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OPEN
SCIENCE SCHOOLING



INTEGRATING OPEN SCIENCE SCHOOLING IN SECONDARY SCHOOLS POLICY RECOMMENDATIONS

Recommendations for policymakers on how to support
the integration of open science schooling, including
recommendations for further research and
experimentation

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The Open Science Schooling Project strongly recommends translating the paper into national languages to make the messages more easily accessible to policymakers.

PREFACE



“While a shift in educational discourse has been observed in many countries, too many practices remain unchanged.”

UNESCO, “Education research and foresight”, March 2019

UNESCO’s statement is not from the 80s or the 90s, but from 2019. One of the practices that requires changes is science teaching. These changes are of course a great challenge to educational policymakers at all levels, which makes the need for Open Science Schooling extremely fundamental.

The ultimate objective and mission of open science schooling is to offer (young) students fundamentally new experience with science, allowing them through this new meeting with science to create new mental images of science and a life in science.

Such new meetings with science are expected to:

- Make young students re-engage in science learning
- Make such re-engagement sustainable
- Open the doors to further studies in science and to science careering
- Allow a more gender-sensitive approach to science and a life in science, attractive also to female students
- Encourage critical attitudes towards science in society, in particular in times of escalating climate change crisis

Joint science education research agrees that the undertaken “modernizations of science education” did not yield the expected results.

Such “modernizations” consisted and still consist of

- Punctual out-of-school activity
- Integrating technology in classroom teaching
- Inviting science professionals to the school
- Students’ participation in science events and competitions
- Various forms of “gamification” of science education
- Introducing more team-based and problem-based work forms

All these “innovations” are well-intended and in general positive, but research and experience show that these initiatives work well for the students already dedicated to science, whereas the initiatives are not fundamental enough to re-engage young students building resistance towards science.

Open science schooling is, strongly guided by the European Commission, a much more fundamental change in the young students’ meeting with science.

Therefore open science schooling is based on a clear set of quality criteria, described in Part 3 below.

The problem is, though, that precisely because open science schooling represents a **fundamental** change in the students’ meeting with science, open science schooling is also more **demanding**; for schools, teachers, students and community collaborators.

It is not demanding to take the students to a stand-alone science event, but very demanding to engage student teams in long and deep science challenges in the community.

As always, the easy way usually does not work, whereas the hard way creates results.

This is the background to this Policy Paper from the Erasmus+ Open Science Schooling 30 months project: schools, teachers, students and community collaborators call for support from local as well as national policymakers to help them make open science schooling a reality.

The position of the European Commission has been clear for a long time: the Commission strongly encourage authentic and uncompromised open science schooling for young students at all education levels - along with big internationals such as the OECD and UNESCO, by the way.

The problem is that European policies and guidelines have not been followed up at national or local levels.

The current Policy Paper is based on 30 months of practice, interactive dialogues with schools from all over Europe and with experienced higher educations, and on critical review of state-of-the-art open science schooling research.

The mission of this Policy Paper is to deliver experience-based recommendations to national and local policymakers in the field of science education: how can they support such open science schooling practice in their country or in their community?

“Experience-based” means that the challenges that should be addressed by national and local science education policymakers have been extracted from the long and hard-working Open Science Schooling project, including through interactive dialogues with all partners, schools as well as academic partners.

Obviously, there is no manual for such support.

Support from policy to open science schooling should result from dialogues in the community or in the country between policymakers, schools, teachers, students and relevant science education collaborators.

The aim the Policy Paper is to help guide such dialogues and to help focus on the most important challenges.

This is why the challenge-based texts below include a variety of input:

- a) **A brief introduction to the challenge: what is the problem?**
- b) **Input from project partners linked to the challenge: what does the problem look like from an educational point of view?**
- c) **Recommendations for policy action: what can policymakers do to address the challenge and support open science schooling?**

The partner input is unedited, as the project wish to deliver authentic voices from practice. The recommendations are divided into national and local policy action, as these policy levels are very different.

Easily seen from the texts below, national and local policymakers can engage in a long line of initiatives that give substantial support to making open science schooling a reality.

A general recommendation to all policymakers in the field of science education is:

It is time to move from administrating education to initiative-taking and pro-actively creating educational policy based on long-term development needs.
If not, we risk losing Europe’s young talent.

POLICY SUPPORT

PART ONE - POLICY SUPPORT TO OPEN SCIENCE SCHOOLING

NEW MENTALITY



How can teacher educations create a [new mentality](#) among new generations of science teachers throughout their professional training? How can policy support such innovation in professional and further teacher training?

Intro

One of the big challenges in innovation of science learning in schools is traditional science teacher mentality. For ages science have been taught in a teacher-centred way in secondary school, based on a precise curriculum and based on teacher-led activity. Science teachers are not known to be among the most innovative teachers.

It is a fact that any innovation in science teaching needs to go through the science teachers. This is how our education system is constructed and how it works.

This means that European or national initiatives in the field of science education, no matter how innovative they might be, are depending on the mentality of the science teachers.

Individual science teachers might dedicate themselves to various forms of science learning innovation and even serve as role-models, but this will not change the general mentality.

The only powerful way to help change science teacher mentality is to engage present science teachers as well as the new generation of science teachers in open science schooling activities through which they can create new images of what science learning could be and how new forms of science learning could benefit 21st century students.

Open science schooling cannot be learned in the institutions or through new material, no matter the possible high quality of such material. Like with entrepreneurial competences, open science schooling competences must be learned through practical activities.

Obviously, it is equally important to address the new generations of schoolteachers along their initial training and science teachers at work. Including open science schooling training in basic teacher education and for science teachers at work is rather demanding, and therefore it takes strong and goal-directed policy initiatives.



What the partners said?

“New technologies and education are transforming the way how we live, work, play and think. And it’s happening more quickly, and on a larger scale, than at any point in human history. The young teachers and the old ones need to adopt to the new environments and requirements to equip today’s young people with the skills to live in tomorrow’s world. Even if we don’t know what it looks like yet. Now that information is widely available, students and teachers can take bigger amount of ownership and guide their own learning.”

“It is difficult to plan teachers' needs in advance (e.g. training) because the needs for the classes will be very much individual and they will depend on the subject and students’ interest. So, designing such training for teachers is really demanding, but really needed.”

“Even small changes lead to the bigger ones; never give up trying new methods and approaches. Educate yourselves to stay up to date with your students and make changes every time you have an opportunity- for example, changing work plan, pace, setting a different atmosphere, etc. Promote collaborative learning and give opportunities to students to participate in planning and carrying out learning goals, topics, different ways of working and evaluation. Doing all this will lead to changing your life or life of your students. Make these methods become a vitally important part of your life.”

“Most classes take place in a school building. Lessons in which students sit in school benches and the school lessons should be varied with this Open Science Schooling methodology, which would cause interest in the topic of the class. So, it makes even harder for designing such training. But it should be pointed out that this methodology requires meeting students’ interests.”

“A constant training of teachers to provide them with new “tools” is important given the constant challenges that education imposes on us. Being able to develop the concept of “Open Science Schooling” in teacher education is extremely crucial to making this concept more easily developed in schools. It is normal for teachers to reveal distrust, discomfort and concern when using new techniques, methodologies in the classroom. This issue can often lead teachers to create resistance to change, to bring down the change one wants to make. In this sense, continuous formation has to be planned not as an isolated process, but as a continuous process. This process can support, trust and encourage the teacher to make the change that is needed in their methodologies. In order for the concept of “Open Science Schooling” to evolve, continuous training is required that can meet the daily demands of the evolution that occurs over time. This evolution stems from the obstacles that are encountered and the new strategies that need to be developed, but this is only possible with the constant monitoring of teachers.”

