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PARTICIPATORY SCIENCE COMMUNICATION FOR TRANSFORMATION

The Group Provisory Conclusion, a powerful tool for science debut

Marima Hvass-Faivre d'Arcier

Abstract

This article will take you through the evolution of our approach in presenting and communicating science. For twenty years '**1, 2, 3, sciences**' has run participatory live workshops for adults. A special tool, the Group Provisory Conclusion or GPC, involving each participant, contributes to the success. Our expectation was to rekindle the public's interest through participatory methods, supported by the emergence of collective intelligence. It describes our actions to help people reduce their apprehension towards science.

Keywords Informal learning; Public perception of science and technology; Public understanding of science and technology

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The context

How did it all start?

"*Hold me down on the bottom of the swimming-pool, I want to look up to see the surface of the water from underneath*". You might wonder in what context such a surprising statement was made. You will most probably be very surprised to find that this was a request during a '**1, 2, 3, sciences**' session dedicated to light refraction! Can you figure out what the person saw?

During the International Scientific Education Days in Chamonix 2005,I was conducting a hands-on workshop about *temperature* and *heat flow* with 20 adults. This session is often entitled '*Distrust your senses, they deceive you!*'. As facilitator, I systematically reminded the audience (20 adults) that everything inside an insulated place is at the same temperature. The difficulty is to verify this when considering solid objects, so we used contact thermometers such as aquarium-thermometers. At that moment, I was astonished to hear a physics teacher behind me, saying: "*I taught that to my high-school pupils, but I couldn't believe it.*"

These two live examples show that if we expect people to develop an interest in understanding science, we have to use examples from their everyday life, with their own perceptions. Otherwise it is no more than a formal school exercise.

This paper will take you through the evolution of our practice: science workshops leading to participatory science practice.

Disappointments as a high-school physics teacher

I had always wanted to teach science and enjoyed my job, even if it wasn't quite what I expected. The real goal of the high-school curriculum in France is to help pupils (15 to 18 years old) succeed in the final exams. Science teachers prepare the candidates to resolve formal exercises and problems. These are theorical questions rather than situations that can be met in everyday life. In this context, young people are learning such notions as *momenta amount* or *carbon atom quadrivalence*, and how to deal with these notions … on paper. At school, modelisation is so simplified that pupils can't recognise what reality these concepts are supposed to represent. The discrepancy between objectives and results steered the evolution of our approach in presenting and communicating science.

In this very constrained context, I with a few colleagues launched several projects departing from the strict curriculum, aiming to train pupils to acquire a scientific way of thinking.

As the French pedagogue Louis Legrand wrote: '*Since the end of the nineteenth century, access to science is considered as the privileged gateway to democracy [...] Unfortunately, science is usually taught as ready-made concepts rather than as a method. This is how primary and high-schools have trained memory over autonomy, reinforcing the hierarchical position of the teacher, of the one who detains the knowledge*' [Legrand, 1970, p. 11]. This is the real weakness of our science teaching to future generations: it doesn't prepare adults to see science in its natural frame all around us. "*Teachers are supposed to prepare their pupils for their adult-life tomorrow. They do not experiment how to build the future knowledge they will need as adults!*" [Dewey, 1938]. The results seem obvious: science education prepares only the future scientists. The public is largely science-illiterate, and worst, has lost an interest in science.

How I learnt to share the pleasure of science with young children

My children went to an alternative primary school where the parents were welcome to lead workshops with groups of children. Science being a blind spot in the teachers' training, I was very welcome to take this responsibility.

Three university researchers/teachers in astronomy, solid-physics and plants biology, parents in the same school, joined me. Our teamwork lasted from 1978 to 2000.

Right from the beginning, we chose to work with the principles of *Education Nouvelle* [Rist and Rist, 1983] as used in that school. The general approach comprises:

- performing a real experiment and testing one's hypothesis
- building self-knowledge in a group from the experiment, as John Dewey emphasised, instead of learning what has been found before.
- heterogeneous groups are more efficient: in our experience, the youngest were not necessarily those with most difficulties.

