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Reimagine Physics Teaching: A workshop designed to sparkle exchanges and creativity

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Abstract. The "Reimagine physics teaching" workshop was held during two weeks at the Institut Pascal, From May 2Nd to May 12th, 2022. It gathered more than 35 participants from various countries including educators, faculty and designers. This program aimed at experimenting new ways of sharing current innovative practices and collectively designing new pedagogical activities in a restricted amount of time. It provided a framework to stimulate reflective thinking about pedagogical practices and how to disseminate them. In this report, we first present the scope, organization, schedule and range of activities held during the workshop, and we provide a brief overview of some of the outcomes of the workshop. In a second part, we discuss the impacts of this workshop, and we focus more specifically on how some elements in the format and organization of this workshop provided a favorable environment for the participants to rapidly and efficiently engage in productive activities centered around innovation in pedagogical practices.

Keywords: physics education, creativity, pedagogical practices, teaching experiment, innovation

1 Context: Teaching physics after covid

Physics teaching has been, like many other disciplines, dramatically impacted by the recent Covid19 pandemic. The development of innovative practices, or even more generally the development of experimenting new ways of teaching was strongly stimulated by the necessity of reorganizing teaching in secondary schools and in higher education. This situation triggered first adaptations installed in a very short time, like the global move to online courses

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and remote teaching sometimes in only a few days. In the following months, whole curicula and academic terms had to be adapted, often leading to a redefinition of learning objectives, assessments formats, and learning activities.

Importantly, one can note a specificity regarding the case of experimental physics teaching during pandemic: with no access to traditional labs, educators had to pile up difficulties linked to the lack of traditional lab resources on top of the collective adaptation to remote teaching.

Importantly, teaching in time of pandemic also highlighted the social dimensions of teaching and learning, as exemplified by the recurring inequities between students (in terms of personal equipment, internet connection, access to digital resources, learning environment and personal situation etc.…) and by a growing need, expressed both by students and educators, to intertwine scientific training with a social and societal dimension also raising students as citizens, willing to address and able to face the big challenge of our times - the first of them being climate change.

The "Reimagine physics teaching" workshop has been organized by a team of 6 people two years after the beginning of the pandemic. They wanted to benefit from the slowdown of the crisis and of the profusion of global experimentation in teaching to think about physics teaching and see what could be built on scales larger than personal initiatives based on the experiences of many educators involved in their pedagogical practices.

The workshop led to several productions from a pure pedagogical practice – nevertheless, the participants and organizers also noted that the framework designed to host this event was also in itself a significant object to consider when it comes to wonder how to make innovation happen in higher-ed practices. In that sense, this article is also a contribution to general thinking on the format of academic conferences and how the design of a conference format can directly contribute to its success in terms of dissemination and knowledge generation [1-3].

In this report, we will first detail the organization of the workshop, and describe the different activities that happened during the two weeks of the seminar. In a second part, we will comment on some of the highlights of the workshop, sharing in our opinion what made this event a success, and an original proposition able to facilitate the development of innovation in physics teaching.

2 Description of the workshop

2.1 The organizers

The workshop has been organized by a team of 6 people, all involved in pedagogy and innovation. Julien Bobroff, Frédéric Bouquet, Lou-Andréas Etienne and Adèle Nyitrai are all member of the "Reimagined Physics" research team, affiliated to Université Paris-Saclay and CNRS. This research team investigates new ways of teaching and disseminating physics with various tools, many of them exploiting tools and methods from designers. The physicists Julien Bobroff and Frédéric Bouquet had previously introduced innovative approaches in their courses, such as the use of fiction and narration in some teaching activities, low-cost or open labs using Arduino for instance. Lou-Andréas Etienne and Adèle Nyitrai are both designers, therefore using their very approaches in the design of new teachings, and for instance, of some of the activities of this workshop that will be developed later.

Jeanne Parmentier is s a physicist, head of pedagogical innovation at Institut Villebon-Georges Charpak, strongly connected to research education networks. She developed a math course for students to follow at their own pace. s teaching physics at Institut d'Optique Grad. School, France.