“A consistent and comprehensive policy strategy that reconciles the school with teacher education, the challenges of our society and the interests of students is needed. The creation of these strategies and objectives would be of enormous support to teachers and schools for the development / introduction of new methodologies / concepts in teaching and in this case in science. This strategy would have to encompass other institutions / companies and professionals outside the school.”

“New mentality in the context of OSS project refers to the receptiveness and willingness to implementing and facilitating innovative pedagogical methods. In order to foster these attributes among pre-service teachers, the teacher education curricula need to make some inclusions. This should start with acquainting teachers with the principles of progressive education which sees the development of experiential education. A periodic reinforcement of the fact 21st

century needs its teaching professionals to be adept with skills that make them efficient in their profession. Building a mind-set that does not deter from accepting innovative changes must be undertaken. “

“Teacher training curricula must train teachers to facilitate innovative pedagogies that foster the 21st century skills, where teachers themselves practice learning-by-doing in a real-world context and reflect on their learning experiences, post facto, meanwhile building strong connections with the community. Pre-service teachers as a part of their lessons must be engaged in problem-based/project-based, inquiry-based, service-learning enterprises where they have the opportunities to understand how learning happens in a real world. Such first-hand experiences they have themselves, will help them facilitate innovative pedagogies effectively, regardless of the discipline. (Add inclusiveness of learning and the teachers need to be trained to be inclusive at different levels).”

“Three things that create a new mentality among new teachers during their training:

1. “Walk the walk” and not just “talk the talk”, teachers should be taught in the same way we want them to teach. Their training period should be an excellent example to the way we want them to teach.
2. We need to introduce the new teachers to an existing science teachers' community, where they can get advice, support, share materials and more.
3. There should be a deliberate, active discussion about new vision for teaching not only in teacher training schools, but also in the schools with the science staff.

It would be good for teachers, during their training to be provided with experiences demonstrating open science schooling, and being provided with examples to be used, directions to think in, and develop further.”



Policy recommendations

National policy can:

- Include solid open science schooling training in initial teacher education, based on teacher student engagement in authentic open science schooling activities in the community in collaboration with local secondary schools
- Offer workshops, seminars and similar at national level to science teacher students
- Encourage more flexible collaboration between science teacher students, secondary schools and community collaborators
- Invite real-life science challenges into the teacher education
- Create or support national level open science schooling training activities for science teachers at work, for example in collaboration with national teacher training institutions
- Help develop relevant assessment methods to evaluate the students' open science schooling learning

It is strongly recommended to make qualified open science schooling training resources available at European and national levels.

Local policy can:

- Assume the role of the driver of open science schooling in the community, bringing schools, science teachers, students and possible community collaborators together
- Help sustain and expand such activity
- Give useful resources to the open science schooling activity

- Support the sharing of open science schooling initiatives across the community, including involving all relevant sectors and the students' families
- Organizing teacher training courses in OSS format

BLENDED LEARNING ACTIVITIES



How can local and regional educational authorities help build open science schooling capacity among science teachers in secondary school, for example through [blended learning activities](#) integrated in the professional life of the teachers?

Intro

Open science schooling is about learning science through engaging in real-life and real-time science challenges in the community, science challenges important to the students as well as to the community. Usually such engagement will take on the form of local science missions that might be linked to global online resources along the learning process.

The challenge is that such science missions include long-term community engagement, collaboration with relevant community resources as well as integrating on demand science knowledge along the missions.

Science teachers at work can only build capacity to guide and facilitate such student activity through practical training. Regardless of hours spent learning about open science schooling online or in teaching rooms, the most important capacity building is the direct involvement in open science schooling activity in the community, and in collaboration with student teams and community resources.

This poses a problem to open science schooling training of science teachers at work: most teachers are under increasing work pressure, have very little free time for experimentation and are forced to push the students towards successfully passing a test or examination.

How can science teachers engage in open science schooling training on these conditions?

The best option is blended learning distributed across considerable time periods, such as a semester or a full school year. Why is that?

Because:

- Such training offers a flexible combination of online learning (individual or in teams) and practical open science schooling activities
- Distributing the training across longer time periods allows better learning, including time to reflect and time to change course if needed

- This training format can be more flexibly integrated in the curriculum than short-term and less efficient training courses
- The training format integrates open science schooling into the everyday science learning community (teachers and students) in the school
- The blended learning format allows the science teachers to participate in solid and authentic open science schooling activity in collaboration with the student teams, relevant community resources and the students' families
- It offers the science teachers practical skills to create open science schooling for the students combined with on demand science knowledge

In short, such open science schooling training offers the science teachers concrete personal experience and not just elements of knowledge.



What the partners said?

“First of all educational authorities should give free choice to teachers in their teaching e.g. topic selection, number of hours spent in activity or the connection they want to create with local community etc. But the teachers' choice should depend on the students' interests and school potential.”

“One of the measures would be to change the evaluation paradigm, if we want to introduce new methodologies we will also have to change the way we evaluate. Another measure would be to change curricula, which are outdated and out of touch with the reality of students, society and their challenges. Another measure is to facilitate the networking process of companies / institutions and the school. These networks would be a huge support in the implementation and development of the Open Science Schooling concept.”

“OSS capacity building must start at the grass-root level, i.e., right from the school, facilitated and fostered by the school administration. Schools and their surrounding communities are not isolated from each other; therefore, a strong connection must be forged between these two entities. The community-school partnership could possibly encourage teachers to adopt hybridized methods of facilitating science learning in the community set-up. This is another way that in-service teachers' can build their capacities, i.e., through being active participants of community and involving students and community members in a shared activity.”

“In Catalonia the Department d'Educació implements a new Project: STEAmcat in order to change the mentality of the teachers of 21st century that includes some issues about OSS. The 50 schools that participate in the project carry out several workshops during the 3 years of the implementation with different examples of bended learning and many experimental activities.”

“In the Finnish in-service teachers context, officially there are three mandatory in-service training days for every teacher each year. The teachers are encouraged to use these days for professional enhancement and capacity building, and any such relevant activity is paid for by the school. This model can be used as an exemplar to promote teacher's capacity building, in the partner countries. Since teaching is a learning process in itself, a constant actualisation of teachers' own skill sets to enable them to effectively perform in their professions, must be given priority.”



Policy recommendations

National policy can:

- Collaborate with national teacher training providers to design and organise such blended learning activities
- Support the creation of qualified online open science schooling material for the blended learning training
- Help create an understanding among schools and science teachers of the urgent need for such science learning innovation and at the same time promote the blended learning training among science teachers
- Develop a reward system for science teachers working through the full blended learning training, including professional merits
- Help develop a relevant evaluation method for the blended learning training

Local policy can, based on such national initiatives:

- Support the open science schooling activity in the blended learning training, including through bringing relevant resources in the community together
- Help the school and the science teachers organise the open science schooling missions in practice
- Actively share the open science schooling training in the community, in particular among other educations
- Help sustain the initiated science missions in the community, including allowing more students and community collaborators to participate
- Make the science missions useful to the community, including engaging groups of citizens in the missions, such as groups of seniors

RESOURCES



How can policymakers promote open science schooling [resources](#) such as the resources provided by the project?

Intro

National and local policy can, of course, help create resources for open science schooling, as discussed elsewhere in this paper. However, they can also help promote, use and share available open science schooling resources. This is a very cost-efficient way to give support to open science schooling initiatives at all levels.