In the school, there were two kinds of workshops, according to the age of the pupils:

1. Five weekly sessions of 45 minutes with six children from four to seven years old.
   When the session finished, there was no written report: at this age writing is an exercise in itself!
   Instead, each child reported by constructing an object that they brought back to their classroom. Participating in their construction improved appropriating the notions. This object carried the scientific idea that was the aim of the session: it was the unwritten summary. When they showed it to others, they could explain with the 'small sentence' that we built together to generalise what we discovered. This type of weekly science-workshops lasted for 15 years. You should see the youngest ones with the roly-poly toy [Faivre d'Arcier, 1986] they built. They left the *balance* session proud as if they discovered a secret of the world, because they knew how it works.
2. We also led six yearly Great Projects [Gloton and Foucambert, 1978] on a scientific theme. Every year, 15 to 20 kids from 8 to 11 years, chose a science project from a proposed list. Based on the same principles as the workshops, these projects were much more ambitious, and the children were more invested.
   At the end of the school year, they reported on what they did, what they discovered: an excellent opportunity to sum up what they had learnt in terms of notions, but also of scientific and personal skills.
   Preparing the presentation of the *Astronomy Project*, I and two children (9 years old), were choosing slides. They were pictures of the NASA that had been shown to the whole group of children a few months earlier.
   Now, on the screen was the LEM (Lunar Excursion Module) on a stony ground. We were puzzled and:
   – Oh yes, said one child, it was taken in one of the deserts… somewhere on Earth!
   – What is the use of picturing it on Earth? I asked. I would rather think it is on the surface of the Moon.
   The answer came at once:
   – Can't you see that the sky is blue?
   I had to admit I was very impressed. Not only that they remembered it, but I was happily surprised that they could argue so adequately to an adult. I considered it was real knowledge because they could use it in a very appropriate way to convince me.

Another year, during the *Energy Transformations Project*, one of the scientists abruptly pronounced the words *potential energy*. It took us almost a month to be able to continue. The pupils could not think ahead because they were blocked trying to make sense out of this *potential energy*. On that occasion our conclusion was that we should not name a concept before the notion had been built through observations and discussions! And we kept to that.

As a general conclusion to our observations: the knowledge the children acquired with either of the two types of workshops

- makes sense for them
- they remembered and know how to use the 'small sentence' they had built with the group
- this appropriation of knowledge made it sustainable

As leaders of the sessions, we learnt that our non-conventional approach was more relevant to share sciences.

It was also more interesting for the facilitator and his/her public, because we were all active, in the authoring of our science session

Many other situations encountered with the young children showed me that our approach had real benefits in the long run. The children retained their curiosity about phenomena, in searching out *why?* and putting ideas together to find the connections.

To our eyes, this collective intelligence developed in alternative education was a form of participatory science. A group of very different people, with very different skills, is more efficient to enjoy and acquire lasting scientific knowledge.

In comparison, the high-school curriculum based essentially on the deficit model, doesn't keep the flame of enthusiasm alight after students finish school. Even worse, the young people feel discouraged and think that science isn't for them. Scientific words, which are not understandable, aren't science, although it's all that remains for many people after they left school!

That's why I decided to stop teaching at high school in 1989.

Synergies with other actors in science education

From 1991 to 1999, with the same team of *scientific parents*, we created a complete set (4 document-books + 5 experiment-books + 2 guides) for the 5 levels of primary-school. We wrote this ensemble with the idea of helping and encouraging teachers so that they dare take up our approach and share the scientific spirit with their pupils [Borg et al., 1996; Borg et al., 1999].

And from 1995 to 2000, we presented lectures with experimentation all over France on behalf of Editions Magnard, which edited the collection.

In 1992, Françoise Balibar of the Société Française de Physique[1] asked me to join the commission she was leading to renew the sciences curriculum of training primary-school teachers. I was the only non-academic member. At the end of our mission, I presented our report to the SFP convention [Balibar and Hvass, 1994]. I was thereafter involved in training future primary-school teachers at University from 1996 to 2002.