Finally, Fabienne Bernard is teaching physics at Institut d'Optique Grad. School. She is involved in many pedagogical innovations on modern optics labs or low-cost electronics such as Arduino. She co-constructed a course with her students, on how to learn more efficiently with metacognition.

The teaching activities of all organizers significantly overlap within the premises of the Centre d'Expérimentation Pédagogique (CEP) from Institut Villebon-Georges Charpak, a structure entirely dedicated to innovation in teaching, and hosting several activities, such as a research action chair in pedagogical innovation sponsored by the university Paris Saclay in partnership with UQAM and supporting a dozen innovative projects within the scope of the whole university.

2.2 The participants

The ambition regarding the pool of participants was focused early on finding a balance between a focus on science and physics teaching by educators with a strong interest in innovative practices in teaching, but a significant effort to build a diverse enough group and to avoid homogeneity, seen as a potential threat to the effort of building innovation from a variety of experiences and viewpoints. While there was no specific profile directly aimed at when looking for participants, the idea was more focused on finding people acting locally in their institutions as innovators in teaching better than wildly recognized, inspiring figures of the community.

A first line-up of participants was pre-selected and personally contacted to be invited to join the seminar by the organizers. The very same participants were then asked to provide suggestions and recommendations for other people fitting to the same frame to get invited.

At the end of the day, the pool gathered around 35 people, mostly physicists with a touch a chemist, with a pronounced effort regarding gender balance (reaching a 60/40 male/female ratio). The level of involvement and experience regarding pedagogical innovation in teaching prior to the workshop was quite diverse, mixing strongly experienced people (around 2/3 of the participants) with youngsters or newcomers in the field, although sharing a taste for the matter (around 1/3).

In terms of nationalities present at the workshop, while the pool was strongly local and French colored, attendees joined from Belgium, Italy, Germany, Mexico, Uruguay and United States.

Fig. 1. The workshop participants.

2.3 Schedule and activities

The workshop was held over two consecutive weeks at the Institut Pascal at Université Paris-Saclay. The Institut Pascal organizes several call rounds to select projects to be hosted over several weeks within its building on the university campus. Successful projects have access to shared workspaces and offices that the participants can invest at will over the time of the workshop.

The program was designed in two parts, one week each, with a different spirit.

The first week was designed to make the participants interact together during activities with well-defined goals and framework, centered on the idea of experimenting the practices of other participants to the meeting. It helped participants share experience not only from a pure theoretical perspective and via formal presentations, but through the scope of living the thing to better acknowledge its strengths and potential weaknesses. The overall goal remained however to make the attendees feel themselves comfortable with each other and to build favorable condition to more creative and open activities to be held during the second week.

2.3.1 The first week: Building a team through living shared experiences

- ***Ice-breaking and team building***

The first day of the conference started pure ice-breaking activities, in an effort to build right from the beginning a team spirit between all participants. For instance, during the first activity, all attendees formed groups of 4-6 people and discuss with each other to explain their own personal reasons to attend the workshop. A second step followed, where members of the group have to introduce their partners in front of all other attendees. Other similar ice-breaking activities were organized for this first half-day of conference.

All activities of this first week (around ten in total not including keynote sessions), happened in small groups, forming often spontaneously, with people strongly encouraged to mix teams from one activity to the other. Activities included both teamwork in groups of 4 to 6 and short interactions with face-to-face discussions and collective restitutions to the whole group.

Figs. 2 and 3. In this ice-breaker, participants had to build a tower with paper and a vertical smartphone on top in 10 minutes.

- ***Brainstorming, and listing practices***

Two activities during the first week were dedicated to a collective work aimed at listing many of the pedagogical practices, either installed by the attendees, or experimented and known or even envisioned by some of them.