Even if a science teacher team in a secondary school is dedicated to start experimenting with open science schooling on their own, it will be difficult for them to access resources they need to prepare and inspire them.

There are typically two types of recourse they would benefit from:

- Open science schooling projects, initiatives and best practice, including lessons learned from these initiatives
- Community resources for the student teams' science missions

BEST PRACTICE

A well-known challenge for secondary schools and science teachers is that they do not have (easy) access to initiatives, projects or best practices from which they can learn about open science schooling.

Schools and teachers are overwhelmed with electronic communication, curricula changes, PISA tests - and too many students in the classes. Against this background very few science teachers in Europe are able to identify and explore good open science schooling resources.

To break through the 21st century noise and stress, very special and dedicated initiatives are needed.

Public education authorities are at the heart of this.

Science teachers engaging in open science schooling with their students should have access to quality material, including best practice, projects and lessons learned.

To a certain extent such resources might be found at European level, but the European level involves several complications:

- It can be extremely time-consuming to identify the relevant resources
- The European resources are often complicated, academic or created in another context
- Most European resources are in English only, and even if some science teachers master some level of English it is much more attractive to many science teachers to work with material in their national language

This calls for strong national initiatives.

Most national education authorities have the needed economic power to undertake national science learning initiatives or to outsource such initiatives to for example a teacher education or a national research body.

What the science teachers need from national resources is:

- Easy access to the best open science schooling projects and experiments, in national language and edited form
- Easy access to lessons learned, guidelines and similar created by open science schooling initiatives

COMMUNITY RESOURCES

Science teachers dedicated to explore open science schooling with their students will definitely face another obstacle: how can they, given their limited resources, help their student teams create open science schooling communities for the science missions?

This challenge should be addressed at local level, unlike the best practice resources described above.

Only at local level it is possible to bring together the most relevant players in the community to collaborate with the science teachers and the student teams in the science missions.

Therefore, initial access to such science learning communities is a very high priority for science teachers entering the world of open science schooling.



What the partners said?

“Of course local officials and school management responsible for education should know and be aware of what is going on at school, what are the projects, needs, progress in the project and final results. When they know they could promote such projects among other schools in the region by presenting the final outcomes of such a project. They could organise educational day where all schools could present their best results of the last years. We think, inspiring each other is a good solution and teachers from other schools do not know too much of what is going on in other schools.”

“Creation of a working group to provide support and tools to teachers.
Development of meetings with other schools for greater knowledge sharing.
Provide schools with more means to implement projects.
Change the physical spaces so that activities and workshops can be developed.
Create favourable conditions for the implementation of partnerships with companies / institutions of the surrounding environment.
Support the dissemination of projects at local, regional and national levels.
Provide schools with more and better technologies and better internet.”

“When it comes to educational resources for teachers and students, we suggest the creation of online platforms, websites and forums which help disseminate knowledge and best practices of fostering OSS schooling. In other words, “spreading the word”. A transnational forum at EU level for open and relevant discussions must be established. Educational resources for teachers’ capacity building are strongly implored.”

“When it comes to material resources for future application of open science schooling, we would like to advocate actively involving the community partners. Recycling, refurbishing material resources for science experiments can be found in such places. Alternatively, crowdsourcing, donation drives, fundraising activities; all planned and carried out by the school students must be considered. This is one of the ways to foster entrepreneurship skills in students. Of course, these activities must be conducted under the guidance and supervision of school personnel.”

“The best resources for the teachers participating in a project as OSS are the support and encouragement of policymakers, and especially of the school managers.
It is fundamental that the manager team of school participates in the project or encourage the team of teachers involved in the project.”

“The main thing that teachers need is time with their colleagues to work together on creating such activities.”



Policy recommendations

National policy can:

- Create an open science schooling unit producing easy-to-use guidance and inspirational material from various forms of open science schooling best practice, projects and initiatives from European and national resources
- Make such material attractive for science teachers and promote the material across the country’s secondary schools

- Ensure the relevance and practical usability of the resources, and that the results are delivered in national language
- Ensure proper updating
- In certain cases outsource such a unit to a teacher education or a relevant research body
- Granting interdisciplinary projects as well as international projects like e-twinning

Local policy can:

- Use its networks to bring together relevant science resources from the community to collaborate with the open science schooling initiatives
- Ensure that science teachers in this way have access to a community of dedicated collaborators, such as science bodies, companies involved in important science challenges, NGO's and citizens' groups engaged in science activities in the community, etc.
- Support the school in becoming an "agent of change" in the community, as recommended by the European Commission
- Ensure that the open science schooling collaboration and initiatives are used in the wider community and for community benefit

SCIENCE CURRICULA



How can [science curricula](#) be adjusted to include dimensions of open science schooling? What innovation in science curricula would be needed?

Intro

While a shift in educational discourse has been observed in many countries, too many practices remain unchanged.”
UNESCO, “Education research and foresight”, March 2019

It is sometimes a major challenge to science teachers and their schools to find creative ways to integrate such learning innovation as open science schooling in the curricula. This is discussed elsewhere in the paper. Another challenge is to adjust and adapt science curricula at national level to the 21st century reality - and to the future.

In general, science curricula across Europe are increasingly overcrowded and restrictive. National policymakers are sometimes more concerned with the competition between nations (how well are our students doing in math?), and less concerned with providing relevant learning opportunities for the students. In our neo-nationalistic Europe, this tendency is continued.

This happens despite mountains of evidence that restrictive curricula do not in themselves lead to good learning. It will take a sea change to innovate education in Europe, says the Commission, and it is naive to expect revolutions in the national curricula.

However, national education authorities are free to give less priority to the competition between countries by at least adjusting education curricula to the needs of the students - and society at large.

They can do this without re-constructing the entire science curricula system by:

- Generally loosening the grip of the curricula and the schools' study plans and giving the schools more freedom
- Cutting down mandatory study to a volume of on average four days a week, leaving one full day per week to experimentation
- Encouraging more project-based work forms across the curricula
- Encouraging schools' use of relevant community resources

Such curriculum adjustments should be accompanied by partly leaving the teachers' old trade-unionism and opening up to more flexible work forms, in and out of school.



What the partners said

“To adjust the topics would not be a problem as the topics of OSS and the ones from the curriculum are very much alike. The innovation is “Active” or “Problem-based” learning which seeks to engage students' natural curiosity, rather than presenting them with information. Instead of saying “Here is stuff to remember “, we say, “Here is the problem to solve” and the students get involved in that problem.”

“So, the science curricula can provide some basis in some context but should be more like open area of science where different teachers and schools could use their best potential. Thus, we would not suggest putting into the curricula any specific and more detailed subject.

I think that the biggest problem is the material (curriculum) at school which is overloaded, which means that there is no time for the implementation of other important activities.”

“Curricula should be based not on concepts and concept learning but on processes. The curriculum should be more geared to continuous project learning and not as airtight. A curriculum based on essential learning allowing the school to develop new learning, according to the interests of students and the challenges of our environment.”

“The structure of curricula delivery must be made flexible to facilitate students to actually practice learning-by-doing. From practically applying theory learnt in books into real life scenario and fostering reflection on the experience, to help understand the meaning of learning.”

“It is necessary that the subjects should be more transdisciplinary. It is impossible to implement a project as OSS in isolated subjects. It is necessary that the project should be a school project, where the teachers of different subjects are involved.”

“Incorporating research skills into the CURRICULA instead of more information and teaching of Concepts. Encouraging experimentation and personal investigating, on the basis of individual' related interests.

