Open Schools for Open Societies

Deliverable D2.1

Open Schooling Model

Funded by the Horizon 2020 Framework Programme of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 741572

Document Control Page

WP/Task	WP2 / T2.1 & T2.2
Title	Open Schooling Model
Due date	31/7/2017
Submission date	
Abstract	This document is one of the three main reference documents for the OSOS project which will be developed in the framework of WP2. The overall objective of these documents (Open Schooling Model, OSOS Strategies, Open Schooling Roadmap) is to describe a framework that could facilitate the transformation of schools to Open Schooling Hubs. D2.1 Describes the Open Schooling Model that will be implemented in the framework of the OSOS project.
Author(s)	Sotiriou, S., Cherouvis S.
Contributor(s)	Mauer M., Bogner F.X., Bagiati A., Sarma S.E., Zygouritsas N., Giannakopoulou A., Mylopoulos G., Fermeli G., Kiriakidi, E., Van Laar, E., M., Guenaga, M., Verboon, F., Parente, R. Di Martino, F., Gaist, O., Bloch, N., Oron, E., Ben-Horin, Y. Note: The description of the ECOWEEK approach is a contribution by Messinas E. (ECOWEEK)
Reviewer(s)	Bogner F. X., Sotiriou, S.
Dissemination level	public

Document Control Page

Version	Date	Modified by	Comments
1.0	30/06/2017	Cherouvis S.	Analysis of the partners contributions (Chapter 4)
2.0	05/07/2017	Sotiriou S. & Bogner F.X.	Finalization of Chapters 2, 3, Draft Chapter 5
Final	30/07/2017	Sotiriou, S., Cherouvis S.	Final Version, References, Formatting

From Scenarios to Practice: The OSOS Open Schooling Model

Innovation is not an isolated event; it is a movement. Innovation is the word we use when an idea is so well received that it becomes the new norm. While a single person trying something new, that person might be considered an innovator, but often this practice does not spread throughout an entire system. However, if people rally around that idea, sharing their failures and successes, this is what we could call ***systematic innovation****. The best model we have then for innovation is a* ***chain reaction****.*

One of the most incredible chain reactions is that of nuclear fission. Fission occurs when a subatomic particle disrupts the nuclear structure of an unstable atom. When the nuclear bonds are broken, energy is released in addition to more subatomic particles, which in turn could disrupt another nucleus and trigger this process all over again. One of the most common fuel sources is Uranium 235 because it is already radioactive, that is to say it is highly unstable and it naturally releases particles which could cause a fission reaction. Yet it does not. In order to induce a ***self-sustaining, cataclysmic release of energy****,* ***conditions need to be just right****.*

Critical mass is the term used to define the condition under which a chain reaction is imminent. If critical mass is not reached, it means that even when a new particle is released, there is a good chance that it will not hit another nucleus and the reaction will not continue. Think about a line of dominoes spread too far apart. The concept of critical mass simply explains that if there isn't enough stuff in a given space, a chain reaction will not occur.

One of the ***biggest barriers to educational innovation*** *is not the lack of great teachers or even the access to proper tools, it is the* ***isolationist structure and dispersed nature of many schools and school authorities****. Even when you have the best teachers coming up with the most original ideas, a chain reaction of innovation is very unlikely to spread throughout the organization. The dominoes are too far apart. Schools should consider how they can create a critical mass of innovators, the condition where a chain reaction of great ideas is imminent. It just so happens that nuclear physicists have several tricks up their sleeves which are essential to creating this condition. These tricks are acting as* ***catalysts to the process****:*

- ***Increase Mass****- The more dominoes you have the longer the chain you can make. Be on the* ***lookout for talent and get more of the right people in your school****. The more innovative individuals you have in your school community the greater chance they will influence each other.*
- ***Increase Density****- Even having a lot of innovators might not guarantee a chain reaction if these people never get together. The closer these people are, the more likely they will be to share. Open days, workshops, and other in person events are great examples of moments of increased density. You will be amazed at the* ***innovative energy produced by bringing the right people together in a closed space****.*
- ***Increase Temperature****- Temperature is really just a measurement of how fast molecules are bouncing off one another. Craft specific times for staff sharing and exploration.* ***The more opportunities you have for teachers to interact with other stakeholders, the more likely these innovative ideas are to move.*** *Open the channels of communication and sharing in your community, mobilise local actors and encourage the transmission of ideas. Open to informal learning settings and industry. Involve more players from the out-of-school world in the process.*
- ***Increase Reflectivity****- Even in a dense mass of radioactive material there are particles which stray outward, away from the other atoms. Surrounding the nuclear fuel in a highly reflective shielding directs those stray particles back toward the center to increase chances of a reaction. Reflective practices can help collect ideas which would otherwise float away into thin air. Through* ***self-reflection and peer-assisted-reflection, innovators influence themselves and others around them*** *by directing their discoveries back into the system for deeper investigation.*

Our schools should be incubators of exploration and invention. They should be accelerators of innovation. *They should promote Open Schooling. School leaders should set a vision for creating learning experiences that provide the right tools and supports for all learners to thrive. Teachers should be collaborators in learning, seeking new knowledge and constantly acquiring new skills alongside their students.* ***A holistic approach to innovation is needed.*** *We need to facilitate the process with a provision of the necessary catalyst:*

This is the foreseen role of the OSOS project, to describe and implement at scale a process that will facilitate the ***transformation of schools to innovative ecosystems****, acting as* ***shared sites of science learning*** *for which leaders, teachers, students and the local community share responsibility, over which they share authority, and from which they all benefit through* ***the increase of their communities' science capital and the development of responsible citizenship.***

