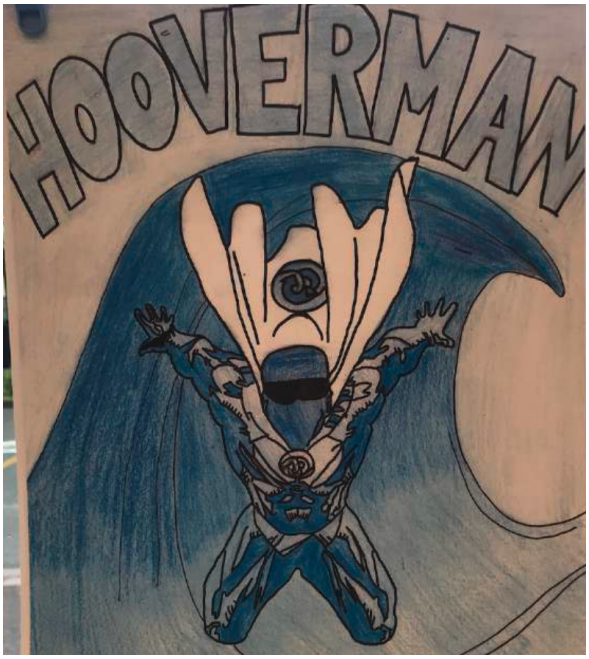
Figure 8. Bee Colony Collapse group — Superhero BeeMan based on the students' final character creation

colonies, has the ability to summon and communicate with bees, who then cluster around Asian hornets and generate heat by vibrating their wings, causing the hornets to explode. This proposal reflects a direct integration of a strategy suggested by the mediators, based on a real defensive behavior of certain bee species. Notably, it replaces the group's initial idea, which involved spraying an unspecified substance to kill the hornets, a solution that was immediate but disconnected from real bees' abilities. A similar evolution is observed in the case of HooverMan, the superhero designed to fight plastic pollution. While the students initially imagined a character who simply "vacuums up all the plastic", thereby making the problem disappear, the final version takes into account what happens to the collected material. This shift was supported by mediator scaffolding and led to a more complex solution: transforming the plastic waste into renewable energy and redistributing it to underserved populations.

These examples illustrate how certain scaffolding strategies, particularly *proposal* and *rule reminders,* contributed to anchoring fictional creations in scientific reasoning, even if the integration remains partial and negotiated within the imaginative frame of the task.

8 ▪ Conclusion and perspectives

This study examined how scientific knowledge, narrative invention, and pedagogical scaffolding interact in an informal science education initiative. The *Science of Superheroes* project offered a unique opportunity to observe how mediators support students as they



Origin: HooverMan is a scientist who lived in the United States until he was 18 years old. His parents disappeared in a plastic tsunami 10 years ago. He works in a laboratory on a plastic recycling project. One day, he accidentally spills a plastic-recycling potion on his right hand, which transforms him into a superhero.
Superpowers: HooverMan can vacuum up plastic and transform it into renewable energy, which he uses to help poor communities in Algeria. He also cleans the oceans by absorbing plastic waste.

Figure 9. The tsunami of plastic group — Superhero Hoover Man based on the students' final character creation.

move from scientific inquiry to creative synthesis. Our findings show that mediators adjust their scaffolding strategies according to the nature of the task. In early phases, when students explore environmental disasters, mediators rely mainly on questioning, reformulation, and information-sharing strategies to stimulate understanding. During the creative phase, scaffolding becomes more differentiated: some strategies such as agreement and information input decrease, while rule reminders, exemplification, and proposal strategies emerge to help students re-anchor their narratives within a scientific framework.

Despite these adaptive efforts, a core challenge remains: the integration of scientific knowledge into the superhero format is uneven and often partial. While many students tend to default to narrative solutions that are only loosely connected, or entirely disconnected, from scientific reasoning, this tendency appears to be more effectively regulated when mediators provide sustained and context-sensitive scaffolding. The tension between the internal logic of superhero fiction and the constraints of scientific plausibility does not disappear, but it can be better managed under certain scaffolding conditions, particularly through the use of proposals, exemplification, and rule reminders. As noted in earlier research [de Hosson et al., 2018], the superhero genre privileges narrative coherence and imaginative power over causal realism. In this context, mediators' interventions help maintain a form of epistemic anchoring, even though the efforts required to negotiate this balance are not always fully visible to them. This suggests that the effectiveness of scaffolding relies not only on strategy choice, but also on an implicit sensitivity to the shifting cognitive and narrative dynamics of the task.

These observations have implications for mediator training. First, it could be fruitful that mediators be introduced to scaffolding as a pedagogical concept. This includes understanding the functions of scaffolding (e.g., task engagement, orientation, difficulty

reduction, epistemic framing), as well as the discursive forms through which these functions are enacted. Mediators often rely on intuitive or experience-based practices, developed informally through fieldwork, rather than through structured pedagogical training [Schiele et al., 2012]. Helping them to name and differentiate their interventions helps to link the theory and practice of mediation and thus contributes to the process of professionalisation undertaken by mediators.[4]

Second, training should explicitly address the role of fictional framing in shaping student responses. Mediators should become aware of how the fictional setting, while engaging, can structurally destabilize the scientific aims of the activity. Understanding this imbalance can help them identify moments where reintroducing epistemic constraints is necessary, not through authoritative correction, but through reflective, well-placed questions that invite students to critically evaluate their own ideas.