There should be more emphasis on teaching and exercising skills and in depth learning of topics instead of many different topics to teach.

Also, giving teachers a choice between few topics, so they can choose the one they are more interested in or feel that they can teach well and would be more confident to explore methods like open science schooling with it.”



Policy recommendations

National policy can:

- Loosen the grip of national science curricula
- Pay less attention to competitions between nations and more attention to the long-term needs of the students and the society
- Reserve one full day a week for experimentation designed at local level
- Encourage more open and student-centered work forms across the curricula
- Help design relevant assessment and evaluation methods of innovative learning, such as open science schooling

EXPERIMENTATION



How can educational authorities support and even initiate practical local [experimentation](#) with open science schooling, and how can cross-sector support be mobilised for this?

Intro

A joint community of science teachers and young students from across secondary schools in Europe clearly states: *we are not encouraged to make experimentations, we are asked to follow the curriculum.*

Learning innovation and in particular open science schooling is not a fixed system; we can integrate it into the schools or be applied with the curricula. For sure, hundreds of years of classroom instruction cannot be changed overnight. So, Open Science Schooling needs experimentation across years and even decades.

Open Science Schooling (and for example entrepreneurial capacity and innovation capacity) cannot be done by replacing just a textbook with another textbook. It needs constant experimentation. Perhaps open science schooling *is* in fact experimentation. Experimentation is crucial to science. No experimentation, no innovation.

But in current science *education*, free experimentation and innovation is not the norm. This is why science teachers and students feel that they are not encouraged to experiment - with how to *learn* science.

As discussed above, national policy can first of all support experimentation in science education by loosening the grip of the national curricula, allowing open “legitimate” space for open science schooling experimentation. They can even provide resources for such experimentation.

But, national policy can do more: national science education authorities can create continued campaigning to secondary schools, science teachers, students and local community, explaining the benefits of open science schooling and encouraging open experimentation in the schools.

This would make it easier for school managements to engage in and support open science schooling initiatives in the school.

However, in the case of experimentation, local education authorities can play more important roles. Even in the case of little national policy support, local policy can create small miracles that can make a difference for schools and science teachers.

Let us give some examples, based on the scenario that no national policy support is available:

- Local policy can decide to change mentality as to the roles of a local education authority: from administrating education to pro-actively supporting science education innovation and community engagement
- Local policy has the power and the resources to bring together relevant science players from different sectors to create a community platform for the science teachers' open science schooling
- Local policy can support the experimentation by helping engage relevant science resources in the community as "support teachers" for the student teams, thus reducing the science teachers' burden
- Local policy can help promote experienced and dedicated young students to serve as mentors for new student teams in the open science schooling experimentation

Easily seen, the ways local policy can support such experimentation is almost limitless.



What the partners said?

"Our parents are so active that they would take their chances to talk to the officials from the educational authorities encouraging them to initiate practical experimentation with open science schooling."

"Schools in our town definitely need financial support and educational authorities support might make a change. Schools cope with serious financial problems.

What is more, they can organize the local competitions for schools where the most active ones could win additional support e.g. new computers or recognition."

"Starting by creating a pilot project that is applied / developed in a school. Accompanying the project with an interconnection with the University, companies and institutions and other observers from other schools. Promote the constant exchange of experiences and knowledge between the project parts, in order to create a path that can later be followed by other schools."

"The educational authorities could create opportunities for students to work in community engagement activities or any ethical practices that can forge a strong school-community bond.

Of course, since we are talking about children here, it is important that families are involved in such initiatives, through coordination with the school authorities."

"The educational authorities must know this new methodology in order to support it. It is necessary to inform them of the wish to develop these initiatives.

The local community must also be informed in order to involve different stakeholders. A good way, maybe to organize a workshop in the city, even inviting newspaper and media.”



Policy recommendations

National policy can:

- Support open science schooling experimentation by making science curricula less crowded and more flexible
- Put less pressure on the schools and the science teachers by paying less attention to international and national tests and competitions
- Support such experimentation by providing various forms of resources
- Openly encourage such experimentation through campaigns and similar initiatives, making it more “legitimate” for schools to engage

Local policy can:

- Change mentality from administration to initiative-taking
- Create a platform of community support for the open science schooling experimentation
- Help science teachers through engaging community resources and student resources as facilitators and guides in the experimentation
- Help link the science learning experimentation and missions to the community and to community benefits

CO-CREATION



How can policymakers and school management promote open science schooling based on young students' [interests](#) and [learning needs](#)?

Intro

It is well understood from a vast amount of validated research that, and as the Commission also states: “innovation is not something that you do TO people but WITH people” (Commission, *Entrepreneurship Education*, 2011), in order for it to be sustainable.

Most educational “innovation” represents top-down initiatives from national governments. Some school organisations and trade-unions might be heard, but not science teachers and students.

Open science schooling has been developed exclusively to help young students create more attractive and relevant images of science, science in society and a life in science.

It has not been developed to support national growth economy or to make education more “cost-efficient”.

From this it becomes clear that open science schooling innovation cannot happen without the direct involvement of young students. Thus this innovation represents to a certain extent a bottom-up innovation strategy.

This does not make open science schooling innovation less complicated and demanding, on the contrary.

However, the long-term benefit for the students is immense and historic.

This is what we call students’ co-creation.

They should not only co-create the open science schooling missions and the results from those missions; they should also co-create the open science schooling innovation.

When science teachers engage in open science schooling experimentation their most important allied is the students.

The science teachers should not build capacity to design and accomplish the science missions, but to help the student teams design, engage and accomplish.

It is therefore a very strong principle in any open science schooling teacher training, open science schooling initiative and experimentation, and in any open science schooling innovation design to include the students in the development of open science schooling - in the schools as well as in the communities.

From these reflections, three major conclusions can be drawn:

1.

Open science schooling teacher training should take place in close interaction with student teams

2.

Any national or local open science schooling initiative should include the co-creation of secondary school students, and in particular female students

3.

The engaged students are not data in the science missions; they are the drivers and the subjects, and the open science schooling initiatives should continuously be transferred to new teams of students, creating an eco-system of co-creation in the schools

Of special importance to the co-creation principle is:

- Student teams engaged in co-creating open science schooling practice should include all kinds of students, not only students already dedicated to science

- The student teams should be heterogeneous, comprising a variety of talents, interests and knowledge from both male and female participants.



What the partners said?

“In Open Science schooling you don’t just learn in the classroom, you learn from each other, you learn outside, at the dining table, at the shop or travelling to another country, doing different unusual activities, gaining real-life knowledge and experience.”

“Local school management or/and policy makers could promote best schools’ practices during organised educational events for all schools. For all schools it should be obligatory. It would give a space and time for all to know the best practices in local schools. Instead of being an inspiration it would also be a

motivation factor for future activities.”

“Listening to the students, their expectations, interests, difficulties, obstacles and opinions.

Giving visibility to the projects developed by them.

Allowing and encouraging students to contact with other institutions / companies / professionals, i.e. another reality outside the school.

Encourage parents (and / or other family members) to be an active part in the development of projects developed by students.

Encouraging students to tell their story to other schools, companies / institutions.

Encouraging sharing and exchange with other schools.”

“The first and foremost action that needs to be taken here is sitting down with the kids and asking them personally, as to how they would like to learn science. Giving them the authority to plan their learning is a great way to start planning the curricular activities.

Once the needs analysis is recorded, including the local, regional, and national stakeholders to participate and contribute towards OSS method of learning is necessary.

Creating participatory design of lesson delivery and learning actualizes democratizing the process of learning through involving the students.”