Executive summary

This document is one of the three main reference documents for the OSOS project which will be developed in the framework of WP2. The overall objective of these documents (Open Schooling Model, OSOS Strategies, Open Schooling Roadmap) is to **describe a framework that could facilitate the transformation of schools to Open Schooling Hubs.** Becoming an Open Schooling hub cannot be seen as an isolated "project" – it demands a root-and-branch rethink, not just in pedagogy, but in every aspect of the way the school is organised: its structure, culture, and the use of space, place, and time. An Open Schooling Hub will be an open, curious, welcoming, democratic environment which will support the development of innovative and creative projects and educational activities. It is an environment which will facilitate the process for envisioning, managing and monitoring change in school settings by providing a simple and flexible structure to follow, so school leaders and teachers can innovate in a way that's appropriate for school local needs. It will provide innovative ways to explore the world: not simply to automate processes but to inspire, to engage, and to connect. It will provide a powerful framework for school leaders to engage, discuss and explore: how schools need to **evolve**, **transform** and **reinvent**; how schools will facilitate open, more effective and efficient co-design, co-creation, and use of educational content (both from formal and informal providers), tools and services for personalized learning and teaching; how schools can become innovation incubators and accelerators.

This document includes five main Chapters.

Chapter 1 presents the project glossary. The terms Open School, Incubators and Accelerators of the innovation process, science capital and responsible citizenship are analyzed and described in the framework of the project.

Chapter 2 describes the re-schooling scenarios proposed more than a decade ago from OECD. They are describing the evolution of schools as core community centers and as learning organizations serving a rich social and knowledge agenda respectively. The OSOS project aims to integrate the key principles and characteristics of the re-schooling scenarios to a holistic approach that will facilitate the introduction of an open schooling culture in current school settings. By building on the strengths of the OECD re-schooling scenarios and by implementing a well-tested approach for the introduction of innovation to schools the OSOS consortium aims to demonstrate at scale how schools can become incubators of exploration and invention and accelerators of innovation in their local communities. Chapter 2 describes in detail the main characteristics of the OSOS schools as well as the key principles that have to be the guiding forces in the development of the school based activities in OSOS schools.

Chapter 3 proposes a generic framework for the design, development, implementation and evaluation (both short and long term) of Educational and Outreach activities that can be used to introduce the principles of Responsible Research and Innovation in science classrooms. The aim of the consortium is to formulate a common set of guidelines and recommendations on how scientific work can be used to provide an engaging educational experience through the exploration of "real science". Research on learning science makes clear that it involves development of a broad array of interests, attitudes, knowledge, and competencies. Clearly, learning "just the facts" or learning how to design simple experiments is not sufficient. In order to capture the multifaceted nature of science learning, the OSOS approach proposes a roadmap that includes a series of "Pedagogic Principles for the design of the Educational and Outreach Activities" and articulates the science-specific capabilities supported by the environment of the Open Schooling Hub. These principles will be the reference point for the development of the Open Schooling Model (Chapter 5) and the definition of the characteristics of the OSOS Incubators and Accelerators (WP4). The OSOS approach is based on the fact that ideas generated through **individual, collaborative and communal activities** have a potent capacity to contribute to engagement and change. The layer of communal engagement is particularly important in terms of the societal level of the Responsible Research and Innovation, and the idea that innovators need to be mutually responsive within and beyond their communities. The idea of communal engagement acknowledges that when working creatively people exist in groups with shared identities which shape their ideas and thinking and which may be challenged by the thinking of other groups.

Chapter 4 is dedicated to the study of various open schooling models and their approaches in addressing the issue of school openness and change, affecting the school itself but also the local community. Some of the examples presented in Chapter 4 are not direct applications of open schooling initiatives, but they certainly demonstrate how schools are trying to introduce innovation in their approaches and – according to our view – demonstrate the potential of local, national and international actions towards the development of an open schooling culture: educational resources generated in school settings according the local needs, holistic approach and vision, effective introduction of RRI principles in the school operation, effective partnerships with external stakeholders and focused policy support actions.

Finally, Chapter 5 presents the Open Schooling Model which will be implemented in the framework of the OSOS project. The OSOS Open Schooling Model presents a three-step process, aiming to Stimulate, Incubate and Accelerate the uptake of innovative RRI practices in school communities and national policies. It describes the full cycle of the school transformation with the support of the OSOS support mechanism. The process starts with the Change Agents who are becoming Inspiring Leaders of the school community. The OSOS support mechanism will offer open, interoperable and personalized solutions meeting the local needs, supports school leaders capture innovation, to decide on the appropriate strategy to diffuse innovation to the school and through constant reflection is guiding them towards the transformation of the school to Open Schooling Hub and finally to sustainable innovation ecosystems.

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1 Project Glossary

Open School Culture: An Open School culture imports external ideas that challenge internal views and beliefs and, in turn, exports its students – and their assets – to the community it serves. Such an engaging environment makes a vital contribution to its community: student projects meet real needs in the community outside of school, they are presented publicly, and draw upon local expertise and experience. The school environment fosters learner independence – and interdependence – through collaboration, mentoring, and through providing opportunities for learners to understand and interrogate their place in the world.

Open Schooling Hub: The development of an Open Schooling Hub (a school based environment that implements the **Open School Culture**) demands a root-and-branch rethink, not just in pedagogy, but in every aspect of the way the school is organised: its structure, culture, and the use of space, place, and time. An Open Schooling Hub will be an open, curious, welcoming, democratic environment which will support the development of innovative and creative projects and educational activities. It is an environment which will facilitate the process for envisioning, managing and monitoring change in school settings by providing a simple and flexible structure to follow, so school leaders and teachers can innovate in a way that's appropriate for school local needs. It will provide innovative ways to explore the world: not simply to automate processes but to inspire, to engage, and to connect. OSOS project will create a core network of 100 Open Schooling Hubs in 12 countries. Each one of these schools will develop a network of at least 9 additional schools to form a national network of schools where the Open School Culture is introduced. Overall more than 1,000 schools will be involved in the project in two implementation phases.