The concern for science education addressing young children was particularly recognised in the nineties. The French Science Academy launched the operation *La main à la pâte* (*La Map*)[2] in 1996, a program to encourage and to help teachers leading scientific activities in primary schools.

In the meantime I took part in the 3rd seminar organised in September 1997, by G. Charpak, P. Léna, Y. Quéré,[3] exchanging ideas on science education for young children, and consequently for their teachers. The final report presented: "*The principle of 'La Boit' à manip', (the experiment box)* [Hvass-Faivre d'Arcier, 1998] *a new device to help teachers training in science by Marima Hvass-Faivre d'Arcier, a physics instructor at the IUFM*[4] *in Versailles. The approach is in many ways similar to that developed by* La main à la pâte*. With simple material, the teacher manipulates, proposes, experiments, compares their point of view with others'. The focus is more on the approach than on the content*" [Colloque "La main à la pâte", Les Treilles, 1997].

Our methods

Who concludes a scientific experimentation?

That is the important issue to me.

The usual answer to this question looks obvious for those who only know traditional school teaching: it's the expert or the one who knows and teaches.

In 1997, during a working group (of about ten people) for *LaMap*, we were discussing how to teach science at primary school. A work-document appeared with a new expression: the *Group Provisory Conclusion* or GPC (la *Conclusion Locale Provisoire* or CLP, in French). The words immediately struck me as corresponding to the "small sentence" I had used with the children. I believe I was the only one in the group to realise how that could change learning science for young ones, and even adults.

In the document the GPC was not described, so I developed the concept behind the expression *Group Provisory Conclusion*.[5] *LaMap*, as an emanation of the Science Academy, could not accept the GPC methodology. They remained within the dialogue model and the traditional deficit model to keep the academic standards.

[1]SFP: French Society of Physics.
[2]Or '*Hands on Program*'.
[3]Three eminent members of French Science Academy. G. Charpak received the Physics Nobel Prize in 1992.
[4]IUFM: Institut Universitaire de Formation des Maîtres or University Institute of Teacher Training.
[5]Screening the Internet for *Conclusion Locale Provisoire* leads exclusively to '**1, 2, 3, sciences**'.

Conceptualising the Group Provisory Conclusion

With the GPC, conclusions are worked out by the group of non-specialised participants that performs the experiments.

During our experimental sessions, we progress from one Group Provisory Conclusion (GPC) to the next. We have now used GPC for twenty years. It is part of our participatory approach as it gives everyone around the table an equal position: each one may take the floor to propose or debate the wording of a common GPC, which has to be agreed among all participants in the end.

This conclusion is expressed with everyday words. Every participant understands it, feels happy with its wording. He/she knows how it was built from both the observations of the day and the discussions that followed. If someone wishes to say it in another way, he/she may propose another version and the group checks that the meaning remains the same. This is a way to ensure that everyone present keeps the same meaning to his/her conclusion. The GPC is the adult equivalent to the small sentence we used to formulate at primary school.

To put our ideas in common, we use simple, understandable words: the ones we use in our lives. We remember the lesson of the '*potential energy*', so we never use science dedicated words to name a notion before that notion has been well defined and understood with simple words and periphrases. Of course, we never conclude at a microscopic level, irrelevant to our direct perceptions.

Going through all this process, we reach the *Group Provisory Conclusion* expressed with the participants' words as small as the group needs it, a conclusion legitimated by group debate and provisory as we will complete it or define it more precisely later if necessary.

The following examples give some GPC created during different sessions:

- To float a piece of matter in a liquid, we must increase the volume of this matter, without changing its mass
- To modify the rectilinear trajectory of an object, we need to apply a force in a different direction
- Liquid from a candle doesn't solidify at constant temperature: we conclude that it isn't pure, but a mixture of different matters.
- As transformation temperature of water to ice is 0°C, it is impossible to find any liquid water at -3°C, nor ice at 1°C.

*Creation of '**1, 2, 3, sciences**'*

In 1999 I created the '**1, 2, 3, sciences**' association with people I met during these very active years. Initially, the purpose was to develop science education for children. It soon appeared that adults also wanted to experiment and conclude. That is how we started our live science workshops for adults.