In order to elaborate this state of the art, participants were asked to interview their peers through the scope of various topics (digital tools, labs, remote teaching…) to fill in some template sheets. The templates were designed to provide a fast overview of the practice exposed by the participant, and to facilitate the aggregation of the production in the perspective of feeding the content of a future website, developed during the workshop and recently completed.

The scope of topics discussed during these activities expanded beyond the border of talking about physics only towards other social and societal considerations, such as inclusivity, emerging countries, or global warming.

- ***Low-cost hands-on experiments***

The attendees were asked to form teams and to design a very low-cost physics experiment for a lab course in a seriously short amount of time (around 90 minutes), being provided only basic resource (paper, tape, pens, play-doh, cups, wire…) and respecting a set of randomly assigned. Constraints (such as making their device as small as possible or being able to survive a high fall). The facility at Institut Pascal, that includes a massive set of stairs surmounting a wide central hall, has inventively been taken advantage of. Groups proposed devices based on pendulums hanging from the top of the stairs; another group could investigate the deformation and compressibility of concrete pillars supporting the building by using a laser shining its beam onto a mirror whose rotation follows the motion of a pillar pushed by the experimenter.

A second activity was inspired by the teaching activities designed by Frédéric Bouquet and Julien bobroff at Université Paris-Saclay and based on the idea of introducing fiction and narration to set a fun and immersive context to a lab work activity. Once the basic ideas behind this activity were explained to all participants, one must note that a quite strange (and

quite disturbing, in our opinion) event happened when the video projector of the conference hall was suddenly hacked to display the live video message from a French spy, under cover in North Korea. This spy had miraculously got the news that an exceptional gathering of French physicists was taking place at Institut Pascal, the only facility he had a direct connection with. A remarkable line of events, that allowed our desperate colleague to ask for help: he needed to get a low-cost solution to pass a smartphone, securely, and stealthily, in order to provide all its secure data across the border between North and South. Few hours remained before our spy could effectively make an attempt, so all participants were asked to form small groups and work parallel to invent a device that could help a smartphone survive a 7-meter drop, fall in less than 2 seconds and make enough noise to bring attention of a spy missioned to retrieve the smartphone without having the phone being filmed during its fall.

Figs. 4, 5 and 6. Various hands on activities held during the first days.

This activity reinvested many of the features of the previous one: short amount of time, constraints, and a friendly but competitive touch. This time additionally, attendees were being asked to form a wide consensus and designate the winning team, based on the performances of their design within the set of constraints.

- ***Keynote sessions***

All afternoon of the first week started with a 1-hour keynote sessions, questions included. During these sessions, some of the participants had the opportunity to give an outlook of their "iconic" practices or insights regarding innovation in pedagogy, mostly for aspects of their practices that cannot be shaped into hands-on sessions during the seminar. Topics of these keynotes included the presentation of a frugal fablab, the design of a whole lab work course exploiting Arduino and smartphone physics, introduction to the activities of a network of physics educators, or personal experience involving dialog between physics and architects.

2.3.2 The second week: Creative thinking and production

The originality of the program of the second week lies in its almost official inexistence. The kick-off of the second week consisted in the collective definition of the framework for the remaining few days: participants were encouraged to think to the topics they would like to investigate and spend some time on, in the very broad acceptance of the workshop topic "Reimagine physics teaching".

Based on the synergies of the first week and on the topics of interests, several "projects" emerged, with the ambition of making the most out of the few remaining days, and to reach

a "real", "concrete" level of production. We report below a brief description of the different projects that were formed and on their production.

- ***Teaching in the forest***

One project was dedicated to design a new teaching session taking place….in a forest. It took advantage of the actual forest 50m from the location of the workshop. The activity was designed as a potential first step toward climate change teaching and also to help undergrad students better understand the interest of physics in larger problems.

Several collective discussions and debates taking place in the forest were followed by works in smaller groups to elaborate a recipe for a full day teaching activity for an audience on the order of 30 students including learning outcomes, a schedule, scientific topics to be investigated and possible experiments. Alternative solutions are included for a more urban environment.

This recipe has been collectively written and is now shared online. The entire project was built in 2 days.