Science Capital: Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job). Science capital is unevenly spread across societal groups. (Archer et al. 2013, p. 3)

Responsible Citizenship: Responsible Citizenship views citizenship as a total practice of responsibility between individuals and their political, social, economic and natural environment. It goes beyond formal relationships of rights and duties between the citizen and the state, and stretches the spatial, temporal and material boundaries of citizenship to those of the global economy (Lister, 2007). Since Responsible Citizenship extends citizenship responsibilities to an expanded notion of equity and caretaking and gives more weight to universal principles of democracy, human rights and global commons (Micheletti & Stolle, 2012), some scholars claim that this new version of citizenship has the potential to challenge and change the underlying structural, root causes that led to environmental and social justice problems in the first place (Barry, 2006).

OSOS Approach: It will provide a powerful framework for school leaders to engage, discuss and explore: how schools need to evolve, transform and reinvent; how schools will facilitate open, more effective and efficient co-design, co-creation, and use of educational content (both from formal and informal providers), tools and services for personalized science learning and teaching; how schools can become innovation incubators and accelerators. The main aim of the OSOS approach is to describe and implement at scale a process that will facilitate the transformation of schools to innovative ecosystems, acting as shared sites of science learning for which leaders, teachers, students and the local community share responsibility, over which they share authority, and from which they all benefit through the increase of their communities' **science capital** and the development of **responsible citizenship.**

OSOS Incubators: OSOS will use the Inspiring Science Education services (www.inspiringscience.eu) to offer numerous tools for the school communities that will be involved in the project. Apart from community building and support tools numerous content creation and content delivery tools will be available for students and teachers. The aim is to help them to become creators of educational activities which will reflect on the real educational needs of their classrooms as well as providing solutions to their local communities. The focus is not only on the integration of external resources into syllabi, but also on subsequent adoption of the modernization of the school organization, school cooperation with external players as well as the teachers' professional development. Localized assessment approaches will estimate the impact on both, individuals and schools as an organization, as well as on the development of effective cooperation with organizations like universities and research centres, informal learning centres (e.g. museums and science centres), enterprises, industries and the local communities.

OSOS Accelerators: The OSOS best practices will act as accelerators of the introduction of OSOS approach in the participating schools. They will help innovative schools to proceed more and develop their innovative ideas to new localised projects that could provide new solutions for the school and its community, for bringing the gap between formal and informal learning settings and creating new opportunities for personalisation at different levels (student, teacher, school). At this level, innovation has to be the norm in the school operation that will act as an **Open Schooling Hub**, an environment that shares a culture that imports external ideas that challenge internal views and beliefs and, in turn, exports its students – and their assets – to the community it serves.

Project-Based Learning: Project-Based Learning is the main pedagogical approach of the **Open School Culture**. Whilst teachers will draw distinctions between project, inquiry, and problem based learning, in reality the differences are minor – particularly in comparison to more transmissive, lecture or worksheet-based forms of learning. Great projects grow from inquiries in order to solve problems. Students found them highly engaging because they are conducting work that is meaningful, to them and their families or communities. Learning begins with a problem to be solved, and the problem is posed in such a way that children need to gain new knowledge before they can solve the problem. Rather than seeking a single correct answer, children interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. They relish the opportunity to make adult-world connections, work across disciplines, and in extended blocks of time.

National Coordinators: The implementation of the project activities and the coordination of the national networks of schools will be supported by the **National Coordinators,** partner institutions that have direct access in school communities. The consortium partners are already working with these schools in the framework of current initiatives. With the support of the National Coordinators, the project team will set in place an effective support mechanism which will provide guidance, training, feedback and recommendations to the actors involved (teachers, museum educators, outreach groups, parents).

Open Schooling Roadmap: The consortium will develop the **Open Schooling Roadmap** to support schools to reflect on, plan and undertake changes in education for 21st Century learning. Applying the **OSOS Approach** in local settings will make it clear that schools have much to gain by fostering connections between formal and informal learning, between existing providers of education and new entrants. such an action asks for knowledge areas integration, effective and closes cross-institutional collaboration, and organisational change in the field of science education. The whole effort will be documented analytically and systematically in the ***"Open Schooling Roadmap"*** document that will be one of the main deliverables of the project. This document will be the first step in a journey of educational reform that might take many years. It will be the map. It has to be noted though that the achievement of high quality science teaching requires the combined and continued support of all involved actors, researchers, science communicators, policy makers and curriculum developers, science teachers' educators, teachers, students and parents.

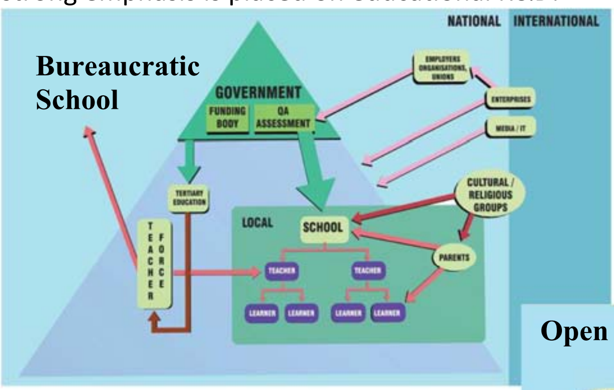
Science: Science, in the broadest sense, refers to any system of knowledge which attempts to model objective reality. In a more restricted sense, science refers to a system of acquiring knowledge based on the scientific method, as well as to the organized body of knowledge gained through such research.

In the context of this proposal (and following the Rocard Report, 2007 recommendations) the choice was made to use the word "science" to refer more precisely to all of physical sciences, life sciences, computer science and technology, and for the purposes of this proposal includes mathematics – subjects that are commonly taught at primary and secondary schools in most European countries.