Third, our results suggest that mediator training would benefit from accompanied reflective practice, for instance through the use of annotated transcripts or video-based autoscopies. When we shared our analytical tools with the mediators involved in the project, they expressed that these materials helped them articulate what had previously been felt but not named. Engaging in this type of structured reflection may foster the development of adaptive expertise.

While some of these approaches overlap with teacher training, particularly in the use of scaffolding as a lever for formative action, they differ in key respects. Science mediators operate outside institutional curricula and are not bound to standardized knowledge or assessment structures. Their challenge is to render scientific knowledge accessible and meaningful in informal, short-term contexts, often with heterogeneous audiences and goals. In this respect, training that focuses on situated scaffolding strategies, informed by empirical analysis, can play a decisive role in maintaining scientific coherence while respecting the narrative and playful nature of such initiatives. Similar approaches have been successfully used in teacher education, where video-based analysis of scaffolding practices has been shown to foster professional development [e.g. van de Pol et al., 2010]. Adapting these methods to science mediation could offer a promising path for the field.

Finally, our study helps to meet the methodological challenge of identifying the appropriate tools for capturing the epistemic dimensions of scientific mediation. As far as the issue of scientific knowledge is concerned, the theory of scaffolding can identify mediation practices, characterize them in relation to the task assigned to students and support an evaluation of their effectiveness in different contexts.

Acknowledgments

We would like to thank the *Instant Science* Association, and the mediators and students for allowing us to observe the workshops.

4. See also the Special Issue Connecting Science Communication Research and Practice [Fischer et al., 2024], which provides insights into researcher–practitioner collaboration and mediator professional development.

References

Achiam, M., & Marandino, M. (2013). A framework for understanding the conditions of science representation and dissemination in museums. *Museum Management and Curatorship*, *29*(1), 66–82. https://doi.org/10.1080/09647775.2013.869855

Al Khatib, J., & Gacogne, M. (2018). La médiation culturelle: du concept à l'activité. *Cahiers d'histoire du Cnam*, *09–10*, 169–188. https://hal.science/hal-03032965v1

Anjos, S., Russo, P., & Carvalho, A. (2021). Communicating astronomy with the public: perspectives of an international community of practice. *Journal of Science Communication*, *20*(03), A11. https://doi.org/10.22323/2.20030211

Brossard, D. (2013). New media landscapes and the science information consumer. *Proceedings of the National Academy of Sciences*, *110*(supplement 3), 14096–14101. https://doi.org/10.1073/pnas.1212744110

Bruner, J. S. (1974). From communication to language—a psychological perspective. *Cognition*, *3*(3), 255–287. https://doi.org/10.1016/0010-0277(74)90012-2

Bruner, J. S. (1978). The role of dialogue in language acquisition. In A. Sinclair, R. J. Jarvelle & W. J. M. Levelt (Eds.), *The child's concept of language* (pp. 241–256). Springer-Verlag. https://doi.org/10.1007/978-3-642-67155-5

Chaumier, S., & Mairesse, F. (2013). *La médiation culturelle*. Armand Colin.

Chevallard, Y. (1991). *La transposition didactique: Du savoir savant au savoir enseigné* (2nd ed.). La Pensée Sauvage.

Colardyn, D., & Bjornavold, J. (2004). Validation of Formal, Non-Formal and Informal Learning: Policy and Practices in EU Member States. *European Journal of Education*, *39*, 69–89. https://www.jstor.org/stable/1503751

Davies, S. R., Franks, S., Roche, J., Schmidt, A. L., Wells, R., & Zollo, F. (2021). The landscape of European science communication. *Journal of Science Communication*, *20*(03), A01. https://doi.org/10.22323/2.20030201

Davis, L., Fähnrich, B., Nepote, A. C., Riedlinger, M., & Trench, B. (2018). Environmental Communication and Science Communication—Conversations, Connections and Collaborations. *Environmental Communication*, *12*(4), 431–437. https://doi.org/10.1080/17524032.2018.1436082

de Hosson, C., Bordenave, L., Daures, P.-L., Décamp, N., Hache, C., Horoks, J., Guediri, N., & Matalliotaki-Fouchaux, E. (2018). Communicating science through the Comics & Science Workshops: the Sarabandes research project. *Journal of Science Communication*, *17*(02), A03. https://doi.org/10.22323/2.17020203

E., C. (1994). L'ambiguïté de la médiation culturelle : entre savoir et présence. *Publics & Musées*, *6*, 53–73. https://doi.org/10.3406/pumus

Fischer, L., Barata, G., Scheu, A. M., & Ziegler, R. (2024). Connecting science communication research and practice: challenges and ways forward. *Journal of Science Communication*, *23*(02). https://doi.org/10.22323/2.23020501