Fig. 7. A meeting about the teaching in a forest... in a forest.

- ***IPSEN: An international network for physics teachers***

A recurring question among some of the participants was the importance of installing a more global trend towards training new generations of physics teachers, and new faculty and making them aware of practices, and continuing interactions among people all over the world to keep on exchanging practices and insights.

Some participants have dedicated some of their time to designing a proposal for a new type of network that could benefit from the momentum installed over the two weeks of the workshop. At the end of the week, this group had produced a complete presentation

explicating the principles behind the envisioned networks, its scope and missions, with potential leads for funding for institutional support.

- ***"Teach me anything", troubleshooting and short keynote sessions***

The rather fast pace of the conference favored exchange of knowledge via informal short discussions during coffee breaks or lunch, when people were not explicitly working on their projects. During the second week, the format of the keynote was modified. Participants were invited, on a voluntary basis, to exchange on their practices and to give their own tips during shorter, 30 min post lunch coffee breaks. This gave the opportunity to discuss a broad range of topics, often related to situations routinely encountered in class, such as designing assessments, working with digital tools, dealing with level heterogeneity in a class, but also more original personal experience, involving for instance music or theater in teaching and dissemination activities. On the same note, the participants seized a similar opportunity to share their experience regarding problems they face in their own teaching during a self-organized a "Troubleshooting" session. Among the issues listed, participants mentioned the difficulty of dealing with a heterogeneous group of students In terms of academic level, or improving student engagement in their own learning in flipped classroom formats.

This was followed by an emerging format of activity, at the crossroads between the short keynote and the hands-on experiments format of the first week: the "teach me anything" session. During this session, several participants supervised a short activity based on their insights and methods for teaching. All activities were proposed consecutively so that 2 hours were dedicated to all activities of the session. Participants were introduced to an innovative way of dealing exam sheets (!), or asked to put in practice the fast-prototyping design methodology to create a way to present the concept of the "teaching in the forest" problem. They also learned some relaxing/fun activities to have with students, involving mimics, dance and music.

- ***The debriefing session***

On the last hours of the workshop, a collective debriefing session was held. All participants were asked to tell others what thing they would remember form the workshop and what they would really take with them and maybe use in their own teaching to improve it or make it evolve. During the conclusion session, spontaneous discussion also significantly helped to clarify what was appreciated by the participants during this workshop, what made it a different and original experience, and what could be envisioned in the future regarding the outputs of this workshop. The participants stressed the importance of the group energy and confidence buildup via fun group activities, and how it positively influenced the ability of the different groups to work efficiently during the second week.

The goal of the next section of this report is to discuss and comment the outcomes of this event. It is difficult to evaluate them in terms of successes and failures, as the format of the workshop itself did not privilege any explicit "goals" in any sense. Moreover, an important ambition behind the project of this workshop lies in the impact that such an event could have, knowing that many different scales could be considered for observing such an impact, from the single classroom to more institutional levels. In the next section then, we will present some of the impressions gathered during the conclusion session, discusses and rediscussed after during informal discussions between the organizers and participants, in order to put some words on the specificity of the workshop, and its potential to favor innovation in pedagogical practices.

3 A format of conference favoring creativity

3.1 The usual science education conferences

All participants agreed on the quite original formatting of the workshop. The practice of discussing pedagogical practices between peers or with colleagues at institution often consists in informal discussions, sometimes more extended collaborations and projects built with colleagues identified as "allies" within one's own institution.

On the other hand, some of the participants were part of educational sciences conferences, that adopts a very standard lecturing format of oral or written communication (ESERA, NARST international conference…).

In other words, traditional schemes of collectively discussing pedagogical practices are rarely associated with producing innovation in teaching in any form. This is exemplified by the personal experience of many of the participants, coming from various institutions, and often leading individual if not solitary efforts to implement new practices, occasionally ceasing the opportunity to interact with peers on the topic, but remaining at the entire initiative of their projects in their institutions.