2 The Open School Environment: Trends and Guiding Ideas

2.1 The idea of Open Schooling

There are currently numerous education reform initiatives in Europe as policy makers try to make schools more effective and provide students an education that prepares them for life in the 21st century. Schools are being asked to increase the quality of education, notably by providing more students than in the past with advanced skills and the ability to be flexible thinkers and problem solvers. These reform initiatives vary from programs to develop educational portals with certified content, to offer professional development opportunities to in-service teachers, to put networked laptop computers into the hands of all students on a routine basis, to equip the classrooms with interactive whiteboards to help make lessons come alive, to install wireless Internet access points in schools (e.g. current governmental initiatives in Greece, Austria, Spain, Portugal) **to large scale ambitious plans to rebuilt and remodeled schools to create learning environments which inspire all young people to unlock hidden talents and reach their full potential**; **provide teachers with 21st century work places**; **and provide access to facilities which can be used by all members of the local community**. All these efforts clearly serve – at a different level – the vision of *Re-Schooling*, towards schools as "Core Social Centres" and "Focused Learning Organisations", strong, dynamic establishments in strong cultures of equity and consensus about their value, following system-wide, root-and-branch reform as it was proposed back in 2004 by the International Schooling for Tomorrow Forum (OECD, 2004). At the core of these reforms is an emphasis on 21st-century teaching and learning in which technology is not merely present, but is used in the most effective ways possible. In the OECD re-schooling scenarios, schools are revitalized around a strong "knowledge" agenda, with far-reaching implications for the organization of individual institutions and for the system as a whole. The academic/artistic/competence development goals are paramount; experimentation and innovation are the norm. Curriculum specialists flourish as do innovative forms of assessment and skills recognition. All this takes place in a high-trust environment where quality norms rather than accountability measures are the primary means of control. Professionals (teachers and other experts) would in general be highly motivated and they work in environments characterized by the continuing professional development of personnel, group activities, and networking. In these environments, a strong emphasis is placed on educational R&D.



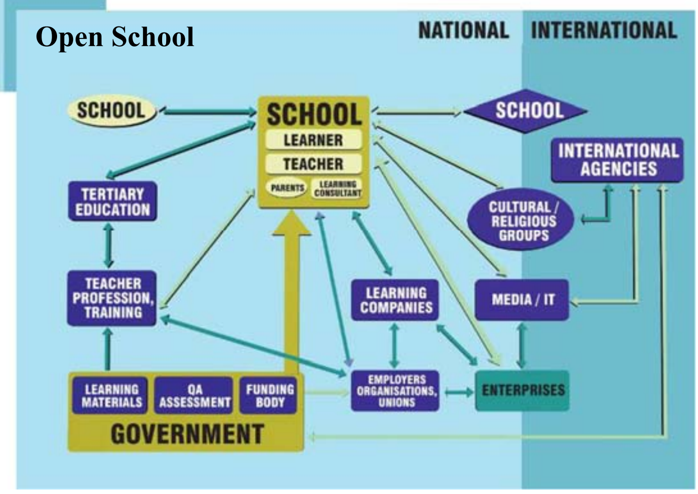


Figure 2.1: *A graphical representation of the Re-Schooling process, that evolves from the current organizations towards schools operating as "Core Social Centers" and "Focused Learning Organizations", strong, dynamic establishments in strong cultures of equity and consensus about their value, following system-wide, root-and-branch reform as it was proposed back in 2004 by the International Schooling for Tomorrow Forum*

In the process of Re-Schooling (OECD, 2006), ICTs are a fundamental support tool to allow educational establishments to comply with their central social function. Technologies are present in different teaching and learning environments, both as access stations to networks, and as tools for information or data analysis and processing. They are used in broadly common ways across disciplines to maximize results (tools for analysis, development, processing, etc.), and they have more specific roles in the learning process. They may allow to develop competencies and to apply relevant knowledge in simulated situations, while at other times they may permit assessments, or self-evaluations, to diagnose competencies. They also provide efficient tools for drawing up reports, portfolios and the presentations of research results and projects, etc. Students and teachers are able to communicate with their peers, have access to quality databases, and publish in digital educational academic magazines.

In these re-schooling scenarios, the purpose of schools will be different from traditional systems, as they will be more focused on building up sufficient knowledge-building as joint activities between teachers and students. In this respect, working networks - with other schools and also with higher education institutions - will become very common. Teachers will be members of virtual associations, organizing, developing and evaluating projects with students from different countries. In addition, as quite an innovative tool records on students' learning activities will be kept as a basis for re-designing educational programmes and methodologies. ICTs will facilitate more effective contact between teachers and parents, who will be able to observe part of what is going on in schools from afar, and thereby participate actively in the education of their children. One or more teachers will be responsible in each school for managing these resources and the methodological support for their use by the other teachers. In general, these educators will be required from the moment of hire to have the necessary skills for accessing these tools, and the competencies to use ICT well.

The OECD re-schooling scenarios describe the substantial strengthening of schools with new dynamism, recognition and purpose. These scenarios have formed the guiding ideas and principles for the development of the Open Schooling concept. In this chapter, we describe the re-schooling scenarios and we highlight their contributions to the design of the open schooling model which will be implemented in the framework of the OSOS project.

2.1.1 Schools as Core Social Centers

- Schools enjoy widespread recognition as the most effective bulwark against fragmentation in society and the family. Strongly defined by collective and community tasks
- Extensive shared responsibilities between schools and other community bodies, sources of expertise, and tertiary education.
- A wide range of organizational forms and settings, with strong emphasis on non-formal learning.
- Generous levels of financial support - to ensure quality learning environments in all communities and high esteem for teachers and schools.
- ICT used extensively, especially for communication and networking.
- A core of high-status teaching professionals, with varied arrangements and conditions but good rewards for all - many others around the core.