“They must listen to the young students’ concerns. If the students can develop a project in order to solve a real problem of the society in their own community, they will increase very much their engagement. The problem is that usually the topics are chosen for the teachers and the policymakers.”



Policy recommendations

National policy can:

- Ensure that any national open science schooling initiative includes the co-creation of secondary school students, in particular students with open science schooling experience
- Encourage students’ and science teachers’ co-creation whenever adjustments are made to science curricula, testing and similar

Local policy can:

- Exploit the fact that local policy is closer to the schools to ensure uncompromised co-creation from the schools’ students, in particular students with open science schooling experience
- Support and promote the participation of all kinds of students, and in particular female students, in any co-creation of local open science schooling initiatives and practice
- Help ensure that student teams are continuously at the centre of the open science schooling, including through transfer of science missions to new students

WIDER COMMUNITY



How can local governments promote a positive mentality in the [wider community](#) of open science schooling, including among key science, research and innovation resources in the community?

Intro

Open science schooling, and in particular successful and sustainable open science schooling, is incredibly dependent on the collaboration of local science resources.

Now, what if such science resources are not interested?

Basically, science teachers and student teams are responsible for mobilizing community resources for the open science schooling activities, as this is an important element in the science missions: creating useful alliances with relevant resources in the community to be able to accomplish the mission.

However, in some cases such community resources are not interested in the open science schooling activities. They might be more concerned with the success of their company, with their research project - or simply not willing to engage with young students.

This is, needless to say, a huge challenge to the science missions: no community collaborators, no science missions.

National policy can do very little here, at least in the short run. However, local policy can do magic.

The challenge is to explain to potential collaborators the importance of young people's engagement in science, the importance of critical young science voices in the community (climate change!) - and that community mobilization for science will benefit the community tremendously in the future. And, perhaps, that not only education is responsible for engaging young people in science, but society at large.

This is where local policy comes in.

The local government and its educational department has the power to, the connections to, the resources to and the long-term interest in mobilising relevant science resources to collaborate with the student teams and their science teachers.

The local authorities therefore play an important role in motivating science resources in the community to engage in open science schooling.

Such engagement typically takes place at two levels:

- Permanent science collaborators, participating in what we might call the "eco-system of open science schooling" in the community
- Science mission collaborators working with the student teams in the context of specific topics and challenges

The most important job for local policy is to help create the first level of collaborators, as experience shows that the engagement of those resources makes it easier to engage additional and more science mission based resources.

Which are the possible collaborators at the first level that local policy should make an effort to help engage?

Typical examples are:

- Any kind of relevant public authorities
- Science communities such as a research centre, a science museum, open science laboratories or an experimentarium
- Educations directly involved in science
- Companies using applied science in design, production and innovation
- Entrepreneurial hubs engaged in science challenges and innovation using applied science
- Science research and innovation bodies



What the partners said?

“These steps could lead to a closer relation/cooperation with the community and then promote positive mentality because of the possibility to be a part of the schooling system. Also it would be nice to try the public-private partnership model. The companies would definitely advertise such a partnership to the wider communities and thus the OSS would be advertised as well.”

“Regional governments could promote a positive mentality of OSS by

- broadcasting special programmes in local and regional TV, radio, newspapers,
- deliver such programmes and competitions to other schools,
- organising courses and workshops for teachers,
- organising the meetings for schools and local stakeholders where all entrepreneur might present its offer for education”

“Through the visibility of what students do.

Through the testimonies of the students who are part of this process.

Through the testimonies of all agents integrated in the development of the projects (students, careers, companies, institutions, professionals and teachers).

Through the presentation of the results obtained by the students.”

“Through opening the doors to students' voices by the municipality and administrative heads.

Students' activities towards science projects, community engagement etc., must be given visibility through media coverage, for starters.

This gives a positive experience to the students and could possibly foster a sense of agency and self-efficacy in them.”

“For example: we work, together with the community, in an inclusive system much like an ecosystem, as a Learning City that brings together the parents, the various communities, the local authority together with the formal educational system. Since the schools are public they all have students who are committed to community involvement. They create connections with the various communities in town, within the project framework, such as: seniors, special populations such as parent committees, in order to spread and disseminate the principles of the OSS project into the daily life in the community and city.”



Policy recommendations

National policy can:

- ... only support the wider involvement of local communities through massive open science schooling campaigns, encouraging such community involvement

Local policy can:

- Use its pan-community network to mobilise level one science collaborators for the science missions and for the creation of a local eco-system of open science schooling
- Help promote the open science schooling initiative in the wider community, including through public communication, local media and local events
- Work to make the community benefit from the open science schooling and from the science missions, and increasingly make open science schooling a community responsibility

POLICY SUPPORT

PART TWO - THE VOICES FROM PRACTICE

RESTRICTIVE CURRICULA



How is it possible to work with open science schooling, given the very restrictive curricula in most countries?

Intro

Obviously, secondary schools, science teachers and students cannot wait for national governments to adjust or change science curricula. Perhaps it will never happen.

Schools and science teachers (and students) are therefore forced to find creative ways to integrate the open science schooling activities in the everyday life of the school, regardless of restrictive curricula.

This challenge becomes more demanding in the case of open science schooling, as this activity needs to be distributed across considerable time periods, such as a semester or even a full school year.

Moreover, most science missions cannot only take place within normal school hours or school days. This is the nature of innovation and entrepreneurship.

In some countries the school management, the educational authorities or the teachers' trade unions make it very difficult for the science teachers to engage in such science missions.

And in some cases the students build up resistance towards engaging after school, at least in the beginning of the missions. Their attitude normally changes once deeply engaged in the science missions.

The question here is: what can national and local policy do to make open science schooling possible, given existing restrictions?

At the national level, the policy can only encourage open science schooling in more or less abstract terms.

It does matter, though, that schools and teachers can refer to such encouragement from their government. It might also encourage local policy to more actively support the open science schooling initiatives.

At the local level, the local policy can do more.

It cannot change the attitudes of trade unions or change the basic educational systems schools are part of.

What local policy can do, however, is to:

- Create a positive atmosphere in the community in support of open science

schooling experimentation, including promoting changed mentality

- Mobilise relevant science resources to support the teachers and the students
- Organise open dialogues with the school management, the science teachers, the students and their families about the need to work in flexible ways, and the benefit of being involved in such science missions
- Help schools and science teachers and students become proud of their initiatives, including through local media
- Help make the science missions community missions, important to people in the community
- Initiate various forms of rewarding engaged schools and science teachers

Experience shows that the more collective the science missions, the easier it is for schools and teachers to find flexible work forms. A very special way to change restrictive mentalities is to link (some of) the science missions to climate change. This often opens up more flexible mentality and more dedication. More about this at the end of the paper...



What the partners said?

“Curriculum integration implies work. Students play a key role, but the success of the initiatives depends on the commitment and creativity of the teachers/project coordinators and administration.”

“Having in mind curriculum there is no time and need to organise such activities.”

“The creation of educational guidelines aimed at greater curricular flexibility and with a strong emphasis on interdisciplinarity and trans-disciplinarity.”

“The curricula must start heading in the direction of flexibility. Teachers must be encouraged to use their imagination and map it to work around the curriculum in a creative way. Of course, the school authorities must first adopt this direction, experiment with it and analyse the novelty of such a practice.”

“This is the most important challenge. A possible way is not changing the curricula, but changing the methodology. The only way is to involve all the teachers of the school, and to develop the project in all the matters (transdisciplinary system), with a strong support of the school managers.”