3.2 Favouring creativity and innovation in a physics teaching conference

A major asset of the workshop was therefore to set the ambition, straight from the beginning, of making the workshop and the Institut Pascal an environment to actively and explicitly build and experiment innovative content, there and now. In that perspective, the design of the conference was an important step to try to overcome the usual passive format of academic conferences to improve learning, dissemination and creativity, as is also explored in other fields and contexts [1-3].

The role of the first week is then to help building the conditions to favor an environment promoting creativity and innovation, by acting on several levers.

A first effect of the first week was ***to make participant learning how to work together,*** *through various team building, brainstorming and hands-on activities*. Affinities and synergies between people that did not necessarily knew each other beforehand were therefore quite established at the time of forming new groups to work on the second week projects, as well as a more diffuse climate of proximity, dramatically decreasing self-censorship or natural inhibition.

This climate of forming a short-lived but tight community was also reinforced by the physical environment set in place for the conference: a beautiful, shared place designed for people to come and work together at Institut Pascal, within a lab environment (that is, not a conference center), providing food and drinks, thus playing an obvious, but quite welcome social role in the process. Importantly, the organizers have been allowed to use freely a variety of places inside the institut Pascal itself, and to rearrange the settings of these rooms at will. The reccurring meeting point of the conference was arguably the "cathedral", a central spot at Institut Pascal. The cathedral is furnished with tables and sofas, but the whole room could easily be reconfigured so that several types of activities have been held in this space : works of the participants have been displayed on the blackboards, windows and walls ; short keynote sessions in a much more informal atmosphere ; some hands-on activities as well. The main hall and its set with stairs was a good spot for hands-on activities requiring a lot of horizontal and vertical space. All participants could have access to "private" office to work freely, individually and quietly on their own projects. One of the office was transformed in a photo studio to take pictures of the participants and also for the designers of the team to coninusouly work on the conference website. The rooftop of the Institut has been extensively used for coffee and lunch breaks. One must highlight that the complete freedom experienced by the organizers regarding the way they wanted to exploit the premices at their disposal made all processes significantly easier, allowing them to

adapt the activities to what seemed to be the most suitable settings almost in real time. Quite notably, the graphical identity of the workshop was designed beforehand by the designers among the organizing team. From the participants ID cards to the numerous tools and templates and decorative items used during creative sessions, to the final production of a website summarizing the conference, the use of a homogeneous graphic design over the course of two weeks contributed to giving strong identity to the workshop, thus reinforcing the cohesion.

Design has been even more influential and key to the success and productivity of the conference. Indeed, most of the planned, supervised activities of the first week were exploiting heavily, if not entirely, techniques inspired from designers or the makers movement. In particular, one should mention the importance of the fast-prototyping techniques. These techniques based on the use of cardboard, paper, pen and ither low-cost material to rapidly materialize ideas have been extensively used in applications such as the design of physical interactive interfaces, services, sofwares, apps or services [4-8]. The hands-on activities involved small groups of participants to create something in a very short amount of time, therefore considerably constraining the participants into taking decisions fast, abandoning high ambitions to make ideas converge rapidly, and form rapidly a consensus within the team. ***Putting the fast-prototyping technique in practice at different occasions during the first week acted as a powerful training towards the second week,*** where the constraints were not explicitly set in place through the rules of activities, but by the limited time of the conference itself and by the initial spirit of the conference: making something out of it. This very lever has been regularly re-activated by the organizing team in the last few days of the conference.

In summary, the two-week structure provided enough time to install a first stage of the conference, focused on the exchange of practices but installing a place, a format and a philosophy of activities improving team building and naturally providing conceptual tools and methods to the participants, designed to enhance the creativity, productivity that is at the heart of the second week of the program. Although this two-week structure faces the obvious but serious disadvantage of making it harder for many people to attend to such an event for its entire duration (considering professional duties and additional difficulties for international participants to join for extended time), the coherence of the program supported naturally the emergence of a significant number of projects and ideas, out of a quasi-non-existent program for the second week. The time constraints, usually playing a role of inhibitor in many situations was here activated as a catalyzer within the spirit of fast prototyping.