During the same period, our training continued, and we enlarged our public to:

– primary school teachers
– journalists: monthly-meetings for 11 years with Bayard-Presse,
– computer science students at Epitech (a computer science engineers school), with weekly meetings for 4 months,
– and many other more organised meetings with targeted audiences, for example facilitators for disabled pupils...

The members of the association also had their dedicated science-workshops: amounting to 8 meetings per year for eleven years. The members of '**1, 2, 3, sciences**' came on Saturday afternoons for the fun of sharing science with other members, without any constraints. Every summer for 11 years, we organised four days' internship sessions around a theme. Each time, 10 to 18 adults participated during their vacations.

Outside France

We were invited to West Africa by DEFI[6] (a French association for development), and to Morocco by the Institut Français of Fez. We monitored 4 live workshops for 1 to 2 weeks, each with 50 participants. Our practice insights needed to be adapted to their respective scholarly environments. Avoiding ready-made equations was an obvious necessity for teachers inclined to teach everything by heart. Furthermore, discussing a result conflicted with the ancestral authority and respect traditionally due to the adults. On the other hand, within their family environment, the children and the adults often live closer than we do to natural phenomena, with examples as simple as a metal door expanding in high temperatures at noon and jamming.

We looked only for material that could be found on the local markets to be in accordance with their lives and habits. It was the only way to ensure continuity after our departure. They were quite surprised to have so much science under their eyes, and so many experiments at hand within their own environment.

In Togo, for example, when visiting primary schools at work in science sessions we could see that experimentation was a very new process for pupils as well as for their teachers... and their inspectors! It became our first goal. On our behalf they started touching, waiting, looking, bending down to see better what is happening. All that was new to them, but the pleasure of discovering was vivid, and they enjoyed the wonders of the child. Then came the collective construction of the GPC: from telling what they observed to a generalization with their own words.

[6] DEFI is a French association "working for education, knowledge and energy" since 32 years. To learn how we worked together: https://3185c664-872b-4319-b52a-c6d48bd066a8.filesusr.com/ugd/2ecc7b_78ca13450ea94d9f854b4f367f3ac047.pdf.

Methods that make our live science-workshops different

Our experiments merely require a few everyday life objects and some curiosity.

With our perceptions, we are not only active but also actors of our experimentation performed within a group. It helps to see all aspects of the experiment, to raise question, discuss ideas, to go further, and to be satisfied, at least temporarily, by our achievements.

We encourage the participants to think aloud. We try to synthesise the observations and note them on a paperboard, so that everyone can see. Each one brings his contribution to the discussion, proposes his formulation, shares his/her ideas. All these social interactions are stimulating and necessary. The collective intelligence improves the group's efficiency and is part of the fun!

As an example, when we asked the public at a live workshop to discuss Archimedes' Theorem, an engineer-woman jumped on her feet to recite it to the comma!

Then the experimental part started with an 'action detector', as we call it: a piece of plasticine at the end of 20 cm of elastic thread. The variations of the elastic thread length show the intensity of the action on the plasticine. In the air, the elastic length is constant. When the plasticine enters the water, the thread starts shortening. It stops when the plasticine is entirely in the water. That surprised the lady because she expected the length to vary with the depth of the ball in the water… Although in the theorem there is no mention of depth at all! One can know a theorem by heart and miss completely its meaning. We bet that she remembers it, now that she experimented it.

The animators prepare the session-scenario: what notion? which way? which experiments? Although on the spot we may change our plans to meet the expectations of the public that day. Furthermore, the facilitators don't know in advance how the GPC will be expressed.

We usually gather in an ordinary meeting room. We bring everything that is necessary for the experiments. Our only requests are electricity and a water-point nearby.

The group-leaders are not '*answer-distributors*'. They warrant that the group doesn't get stuck in conjectures and they can steer the discussions. Their facilitating ability is more important than their scientific knowledge, and it is essential that everyone should avoid the temptation of ready-made explanations.

They also take pleasure in participating before and during the workshops: planning the experiments, trying them before to be sure it works… and have fun testing the manipulations.