Policy recommendations

National policy can:

- ... not directly encourage rule-breaking in schools, but they can communicate strong support for open science schooling and continuously encourage schools and science teachers to find creative ways through the curricula
- In ideal cases national policy could create a set of simple guidelines for the schools to work with open science schooling within the restrictions of unchanged curricula

Local authorities, school managements and science teachers could use such communication and guidelines to justify local flexibility and rule-breaking. In a wider perspective national policy should make an effort to explain to

teachers how new forms of engagements might benefit their professional as well as personal lives, and even create more job satisfaction.

Local policy can:

- Make a big effort to help organise open science schooling activities in creative ways and in open dialogues with all players, including community collaborators and the students' parents
- Make their support for open science schooling very visible in the community, adding further justification to schools and science teachers' engagement
- Work to make the science mission collective community missions and activities, thus reducing the direct burden of schools and science teachers

QUALITY MISSIONS



Compared to the project's "criteria for quality missions", to what extent did the students' science missions meet those criteria?

Intro

Why do we use such expressions as "authentic science missions and open science schooling" or "full science missions and open science schooling"?

First of all, because open science schooling is demanding, and in very many cases it takes considerable time and experience to create real open science schooling.

Second, because science teachers and student teams are limited in their actions and therefore sometime make short-cuts and create simpler and also superficial science missions.

The most important open science schooling principles are briefly presented in Part 3.

There are several reasons for not engaging fully in open science schooling. Let us list the most typical - and ask what policy can do.

- The open science schooling principles are new to science teachers and perhaps not fully understood
- Most science teachers find it difficult to work outside school
- Many science teachers do not have sufficient time to engage, often due to other obligations
- Students are not used to be players on the community scene, and do not know their full potentials
- Science teachers and students are not always motivated to take things further
- Science teachers and students are not used to create collaboration and alliances with science resources in the community
- The nature of the science missions do not always allow full open science schooling

A general problem is that open science schooling often is misunderstood to include all sorts of activities taking place outside the school building, which is of course not the case.

Evidently, national policy cannot do much to support full local open science schooling engagements.

However, local policy if sufficiently pro-active can support the full implementation of open science schooling in several ways:

- Local policy can create stronger consensus on open science schooling and its principles
- Local policy can help increase community engagement in the science missions and thereby help taking the missions further
- Local policy can create open dialogues between science teachers, students and the community to create mutual understanding of the science missions and how the science mission can benefit the community
- Local policy might identify resourceful science players in the community and bring such resources into the centre of the missions

Easily seen a major role of local policymakers and educational departments is to be a bridge between the science teachers and students on one side and the community resources on the other.



What the partners said?

“Teachers and student were able to:

- solve challenging scientific tasks successfully
- build a positive OSS identity and a sense of agency
- and teachers could teach in ways that ensure that each student is reasoning and making sense of Science on a daily basis”

“We cooperated with Faculty of Biology and this is our resource in the community. Long cross-subject project enabled students with different learning styles and made it a real mission. We had to visit reserve quite often and even stay there for few days several times. Being totally engaged in the activities result in scientific papers and conferences.”

“They went as far as time and school schedule constraints allowed. The criteria for quality missions have always been taken into account, however their depth has not always been in accordance with what they intended and the objectives set and desired.

Of course it would be our intention to create / develop a mission that meets all quality criteria and could take it to another level. However, given all the limitations, we consider the balance positive.”



Policy recommendations

Local policy can:

- Serve as a bridge between the schools and community
- Reinforce the science missions through creating strong relations between the school and the science resources in the community
- Support the quality of the science missions through creating collective consensus on the basic principles of open science schooling
- Identify and help involve strong science resources from the community

FURTHER EXPERIMENTATION



What kind of further experimentation with open science schooling do we need?

Intro

Open science schooling is in its early days, appearing more in rhetoric than in practice.

It takes a sea change, says the Commission (Commission, *Entrepreneurship Education*, 2011). We say it will take years and decades, and to make open science schooling a reality we need considerable experimentation in very many directions.

Obviously, the success of open science schooling is depending on national governments' dedication to change course in curricula design. However, there is no guarantee whatsoever that this will happen in the near future. This means that the needed experimentation must be carried out on status quo conditions.

National and local policy plays important roles in driving and initiating such experimentation - with or without curricula change and with or without European funding.

The following list of highly needed key experimentation is based on the Open Science Schooling project along with several other similar projects. In short, the list is based on practical evidence and much research and documentation.

Key topics for further open science schooling experimentation:

WHAT RE-ENGAGEMENT TAKES

What are the core mechanisms in open science schooling that have the potential to change resistance to re-engagement among young students?
What kind of open science schooling can accomplish such change, what kind cannot?
How can biased stereotypes of science be overcome so that science engagement is also more attractive for female students?

THE NEW GENERATIONS OF SCIENCE TEACHERS

In what ways can open science schooling capacity building be integrated in the initial training of science teachers?
How can such capacity building include open science schooling practice with secondary school students?

CAPACITY BUILDING INTEGRATED IN SCIENCE TEACHERS' PROFESSIONAL LIFE

How to integrate capacity building for open science schooling in the professional lives of science teachers?
How can such capacity building be distributed over considerable time periods

and build on real-life open science schooling practice?

DEVELOPING PERMANENT ECO-SYSTEMS OF OPEN SCIENCE SCHOOLING

In what ways can the schools and the community build up permanent, flexible and expanding open science schooling collaboration?

How can the science missions be linked closer and closer to the needs of the community?

SCHOOLS AS DRIVERS OF CHANGE

Why does the Commission invite schools to be drivers of change in the community?

How can such invitations be turned into practical action among schools, teachers and students?

CURRICULUM DESIGN

How to design new 21st century science learning curricula, allowing considerable open science schooling to be integrated in the study planning?

How can new science curricula give more local freedom to schools, science teachers and students?

ASSESSMENT OF OPEN SCIENCE SCHOOLING

How to design qualitative assessment of the students' open science schooling experience and accomplishment?

What changes are needed for this in the national assessment systems?

These key experimentation needs should be addressed systematically at national or European level.

However, also at local level it is possible for local educational authorities to involve schools and community in such experimentation.



What the partners said?

“Firstly, further experimentation can only be successful if is developed in close collaboration with the local authorities, stakeholders and researchers. So, we need to attract more stakeholders to be actively involved. The further experimentation should reflect the values and needs of today’s young people and the society.

Secondly, teachers need to further explore attitudes towards open science schooling, the motivations and disincentives to participate, the role of teachers, parents, stakeholders, authorities. So, we need to collect more shareable data.”

“Experiences that allow us to improve the process we started with this project. Experiences that may encompass new local partners (companies, universities, institutions). Experiences in partnership with other local, regional, national and international schools. Experiments that allow us a complete view of the concept Open Science Schooling. Experiences in which we can encompass a new form of assessment and a new form of teacher education.

This set of experiences will provide us with a very detailed set of information that would enable us to create / develop a way forward for a more effective implementation of this concept throughout the school, involving as many students as possible.”

“Including pre-service teachers into OSS activities to give them hands-on experiences of becoming teachers of the 21st century.”

“Developing different scenarios to provide European teachers with examples in order to they can implement their OSS project easily.

Developing teacher training courses in order to show how to implement OSS methodology.”