In this re-schooling scenario, the school comes to enjoy widespread recognition as the most effective bulwark against social fragmentation and a crisis of values. There is a strong sense of schooling as a **public good** and a marked upward shift in the general status and level of support for schools. The individualization of learning is tempered by a clear collective emphasis. Greater priority is accorded to the **social and community role of schools**, with more explicit sharing of programmes and responsibilities with the other settings of further and continuing education/training. Poor areas in particular enjoy high levels of support (financial, teaching, expertise and other community-based resources). Overall, schools concentrate more on laying the cognitive and non-cognitive foundations of knowledge, skills, attitudes and values for students to be built on thereafter as part of lifelong learning. Norms of lengthening duration in initial schooling may well be reversed, and there is greater experimentation with age/grading structures and the involvement of learners of all ages.

Schools come to **enjoy a large measure of autonomy without countervailing central constraints**, as levels of public/political support and funding have been attained through a widespread perception of high standards, evenly distributed, thereby reducing the felt need closely to monitor conformity to established standards. Strong pressures for corrective action nevertheless come into play in the face of evidence that any particular school is under-performing. There is more active sharing of professional roles between the core of teachers and other sources of experience and expertise, including different interest, religious, and community groups. In this framework, we are describing **a strengthened, creative school institution available to the community that it serves**, meeting critical social responsibilities while silencing critics. This school fits a longstanding tradition advocating that closer links be forged between schools and local communities. More recently, such arguments have acquired an added urgency and relevance with the fragmentation occurring in many family and community settings, raising new concerns about the socialization of children. In response to these concerns, an open school could thus **become a much-needed social anchor** and constitute the fulcrum of residential communities. The open school is instrumental in **raising the science capital of the community it serves**, benefiting in the process from the positive impact on educational achievement of strengthened infrastructure and belief in the values upheld by schools. Such an educational environment is predicated not only on critical re-definitions of purpose, practice and professionalism, but also on the new definitions being widely endorsed by the main stakeholders throughout society. **Generous resourcing would probably be called for**, given the need for very even patterns of quality learning environments across all communities and for **establishing high esteem for teachers and schools**, though some of this might be attained through more cost-effective resource use. **Greater flexibility of action would also be needed**. If schools could rely on the existence of universal opportunities for continuing education and the certification of competences outside education, this would be a major step in liberating them from the excessive burdens of credentialism; in these circumstances, such flexibility might well be more attainable.

It has to be noted though that such very promising re-schooling scenarios that are focusing on the strong links to the community and on the effort to increase their science capital that make such an approach attractive could equally be the very factors that prevent the realization of the full potential of such open environments. Far from equalizing the effect of different socio-economic environments, the strategy of linking schools very closely with their communities might only serve to exacerbate the gaps between the vibrant and the depressed. Hence, without powerful mechanisms equalizing resources and status, and without a strong sense of common purpose, the risk is that such a school environment would reflect, even exacerbate, existing inequalities between different communities.

2.1.2 Schools as Focused Learning Organizations

- Schools revitalized around a strong knowledge rather than social agenda, in a culture of high quality, experimentation, diversity, and innovation.
- Flourishing new forms of evaluation and competence assessment.
- Large majority of schools justify the label "learning organizations" - strong knowledge management and extensive links to tertiary education.
- Substantial investments, especially in disadvantaged communities. ICT used extensively.
- Equality of opportunity is the norm, and not in conflict with “quality” agenda.
- Highly motivated teachers, favorable working conditions. High levels of R&D, professional development, group activities, networking, and mobility in and out of teaching.

In this case, schools are revitalized around a **strong knowledge agenda**, with far-reaching implications for the organization of individual institutions and for the system as a whole. The academic/artistic/competence development goals are paramount; **experimentation and innovation are the norm**. **Curriculum specialisms flourish as do innovative forms of assessment and skills recognition**. As with the previous scenario, all this takes place in a **high-trust environment** where quality norms rather than accountability measures are the primary means of control. Similarly, generous resourcing would probably be required, though there would be very close attention to how those resources are used in pursuit of quality. Professionals (teachers and other specialists) would in general be highly motivated, learning groups are small, and they work in environments characterized by the continuing professional development of personnel, group activities, and networking. In these environments, a strong emphasis is placed on educational R&D. ICT is used extensively alongside other learning media, traditional and new.

In this case, the very large majority of schools merit the label **learning organizations**. They are among the lead organizations driving the "lifelong learning for all" agenda, **informed by a strong equity ethos** which also holds a great potential for the realization of the Responsible Research and Innovation agenda. Close links develop between schools, places of tertiary education, media companies and other enterprises, individually and collectively.

This differs from the previous scenario by its stronger "knowledge" focus that is well understood by the public and avoids the risk of ever-widening social remits making impossible demands on schools. It assumes strong schools, enjoying very high levels of public support and generous funding from diverse sources, as well as a large degree of latitude to develop programmes and methods.

2.1.3 Developing the Open Schooling Culture

The OSOS project aims to integrate the key principles and characteristics of the re-schooling scenarios presented in the previous section to a holistic approach that will facilitate the introduction of an open schooling culture in current school settings. By building on the strengths of the OECD re-schooling scenarios and by implementing a well-tested approach for the introduction of innovation to schools the OSOS consortium aims to demonstrate at scale how schools can become incubators of exploration and invention and accelerators of innovation in their local communities. The OSOS project will describe and implement at scale a process that will facilitate the **transformation of schools to innovative ecosystems**, acting as **shared sites of science learning** for which leaders, teachers, students and the local community share responsibility, over which they share authority, and from which they all benefit through **the increase of their communities' science capital and the development of responsible citizenship.**

Becoming an Open School cannot be seen as an isolated "project" – it demands a root-and-branch rethink, not just in pedagogy, but in every aspect of the way the school is organised: its structure, culture, and the use of space, place, and time. An Open School will be an open, curious, welcoming, democratic environment which will support the development of innovative and creative projects and educational activities. It is an environment which will facilitate the process for envisioning, managing and monitoring change in school settings by providing a simple and flexible structure to follow, so school leaders and teachers can innovate in a way that's appropriate for school local needs. It will provide innovative ways to explore the world: not simply to automate processes but to inspire, to engage, and to connect. It will provide a powerful framework for school leaders to engage, discuss and explore: how schools need to **evolve**, **transform** and **reinvent**; how schools will facilitate open, more effective and efficient co-design, co-creation, and use of educational content (both from formal and informal providers), tools and services for personalized learning and teaching; how schools can become innovation incubators and accelerators.