During the session, they watch what is happening, trying to guess what the participants have in their mind: actually, it is so obvious that they can almost read it as an open book! Everyone thinks aloud, nobody hides. It is really fascinating.

*Results of surveys on '**1, 2, 3, sciences**' participants*

We are a very small structure, without public money nor private! We did not have to account for subventions, and we were all volunteers: this status gave us more freedom to try a different way to bring the public nearer to science. The reactions of those who came and came again to practice sciences with us were part of the evaluation of our sessions. The evaluations we led were meant to tell us how to evolve to be more efficient.

All our sessions amount to an experience of some 1000 days with multiple participants.

The surveys, by means of anonymous open-questionnaires and through individual interviews, helped to outline the impact of our sessions and adapt our methods.

Comprising a very diversified panel in terms of social environment, professions and age groups, the answers could be grouped according to 4 general themes associated to the characteristics of the method. Below is a compilation of the most frequent answers formulated by participants to our surveys.

1. How do the participants view science?
   - The concrete approach, the experiments, manipulations and observations greatly impacted the view participants have on science
   - They allowed departing from magical explanation to discover relation of causality
   - The scientific approach is interesting and more natural through choosing to study subjects issued from everyday life and using familiar material
   - Participants considered that they learnt to question the world and realised that they encounter science in all fields of life.
2. The process of acquiring knowledge
   - Acquisition process is enhanced by the Group Provisory Conclusion. Constructing the GPC collectively helped to appropriate the knowledge
   - Participants appreciated the fact that they were not asked to accept ready-made concepts
   - It brings answers to everyday problems, applicable to other situations
   - They feel that they learn, un-learn, each one building differently a better structured understanding
   - They learn to organise their approach to the given subject
   - After the sessions, they want to share the experience with others
3. Working in a group and with the guidance of the facilitator is very encouraging
   - They appreciate having time and being free to explore various answers
   - The intervention of the facilitator establishes a relation of confidence, frees tongues and avoids failure situations

- The facilitator takes us at our level.
- Having one's point of view valued is gratifying
- Within a group one progresses safely

4. The subjective effect on participants
   - Participants come for the pleasure of discovery
   - The activities develop a critical mind, a way of thinking
   - Understanding by oneself and acquiring the conviction of having forwarded the right hypothesis is very satisfying
   - Speaking up, shielded of any judgment, develops self-confidence
   - Discovering how the others think and proceed is very interesting
   - Accepting uncertainties, doubts and questioning beliefs is rewarding.

How many of our young participants became scientists? We presently cannot answer the question. But we do know that many journalists, school and university teachers were influenced by our methods. We believe that most of those results are to be put on the credit of the GPC.

Discussion

How do we position ourselves with the GPC compared to other science educational programs for non-specialists?

Let's first consider a very revealing experience: from 2005 to 2011, as part of ASTEP,[7] we led a special experience *A l'école du labo* (School at the lab').

We collaborated in yearly workshops with the Espace des Sciences P. G. De Gennes[8] dedicated to Public Communication of Science within the ESPCI, the prestigious Ecole Supérieure de Physique et Chimie Industrielle de Paris.[9]

During a week, 15 primary school teachers were welcomed. They visited labs and met researchers and had experimental sessions with the organising team: 3 researchers with their lab material and 3 members of '**1, 2, 3, sciences**' with our usual unsophisticated material.

Analysing the ESPCI surveys written by the participating teachers showed that beside their enthusiasm to be invited in such a prestigious place, most were surprised and interested in our approach. They discovered gaps in their global science understanding. The group experiments demonstrated how teachers could take our methods back to their schools, how to progress by steps and offering paths to create their own experiments to test with their pupils. Their self-confidence improved. The method appealed to most.

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[7] ASTEP: Support in Science and Technology at Primary school (Accompagnement en Science et Technologie à l'Ecole Primaire).

[8] P.-G. De Gennes was the director of ESPCI. He received the Physics Nobel Prize in 1991.

[9] Superior School of Industrial Physics and Chemistry of Paris. *L'Espace des Sciences* is conceived as an opening between the Science world and the City.