4 Perspectives

This workshop had no planned follow-up event prior to its beginning. Designed and imagined essentially as a one-shot event, the question of outlooks and dissemination was part of the interrogation that the participants had to answer at least partly themselves.

A key production of the workshop is a website, centralizing all productions of the workshop, that is the reports of the different supervised activities of the first week, as well as productions from the projects of the second week, but also including new formats of activities that spontaneously emerged over the course of the conference. The website was imagined in line with the graphic design and identity of the workshop. In term of further dissemination, communication efforts have been performed online and via social networks (and Twitter in particular) to advertise the launch of the website to the academic and physics teachers' communities. An article has been published in the online media "The Conversation", and is focused on discussing the specific format of the conference.

Other outcomes from the seminar are deeply connected to the human component of the workshop. The pool of participants shared a lot prior to the meeting: a solid affinity with

innovation in pedagogical practices, an affirmed taste for science and physics obviously, but also professional situations that leave them often isolated, and sometimes demotivated. For many of the participants, the meeting was the opportunity to build friendly connections, that many intend to maintain through informal and non-necessarily institutional exchanges, and with some collaborations already in mind. While networking is at the heart of the concept of scientific conferences, it is often limited to a bare exchange of contacts, preceding more established exchanges, often when visitors are all back to their institutions. Both the structure of the workshop and the workplace at Institut Pascal allowed all participants to have much more exchanges than in a regular conference, and to engage into common projects before leaving the conference site.

The dissemination of the results and outcomes of the seminar relies at large extent on the personal initiatives of the participants, many of them stating their intentions to rethink their own teaching and try to implement some of the practices they discovered during the seminar, but also feeling re-energized and willing to share their experience with their colleagues. In that sense, the motivational and team building component of the meeting must also be considered as one of the main engines regarding the longer-term effects of this meeting. The opportunity of planning another meeting in the upcoming years and its potential format has been only briefly discussed.

5 Conclusion

In this report, we presented the activities held during a two-week workshop initially centered around the exchange of pedagogical practices in physics teaching and the collective design of new activities. The community of participants was chosen with care to allow for some diversity among a group of very engaged participants. The conference was based on a two-week structure, with all participants hosted at the Institut Pascal and sharing the same premises during workdays for the whole conference.

A first week with a strong team building component made the participants share some appreciable amount of time working together on supervised activities. These activities were designed to make the participants use methods and tools from the designer community and enhancing creativity and productivity. These tools and the sense of community developed during the first days were then re-invested during the second week which led to several original productions is a short amount of time.

The philosophy behind the workshop was centered around the idea of experimenting and trying things. In that sense, the seminar was not only the place to discuss practices in physics teaching, but also to experiment new ways of working together and to foster innovation in pedagogy.

The serious constraints of the chosen format (participants being required to be present for two weeks; many time-limited activities to supervise and requiring dynamism and reactivity from all attendees; heavy organization including a strong design component) led to catalyze the efforts of the participants into a highly creative event, and could inspire the community of faculty for future events.

From our perspective, innovation in pedagogy in general, and in physics teaching in particular cannot rely only on individual initiatives. It must be a long-lasting community effort. The format of conferences gathering this community is therefore a crucial issue to transform these efforts into successful sustainable changes and widespread collective practices. As exemplified several times in this paper by the activities performed by the participants, physics teaching is strongly entangled with experimental teaching, and virtually all educators present at this meeting had a connection with experimental physics at some point. When it comes to organizing a conference in pedagogy, we advocate in this paper for

a format based on this affinity between the participants and experimental physics: considering physics course design itself as an experimental process, framed by fast feedback loops, and encouraging educators to not only reflect about their practices and to think about new ones, but also to experience them with help of other fellow educators.

All the workshop productions and formats are detailed in the website:
https://hebergement.universite-paris-saclay.fr/supraconductivite/physics-teaching/

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