Policy recommendations

European and national policy can:

- Create dedicated funding schemes for open science schooling experimentation, for example focused on the experimentation topics listed above
- Ensure that the experimentation includes the active co-creation of science teachers, students and key community resources

Local policy can:

- Bring relevant stakeholders together to organise smaller but valuable open science schooling experimentation at local or regional level
- Invite joint funding of such initiatives from key open science schooling players
- Ensure that the experimentation includes the active co-creation of science teachers, students and key community resources
- Link such experimentation to the interests and needs of the community
- Work to ensure that such experimentation contributes to the development of local eco-systems of open science schooling
- Make experimentations attractive and more relevant to students' everyday lives
- Preparing workshops related to empowerment, emotional intelligence, and self-esteem to break the stereotypes and barriers concerning science learning

MESSAGES



What messages to send to educational policymakers?

Intro

Various science education innovation initiatives are being taken at different policy levels. Even though the guidelines from the European Commission are quite clear and direct, it can be expected that national and local educational authorities will address science education innovation in very different ways.

Some authorities will try to create real innovation, while others will limit the initiatives to more symbolic or decorative “adjustments”.

Regardless of the scope, volume and direction of those initiatives, it is important to point to some absolutely crucial principles that should be included in such science education innovation. These principles are presented below as recommendations.

These recommendations in fact represent a few but crucial *messages* to policymakers.



What the partners said?

“To make it easy for policy makers to understand and connect to our message, we should create a narrative to bring our research to life. We need to create human interest in our success stories. To do this we need to be aware how policy works, who is who and what issues are on their current agenda. We need to be persistent.

When we are ready with all this, then we will show the policy makers that we are the power of many young people, parents and teachers representing the same opinion and sharing our findings and good practice.”

“We are not happy with our government’s education system. I have always wondered what we can do to make it better. While improving the education system isn’t easy, the OSS project has been the way to make a positive impact. We are proud to be a part of it.”

“Student could do local, national or international project but would obligatorily be done in cooperation. The best international projects in each school could be granted by international 2 days meeting with the international partner. Such motivation may increase the quality of the projects, students and schools engagement and virtual group skills.”

“Being in constant virtual touch and having the tasks to be done together in the international teams would only make things much better - increase students engagement, improve group working skills and enable mutual inspiration.”

“It’s time to listen to teachers, students and the educational community. It is time to sit down, gather (teachers, students, careers, businesses, institutions and other professionals) and outline a strategy / path that is consistent with today’s concerns, needs and challenges.

It’s time to value (seriously) what the school does.

It is time to let the school open its doors to society and not be afraid to do so.”

“The Open Science Schooling project was extremely important in showing a different perspective of science and how the school can work science. It allowed us to recognize that, after all, the surrounding community is more open to these experiences than the school itself. The concept of Open Science Schooling is a concept that continues to work in constant articulation with as many subjects as possible. This is also a way of pressuring policy makers to assume the need for changes in current educational policies.”

“We would like to present that as we are progressing further into the 21st century, changes in teaching and learning methodologies have to be implemented. Traditional methods alone are not sufficient, experiential learning is gaining impetus and need to be fostered for preparing students for a demanding future. Policies to be made must consider flexibility in curriculum delivery and helping with capacity building avenues for the teachers.”

“We cannot use the same system in learning methodologies as 100 years ago! It is urgent to change and adapt the education to the real world!”

“We would like to request and encourage keeping the structure of the study curricula flexible. And provide allocated time for development of thought and experimentation.”

“Watching this activity take place, the curiosity, the exploring, the enjoyment, the collaboration between the students really crystalizes the benefits of this “new mentality” which is actually going back to a more natural way of learning that existed the entire human history.”



Policy recommendations

Messages to policymakers engaged in science education innovation:

Any open science schooling experimentation and innovation should include the active and uncompromised co-creation of science teachers and secondary school students

Any student co-creation should not only include students dedicated to science, but on the contrary include all kinds of students, also students not interested in science

Any student co-creation and open science schooling experimentation and innovation should include a strong focus on female students, how they see science and a life in science, and how open science schooling might help re-engage female students

Any open science schooling experimentation and innovation should be dedicated to pursue authentic open science schooling, not simply advocating “modernizations” of traditional classroom teaching

Open science schooling initiatives should try to avoid symbolic innovation: innovation in programmes and words but not accompanied by changed practice

Open science schooling initiatives should try to avoid tokenistic innovation: showing off young students dedicated to science, but not making a difference for other students

Any open science schooling experimentation and innovation should make an effort to be sufficiently future-oriented and downplay short-term nationalistic competition interests

POLICY SUPPORT

PART THREE - CRITERIA FOR AUTHENTIC OPEN SCIENCE SCHOOLING

WHY OPEN SCIENCE SCHOOLING?



What is the background to the European Commission's open science schooling agenda?

Why is open science schooling so high on the European Commission's agenda?
Why is open science schooling so urgently needed?

Is it because it is fashion? No.

Is it because it is an easier way to learn science? No.

Is it more (short-term) cost-efficient? No.

Is it easier for the schools, the science teachers and the students? No.

Why then?

Simply because students in the 21st century create resistance towards science, science education and a life in science, based on negative images of science built up in secondary school.

Result: Europe is losing most of its young potential science and innovation talent, which is unaffordable in times of serious challenges to life on earth and to human welfare.

The problem is not the young students.

The problem is science, science education and science in society.

Open science schooling is the most promising innovation in science education so far. It allows young students to create fundamentally new images of science, to influence science in real-life and to integrate new attitudes towards science in the development of their identities.

In short, open science schooling allows young students to re-engage in and change science.

REAL-LIFE



Engaging students in [REAL-LIFE](#) science challenges in the society:

- Open science schooling is fundamentally different from classroom instruction, reading textbooks, working with artificial cases or performing small experiments in the school laboratory.
- Open science schooling is about student teams engaging deeply in real-life and real-time science in the surrounding world, in the community.
- Such engagement takes place in the form of science missions, designed and carried out by the student teams, guided by their science teachers and in collaboration with relevant science resources in the community.
- The science engagement should be immersive, allowing students to go deep into the science challenges. This means that the science mission should be carried out across considerable time periods - months, a semester, an entire school year.
- This is why it is important to integrate the science missions well into the normal life of the school.
- The students, their support teachers and the community collaborators should try to accomplish the missions to the extent possible, or pass on the missions to new teams of students.
- An important element is to help the student teams link the local science engagement to (online) global resources and knowledge.
- For example: if robots are used at the local elderly home, how are they using robots in Japan?
- The science teachers should insert time-outs of science knowledge creation when needed in the missions.

COMMUNITY



Engaging schools and students in practical science collaboration with resources in the [COMMUNITY](#), including research, science, innovation and social resources and stakeholders

Open science schooling not only takes place in the community, but in close collaboration with relevant science resources in the community. Community science resources can be accompanied by online science resources.

In this way the young students learn to build teams, to plan and pursue goals, to create alliances and to collaborate with a wide range of very different community resources - 21st century competences they would never acquire in the classroom. Some of these competences might be called entrepreneurial and innovation competences.

There might be two levels of community collaborators: resources that work with the schools permanently, delivering guidance and knowledge resources, and resources that are engaged in the specific science missions.

Depending on the nature of the science engagement, such collaborators could for example be:

- Local educational authorities
- Science educators
- Research and innovation centers
- Entrepreneurial and innovation hubs
- NGO's working with science challenges in the community
- Groups of citizens engaged in local challenges linking to certain science topics
- Youth groups for example addressing local climate change

MISSIONS



Offering students direct participation in epic, immersive and exciting MISSIONS

The heart and soul of open science schooling is the student teams' science missions in the community.

We might also call such activity for "projects"; however, whereas a science project can easily be carried out in a few days in the classroom, a science mission cannot.