2.2 Open Schools in the Framework of OSOS Project

As stated in the recent report on "Rethinking education. Towards a Common global goal?" (UNESCO, 2015) the changes in the world today are characterized by new levels of complexity and contradiction. These changes generate tensions for which education systems are expected to prepare individuals and communities by giving them the capability to adapt and to respond. Overcoming the complex societal challenges of today will require all citizens to have a better understanding of science and technology if they are to participate actively and responsibly in science-informed decision-making and knowledge-based innovation as it is stated in the recent report to the European Commission "Science Education for responsible citizenship" (EC, 2015) produced in 2015.

On the other hand, there is growing concern, among the world's "developed" countries, about levels of student engagement in science learning at school (Paul Hamlyn Foundation, March 2012). This manifests itself most obviously in dropout rates, in poor levels of achievement, and in disengagement with what many perceive as a boring and irrelevant experience. However, focusing on students who drop out from school masks a bigger issue, because it only takes account of the visibly disengaged. There is a much larger group of students who do reasonably well in school but do not become self-motivated, self-directed learners: they may appear to succeed in exams but struggle when left to their own devices at University, or at work. Schools and businesses are becoming increasingly conscious of "disengaged achievers": students who are adept at achieving high marks, but not at dealing with the more complex challenges that they will face as 21st century workers and citizens. Additionally, many disengaged achievers decide that the way learning is "delivered" in school education is not for them and, even though they have the requisite qualifications, decide to end their formal education upon leaving school. Arising from this came two obvious questions: Which are the main characteristics of the environments which are engaging for the students? What design features might we need to incorporate into learning activities to see more students deeply engaged?

2.2.1 Characteristics of the Open Schools

In the framework of the OSOS project we will support the participating schools to set forward and innovation agenda that has the following characteristics:

- **Promotes the collaboration with non-formal and informal education providers, enterprises and civil society enhanced** to ensure relevant and meaningful engagement of all societal actors with science and increase the uptake of science studies and science based careers, employability and competitiveness. The OSOS project brings together individual schools, the European school headmasters association, science centres and museums, industries, research institutes, universities, national school networks and teacher trainings associations in an innovative collaboration towards the introduction of open schooling approaches in numerous European schools through **a bottom-up approach**. With the focus on science learning in both primary and secondary education level the project proposes new and diverse models of collaborations between the above-mentioned stakeholders. By building on the best of current practice, the OSOS approach aims to take us beyond the constraints of present structures of schooling toward a shared vision of excellence. Such an innovation programme holds great potential. If we want a powerful and innovative and open culture in schools that is self-sustaining we have to empower system-aware practitioners to create it, whilst avoiding simply creating interesting but isolated pockets of experimentation. We have to instill a design based approach of **collaborative learning and inquiry between professional practitioners, thus creating a "pull" rather than "push" approach.** To promote such an approach in the current schooling practices, an **ecosystemic standpoint** should be taken from the side of the remedying initiatives. More specifically, the latter should aim to capture the profiles, needs, contributions and relationships of all these school-related actors and elements towards **a sustainable innovation ecosystem** that will operate under a **holistic framework** of organizational learning and promotion of educational innovations.

- **Supports Schools to become an agent of community well-being.** OSOS aims to support the introduction of an Open Culture in 1,000 European schools in order to develop projects that are proposing solutions to the needs of their local communities. To do so the OSOS approach will explore the notion of well-being of the school's students (including concepts of equity, gender inclusion and empowerment). By creating a model of collaboration with local stakeholders and by using activities that require the involvement of different actors, the participating schools will be linked with their local communities in a much deeper level. The adaptation of the activities will entail linking their subjects to issues of national interest in connection with the grand challenges as set by the European Commission. Schools will thus aim to "act locally but think globally", a motto developed already a few years now but still far from the reality of the majority of schools in Europe today. In this way, these schools will enrich the science capital of the local communities and will promote responsible citizenship.
- **Promotes partnerships that foster expertise, networking, sharing and applying science and technology research findings and that bringing real-life projects to the classroom.** The project partners, both individually and in collaboration, have been developing, testing and promoting innovative educational applications and approaches for European schools (supported by relevant appliances and resources) for many years, which promote sharing and applying of frontier research findings in schools, supporting the developments of 21st century competences through creative problem solving, discovery, learning by doing, experiential learning, critical thinking and creativity, including projects and activities that simulate the real scientific work (e.g. nanotechnology applications in different sectors, organic farming and healthy food, implementing