This experience ended in 2011, when the ESPCI students were committed to scientific coaching at grammar schools (pupils from 11 to 15 years). This was part of their curriculum. An internal document was edited to help these future engineers. Here we find important recommendations to conclude their sessions comprising:

- "Put participant's ideas together and discuss them
- Build a Group Provisory Conclusion
- Compare the results to those obtained with the theorical model
- If the results don't match propose another model"

We were pleased to find *our* GPC among the recommendations.

But the way the internal document advises these engineers to 'conclude' an experiment with the pupils distorts the GPC objectives. You can't tell the experiment what it should be by comparing it to the theoretical model! You need to observe it carefully and when it seems not to coincide with the expected *theorical model* of the books, the experimental conditions should be expressed in the GPC that the group constructed.

If the GPC found by experimentation is not validated, because it doesn't fit in with the canonical knowledge, that creates a very prejudicial conflict. Is the ready made knowledge from the "past" considered more valid to enrich future knowledge of the pupils [Dewey, 2014] rather than the experience that they have just had?

The pupils are not researchers trying to discover new scientific issues, they explore already well-known science, based on macroscopic experiences. It is a very different pattern from research work on a new phenomenon.

An example: a group of youngsters (around 10 years) was testing the way to get fresh water from a salty one by (very) artisanal distillation. They found that the water they got at the end was still salty. Their teacher was very puzzled and did not know how to handle that result. Had they to change the model? A much more instructive way of doing was to taste (using one's perceptions) the water before and after the 'distillation'. And to conclude on what they really observed: that the water was still salty, but less than the original salty water.

The experience is valid, not the established model. Of course, we do not validate just anything, but science is not only true in the scientist's laboratories.

Participatory science: collective intelligence and personal development

Collective intelligence was very much demanded in our science live workshops, for children as well as for adults. Our members-sessions were attended by very different people, including seniors up to 80 years, some with very little science education and others recognised scientists. The latter were often astonished to be able to reconstruct their knowledge step by step with ordinary words. "I am happy because I manage to forget all what I learnt and to build it all again from the start" as a science-university professor declared in our journal 'L'agitateur' [Viratelle, 2013]. No one was bored!

The collective intelligence allowed them all to give some sense to the world around them, instead of keeping to misleading preconceived representations.

At '**1, 2, 3, sciences**'[10] our objective is to make the children and adults interested in finding answers to their questions and discovering principles of basic science that allows them to grasp what happens in the world they live in.

The enthusiasm for our approach is a marker of its success.

Our sessions dedicated to future and actual teachers enhanced the interaction between the scientific world and educating citizens. Those dedicated to journalists improved their awareness on the procedures of scientific reasoning and changed them into more efficient intermediary facilitators [Lacombe, 2021].

Every category of participants in our sessions expressed a sense of personal development that the classical approach to science had not offered with the same conviction.

Children and adults developed a critical mind and questioned more efficiently the declarations and explanations proposed by journalists as well as those of professional scientists. In our mind, they become the most adequate debaters and tenants of citizen curiosity.

'Yes, you can!' is the motto. Becoming 'able to' changes our receptivity of science contents in conferences or papers. We think that this type of live activities can help to understand how science progresses, what is needed to achieve an unbiased report, and for example, how to think with others in small groups or large ones, as may be citizen's conferences.

Our sessions are an instrument that partakes in the dialogue between science and society. Live science workshops where a scientist finally declares what the conclusion is does not reach the same goals, spoiling the participant's attempted involvement. It's only a simplified variant of the deficit model.

Conclusion

Collaborative and participatory experimental science that relies on the Group Provisory Conclusions stimulates a scientific interest within the workshops, validating our saying 'be ambitious, do small things.' Self-appropriation through live experiments and group interaction enforces our ability to remember and to know how to use what we have learnt. It proved to be more lasting than ready-made knowledge.

It has made the actors more receptive and critical minded towards science information coming from specialists and what they read in the media.

[10] '**1, 2, 3, sciences**' to know more about us, to find documents and help in conceiving live workshops or. . . , visit our site at https://123-sciences.asso.fr.

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