We prefer the term "mission" because it indicates:

- A strong intentionality: the students' have an important mission to accomplish
- A complex process with many steps and through creating useful alliances
- Real-life engagement and change
- Longer time spans with many steps, road-blocks and problems to solve on the way
- A more personal approach for the students: it is important for me and the community that we engage in this challenge

Who chooses the missions, who benefits?

It is important that the science missions are based on student as well as community interests.

If only student interests, then it will be difficult to accomplish anything in the community and difficult to create the needed collaboration.

If only community interests, the students will lack motivation and ownership.

EPIC

We say that the science missions should be "epic". This means that they are long and deep engagements, stories, and narratives with a beginning, middle and an ending. And stories that the students can take personally place in.

IMMERSIVE

We say that the science missions should be “immersive”. This means that it should be possible for the students to go deep into the science challenges, to identify with the missions and “become so interested that they forget they are learning”.

EXCITING

We also call the missions “exciting”. Science projects in the classroom are rarely exciting to the students, neither are textbooks to memorize for the upcoming test.

However, it can be extremely exciting to be an agent of change and innovation in the community, collaborating with people and institutions the students never dreamed of working with.

And to address important things in the community for many people, and even making this engagement very visible in the media.

Easily seen, such qualities cannot be produced by classroom instruction, punctual visits to a science center - or a small project addressing an artificial problem. And the big issue is: only epic, immersive and exciting science experience can create new images of science among the young students with the potential to allow them to pursue science and a life in science in the future.

LEARNING STYLES



Offering students with different **LEARNING STYLES** a variety of practice oriented work forms very different from traditional theoretical and laboratory-based science teaching, also benefitting less academic learners

It is well-known and documented across mountains of research that science in secondary school, taught in traditional ways, only attracts academic and theoretical learners, or even: mathematical-oriented learners.

Open science schooling offers, on the contrary, a rich variety of science engagement, from collaborative team engagement via practical tasks to concrete problem-solving.

Open science schooling is therefore inclusive learning: many students with different learning styles can find rich engagement opportunities along the long and challenging science missions.

Female students concerned with the welfare of the community, entrepreneurial-minded students and students not learning well from theoretical textbooks can all find a place in the science missions - and in their student teams.

This huge benefit from open science schooling is totally underestimated.

SCIENCE IMAGES



Providing students with the opportunity and resources to develop a different **IMAGE** of what science is and what science could be for them, linking in much more narrative ways to the identity and personality of the young students

This is the whole point!

Overwhelming science education research from recent decades jointly concludes that young students in secondary school are increasingly creating resistance towards science and science learning.

The resistance is built up systematically in secondary school when science becomes more theoretically, abstract and “irrelevant”, and along the teenage years in which the young students start creating their identity.

The problem is that most students do not allow science to participate in this identity creation.

The same joint research also concludes that the problem is the meeting with science in secondary school.

Young students are no longer as “obedient” as former generations of students. They ask questions, for example about the relevance of the education.

The meeting with science in secondary school creates images of science among the young students as “formal”, “theoretical”, “abstract” and without any relevance to the young people’s 21st century lives.

So, even if some of the young people actually are able to cope with this abstract form of science learning and pass the tests, these images prevent them from any idea of working with science in the future.

Against this background it becomes clear that superficial modernizations of traditional science education will not do the job; it will not allow most students to create *fundamentally* different images of science.

To help young students re-engage in science and a life in science, science must change and science education must change.

Not in the form of adjustments, but in the form of a fundamental change.

This is what open science schooling offers.

Open science schooling and the science missions offers totally different opportunities for young people to create different images of science than traditional science education.



THINGS TO BE CRITICAL TOWARDS IN OPEN SCIENCE SCHOOLING MISSIONS

- punctual activity, such as visits or competitions
- short, superficial activity
- missions not sufficiently linked to important science challenges
- missions not important to the community and missions that do not accomplish anything in the community
- missions only involving students, teachers and the school
- very narrow missions mostly relevant to the students
- missions with very low complexity
- missions that does not create new images of science

Missions simply taking place outside the school building are not in themselves science missions.

The reason for such “critical concern” is obvious: these science learning activities do not allow students to create a fundamentally different attitude towards science.

POLICY SUPPORT EXTRA

CLIMATE CHANGE: A HISTORIC OPPORTUNITY FOR POLICY SUPPORT TO RE-ENGAGING YOUNG STUDENTS IN SCIENCE



Climate change is now a great concern everywhere in the world and at all levels. We all know the threats and the possible nightmares.

Therefore it is a giant historical irony that climate change is the most powerful driver of re-engagement of young students in science ever seen. Climate change prevention and adaptation represents a giant scientific field for young students' re-engagement: it includes all scientific fields, it is relevant in all communities and it can offer the most exciting and useful challenges to young people.

Climate change emergency is even a powerful justification of "rule-breaking": schools, teachers and students engaging in local science challenges regardless of restrictive science curricula.

Some initiatives are and will be taken to include climate change as a topic in the science curricula. This is, of course, positive, but at the same time it is losing the great open science schooling potential for climate change learning.

Climate change in schools should be used - as a privileged historic momentum - to innovate science education and make science much more relevant to young students.

*What could be more relevant to the young students than meeting science through taking community action on climate change?
What could be more benefitting for the community and for local policymakers?*

In other words, climate change challenges are perfect challenges for student teams learning and meeting science through open science schooling. Climate change missions are perfect science missions. Even more: climate change threats will increase across the next many decades, which means that young students will be able to use climate change action to meet and learn science for as long as we can forecast.

What is it about climate change that makes it perfect open science schooling challenges and missions?

The most important elements are:

- Climate change needs to be seriously addressed at local level, in all communities
- Climate change is taken seriously by almost all community players and science resources, offering community collaborators a strong motivation for working with the student teams
- The local authorities have a great and increasing interest in mobilizing its young people for climate change prevention
- Climate change is at the same time local and global: think global, act local
- Climate change engagement can be made very attractive to young students and to their science teachers
- The young students can engage in serious community challenges to better their own future
- Climate change missions can be passed on continuously from one student team to another, thus fuelling the idea of eco-systems of open science schooling
- Climate change is everybody's concern, and it can be foreseen that almost all citizens and institutions in the community will be willing to collaborate with the student teams in such missions
- Climate change offers the students rich opportunities to develop critical attitudes towards "science and society": science can help prevent climate change, but science also created climate change
- Climate change engagement is in particular attractive to female students, as they can bring in their values, personal preferences and societal concerns

What does all this mean for national and local policy support to open science schooling?

Climate change should be no less than a **CARPE DIEM** for national and local educational authorities wishing to re-engage more young people in science. For policy this is a historic momentum that should not be lost: policy can, at different levels, help innovate traditional science education, engage young students in science and at the same time fight climate change.

At national level policy can:

- Create long-term national programmes for integrating climate change in science education in secondary school, with the double purpose to re-engage young students in science and mobilize young people for local climate change prevention
- Create guidelines for local communities on how to make schools, science and other teachers and students drivers of local climate change prevention
- Collaborate with national and regional teacher educations to provide guidelines for the capacity building of new teachers to support the engagement of students in local climate change through open science schooling; guidelines can be provided for initial teacher training as well as at-work teacher training
- Create a national platform sharing local climate change and open science schooling missions and actions

At local level policy can:

- Take local initiatives to engage young students in climate change prevention, independent of national initiatives
- Help create cross-sector collaboration on climate change prevention, using student teams and science teachers as drivers
- Help students and other players contextualize local climate change prevention in a global perspective
- Support the development of permanent cross-sector climate change collaboration in the community, including by mobilizing citizens and institutions



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