> **"Beyond the Lab: The DIY Science Revolution"** is a pan-European exhibition that shows how ordinary people are harnessing science in all sorts of ways: from patient-innovation to DIY biology, tackling public health challenges such as air pollution, antibiotic resistance or disease outbreaks. Equipped with low-cost sensors, smartphone apps and the ability to share information with communities online, these DIY science pioneers are challenging our ideas of who a scientist is and what science and our societies will look like in the future. Through a combination of objects, images and films, "Beyond the Lab" examines seven real-life case studies, giving the visitor the chance to hear from the DIY scientists themselves about the

project with aero-space industry, analyse data from large research infrastructures like CERN or networks of robotic telescopes). The aim of the project is to analytically map the process for the effective usage scenarios of the afore-mentioned applications in school environments as part of curriculum-led learning (integrating/embedding them in the everyday school practice) and or extra-curricular activities (e.g. visits to museums, science centers, research centers, field trips), coupled with home- and community-centered (informal) learning experiences. Each open schooling hub will bring together representatives from industry and civil society associations who – in cooperation with school community – will scan the horizons, analyse the school and community needs and will cooperate to design common projects and to propose innovative solutions.
- **Focuses on Effective Parental Engagement.** The Open Schooling Model builds on the notion of science capital of students' families. As it has been recently discovered whilst science and technology are often seen as interesting to young adolescents, such interest is not reflected in students' engagement with school science that fails to appeal to too many students. Girls, in particular, are less interested in school science and only a minority of girls pursues careers in physical science and engineering. The reasons for this state of affairs are complex but need to be addressed. (Osborne & Dillon, 2008, p. 15). The Aspires Project led by Louise Archer at King's College London has attempted to tease out some of the complexity of these issues. Their study produced a series of findings that confirm that while interest in science is important, it is not the only issue. Many students who express high levels of interest in science may not choose science subjects because: a) they think that choosing science leads only to working in a laboratory; and, b) that

science is for other people. These are issues of identity – of science and of the students themselves. The study suggested that the role of students' families in their selection of future career has been much stronger than what previously expected. So, what can be done to modify this situation? The OSOS approach is suggesting four courses of action: effective parental engagement in the projects that will be developed by a) *Planning*: Parental engagement must be planned for and embedded in a whole school or service strategy. The planning cycle will include a comprehensive needs analysis; the establishment of mutual priorities; ongoing monitoring and evaluation of interventions; and a public awareness process to help parents and teachers understand and commit to the Open School Development plan. b) *Leadership*: Effective leadership of parental engagement is essential to the success of the OSOS Open Schooling Strategies. A parental engagement programme is often led by a senior leader, although leadership may also be distributed in the context of a programme or cluster of schools and services working to a clear strategic direction. c) *Collaboration and engagement*: Parental engagement requires active collaboration with parents and should be proactive rather than reactive. It should be sensitive to the circumstances of all families, recognise the contributions parents can make, and aim to empower parents. d) *Sustained improvement*: A parental engagement strategy should be the subject of ongoing support, monitoring and development. This will include strategic planning which embeds parental engagement in whole-school development plans, sustained support, resourcing and training, community involvement at all levels of management, and a continuous system of evidence based development and review.

- **Teaching science for difference: Gender Issues.** Instructional methods that foster students' understanding while decreasing competitiveness in science classes might contribute to girls' participation and performance in advanced science classes while also supporting the learning of many boys. The Open Schooling approach recommends replacing the competitive-type classroom environment by more a more girls friendly instructional approach in which enough time and conditions are given to think, inquire, and understand thoroughly. This could be accomplished by for example sharing ideas, arguing, asking questions and analyzing data in small groups of students who work in collaborative manner. This is an approach that clearly reduces the competitive nature of the whole classroom (teacher-centred) approach. The OSOS educational activities and projects are based on pedagogical approaches that produce the outcome of proportional participation of both genders. More specifically the proposed standardization process will:
  - Adopt and integrate informal and formal educational experiences that intervene and reverse traditional patterns of low participation; encourage girls' interest, enthusiastic participation, and election of continued study in math and science; increase confidence; and give girls positive images of math and science learning and careers.
  - Integrate awareness of gender bias in educational environments, and change organizational commitment, policy, and action to remedy under representation through student and faculty programs, for example, undergraduate departments in engineering, physical science, or computer science making a concentrated effort to increase recruitment and retention.
  - Adopt and integrate new courses and curriculum that are gender-neutral or appeal particularly to girls and women. For example, ways of teaching math that utilize girls' verbal skills, sequencing material in computer science to introduce real-world applications of technology before intricacies of programming languages, teaching young girls principles of engineering design and invention in everyday life.

The consortium will identify the "model approaches" to be adopted, its theoretical basis and the research or evaluation basis for the "model," and address the benefits and issues bearing on integration in their educational setting. Using the expertise of partners as NEMO Science Museum and Bloomfield Science Museum and the findings of the Horizon2020 European funded project Hypatia (www.expecteverything.eu), **OSOS will be addressing gender inclusion in different levels**: cultural – country level, institutional – school level, interactional – student-teacher and student-student level and individual level towards each student). OSOS will look at gender from both the perspective that it is not a binary subject but also from the assumption that science is gendered and the way we communicate science is influencing a great deal the decisions of both boys and girls towards their career paths. The assumption that girls and boys belong to distinct, internally homogeneous groups based on their biological sex creates a stereotype of girls and boys that fits no one in particular (Brickhouse, Lowery, & Schultz, 2000). The OSOS project will keep away from making this assumption creating activities that acknowledge gender should be studied as something individuals do rather than something they possess. Following the approach supported by Achiam and Holmegaard in the Hypatia project, science cannot produce culture-free, gender-neutral knowledge (Brickhouse, 2001). In fact, much of STEM is constructed in terms of the rational, intellectual, and independent; characteristics that are often symbolically connected with masculinity (Due, 2014; Faulkner, 2000; Phipps, 2007). This means that for individuals (boys or girls) who do not identify with such characteristics, a position within STEM is not available to them on the same terms as for individuals who do identify with such characteristics (Due, 2014). OSOS will aim to address this issue and propose an approach that aims to overcome the above mentioned identified barriers that hold back a great number of students in Europe from following science related careers.