Gardair, E. (2014). Cognitions "rationnelles" et "irrationnelles" : Quels liens entretiennent la pensée magique et la pensée scientifique dans les raisonnements quotidiens? *Intellectica. Revue de l'Association pour la Recherche Cognitive*, *62*, 51–68. https://psycnet.apa.org/record/2015-08704-003

Gascoigne, T., Cheng, D., Claessens, M., Metcalfe, J., Schiele, B., & Shi, S. (2010). Is science communication its own field? *Journal of Science Communication*, *09*(03), C04. https://doi.org/10.22323/2.09030304

Guenther, L., & Joubert, M. (2017). Science communication as a field of research: identifying trends, challenges and gaps by analysing research papers. *Journal of Science Communication*, *16*(02), A02. https://doi.org/10.22323/2.16020202

Han, H., & Stenhouse, N. (2014). Bridging the Research-Practice Gap in Climate Communication: Lessons From One Academic-Practitioner Collaboration. *Science Communication*, *37*(3), 396–404. https://doi.org/10.1177/1075547014560828

Hurstel, J. (1975). Formation de l'animateur. *ATAC*, *64*, 26–30.

Johnson, M., & Majewska, D. (2022). *Formal, non-formal, and informal learning: What are they, and how can we research them?* Cambridge University Press & Assessment Research Report. https://www.cambridgeassessment.org.uk/Images/665425-formal-non-formal-and-informal-learning-what-are-they-and-how-can-we-research-them-.pdf

Kahneman, D. (2012). *Système 1 / Système 2: Les deux vitesses de la pensée*. Flammarion. https://editions.flammarion.com/systeme-1-systeme-2/9782081211476

Marzin-Janvier, P. (2015). Étayer la conception expérimentale par des environnements informatiques : études en génétique. *RDST*, *12*, 87–112. https://doi.org/10.4000/rdst.1135

OECD. (2018). *The Future of Education and Skills: Education 2030*. https://www.oecd.org/content/dam/oecd/en/publications/reports/2018/06/the-future-of-education-and-skills_5424dd26/54ac7020-en.pdf

Osborne, J., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections*. The Nuffield Foundation. https://www.nuffieldfoundation.org/about/publications/science-education-in-europe-critical-reflections

Piaget, J. (1926). *La représentation du monde chez l'enfant*. Librairie Félix Alcan.

Rasse, P. (2014). La médiation, de l'utopie à la transformation sociale. *Hermès*, *n° 70*(3), 46. https://doi.org/10.3917/herm.070.0046

ReMédiS. (2023). *ReMédiS 2023 study day: Science mediation under scrutiny [Conference session]*. Cité des Sciences et de l'Industrie, Paris, France. https://www.universcience.fr/fr/professionnels/remedis/actualites/journee-remedis

Richard, E., & Chevalier, J. (2023). *The professional profiles of science mediators [Paper presentation]*. ReMédiS study day. Universcience. https://www.universcience.fr/fileadmin/fileadmin_Universcience/fichiers/ReMediS/Documents/PPT_Enquete_Remedis.pdf

Scheufele, D. A. (2022). Thirty years of science–society interfaces: What's next? *Public Understanding of Science*, *31*(3), 297–304. https://doi.org/10.1177/09636625221075947

Schiele, B., Claessens, M., & Shi, S. (Eds.). (2012). *Science Communication in the World: Practices, Theories and Trends*. Springer Netherlands. https://doi.org/10.1007/978-94-007-4279-6

Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, *46*(1), 1–44. https://doi.org/10.1080/03057260903562284

Subbotsky, E. (2010). *Magic and the Mind: Mechanisms, functions, and development of magical thinking and behavior*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195393873.001.0001

Trench, B. (2017). Universities, science communication and professionalism. *Journal of Science Communication*, *16*(05), C02. https://doi.org/10.22323/2.16050302

van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in Teacher-Student Interaction: A Decade of Research. *Educational Psychology Review*, *22*(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Woods, D. (2019). *Transana: Automated transcription: Data collection software*. https://www.transana.com/

About the authors

Florence Vigneron is an associate researcher at the University of Montpellier (France). Her work focuses on the role of fiction, comics and pop culture in science education. As a scientific illustrator and comic strip author, she explores alternative forms of writing for her research and for the dissemination of scientific knowledge.

florence.vigneron@outlook.fr

Cécile de Hosson is a Full Professor of Physics Education at Université Paris Cité and a researcher in the LDAR research team (Mathematics and Science Education Research). Her current work focuses primarily on the processes through which physics knowledge is translated and transposed in teaching and science mediation contexts, with particular attention to their mobilization in comics.

cecile.dehosson@u-paris.fr

Muriel Guedj is full professor at the University of Montpellier (France). Specialist in epistemology and the history of science, her work focuses in particular on science communication between formal and non-formal education.

muriel.guedj@umontpellier.fr

How to cite

Vigneron, F., de Hosson, C. and Guedj, M. (2025). 'Scaffolding in science mediation: a superhero-based educational initiative to explore how mediators support students' knowledge appropriation'. *JCOM* 24(07), N01.
https://doi.org/10.22323/145720250924052856.

ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it