2.2.2 Design Features of the Open School Activities

The OSOS pedagogical framework builds on the essential features of creative learning including exploration, dynamics of discovery, student-led activity, engagement in scientifically oriented questions, priority to evidence in responding to questions, formulations of evidence-based explanations, connection of explanations to scientific knowledge, and communication and justification of explanations. These elements support creativity as a generic element in the processual and communicative aspects of the pedagogy and proposing innovative teaching strategies that will offer students high participation and enable them to generate highly imaginative possibilities. At the same time, the OSOS framework is based on the main principles of Responsible Research and Innovation process: learners' engagement, unlock of their full potential, sharing results and provide access to scientific archives, designing innovative activities for all. Based on that, the OSOS Open Schools will promote a series of educational activities in the form of real-life projects that will utilize innovative ideas and creativity and empowers students to actively engage themselves in the learning process and improve their conceptual understanding in various scientific topics. It is therefore intended that the educational practices and strategies presented will allow science educators and specifically late primary and early secondary school teachers to identify creative activities for teaching science. Furthermore, the proposed pedagogy will aim to enable teachers to either create new creative activities or to properly assemble parts of different educational activities into interdisciplinary learning scenarios. In the framework of the OSOS project the proposed activities will have the following four characteristics. They must be

- **Placed:** The activity is located, either physically or virtually, in a world that the student recognizes and is seeking to understand.
- **Purposeful:** The activity feels authentic, it absorbs the student in actions of practical and intellectual value and fosters a sense of agency.
- **Passion-led:** The activity enlists the outside passions of both students and teachers, enhancing engagement by encouraging students to choose areas of interest which *matter* to them.
- **Pervasive:** The activity enables the student to continue learning outside the classroom, drawing on family members, peers, local experts, and online references as sources of research and critique.

These four criteria can provide a useful checklist for teachers formulating their learning designs, but also suggest what a science classroom and a school as an organization needs to offer to become more engaging in itself: **a place-based curriculum, purposeful projects, passion-led teaching and learning, and pervasive opportunities for research and constructive challenge.**

The activities that the project will produce will be based on existing best practices of the partners and will range from collaborative workshops, to citizen debates, participatory conferences and more. These activities will be adapted by the Open schooling hub members that will involve representatives from educational providers, industries, civil society associations and even students themselves. The activities used in the project will promote collaborations and the opening up of the classrooms to the society. The participating schools will include both primary and secondary education level and activities will be selected and adapted accordingly to fit the different levels.

In our view the OSOS school environments should provide more challenging, authentic and higher-order learning experiences, more opportunities for students to participate in scientific practices and tasks, using the discourse of science and working with scientific representations and tools. It should enrich and transform the students' concepts and initial ideas, which could work either as resources or barriers to emerging ideas. The OSOS schools' environments should offer opportunities for teaching tailored to the students' particular needs while it should provide continuous measures of competence, integral to the learning process that can help teachers work more effectively with individuals and leave a record of competence that is compelling to students.

3 Introducing Responsible Research and Innovation in schools

This chapter proposes a generic framework for the design, development, implementation and evaluation (both short and long term) of Educational and Outreach activities that can be used to introduce the principles of Responsible Research and Innovation in science classrooms. In order to capture the multifaceted nature of science learning, the OSOS approach proposes a roadmap that includes a series of "Pedagogic Principles for the design of the Educational and Outreach Activities" and articulates the science-specific capabilities supported by the environment of the Open Schooling Hub. These principles will be the reference point for the development of the Open Schooling Model (Chapter 5) and the definition of the characteristics of the OSOS Incubators and Accelerators (WP4).

3.1 Responsible Research and Innovation (RRI)

RRI is an inclusive approach to research and innovation (R&I), to ensure that societal actors work together during the whole research and innovation process. It aims to better align both the process and outcomes of R&I, with the values, needs and expectations of European society. It allows all societal actors (researchers, citizens, policy makers, business, third sector organizations etc.) to work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of European society. In general terms, RRI implies anticipating and assessing potential implications and societal expectations with regard to research and innovation. In practice, RRI consists of designing and implementing R&I policy in the organization that will:

- engage society more broadly in its research and innovation activities,
- increase access to scientific results,
- ensure gender equality, in both the research process and research content,
- take into account the ethical dimension, and
- promote formal and informal science education.

RRI addresses a number of agendas and involves every key stakeholder (including policy-makers, researchers, industry and commerce, science educators, and civil society organizations as well as the public at large) essential for a fair society. In addition, it is through a wide umbrella how different features in the relationship between science and innovation and society are brought together, comprising the dimensions of ethics, gender equality, open access, public engagement, and science education. The large-scale Coordination Action RRI Tools has developed a series of tools that guide the introduction of RRI in different educational organizations both in formal and informal learning sector. The project has produced a handbook for school teachers (along with a series or self-reflection tools) with the main aim of accommodating Research and Innovation (R&I) practices in schools, and particularly in the teaching of STEM disciplines (science, technology, engineering and mathematics). It is designed as a way to guide and support educators along the process of introducing RRI in the classroom through innovative science pedagogical methods and by offering a range of inspiring resources for designing and implementing class activities (RRI-Tools, 2016).

RRI processes can be broken down into four components – 1) outcomes, 2) process dimensions, 3) policy agendas and 4) stakeholders.

- Specific **outcomes** act as drivers for the efforts involved in adopting responsible research and innovation practices. These can be classified into leaning outcomes, R+I outcomes and solutions to societal challenges.
- A number of **process dimensions** are essential to develop RRI practices, too. In particular, up to 8 dimensions have been identified and classified in 4 different clusters (namely Diversity and inclusion, Anticipation and Reflection, Openness and transparency and Responsiveness and Adaptive change).

- Furthermore, 6 influential **policy agendas** have been recognized by the European Commission with enough potential to maximize responsibility in RRI and overall, to ensure all actors keep working together to achieve common RRI goals.
- Last, the involvement of **certain key stakeholders** will be necessary to work taking into account different policy agendas and outcomes of RRI processes. Within these: civil society organizations, policy makers, both the research and the education community and other business and industry actors, in addition to society as a whole.

From the mentioned components, it is essential in the case of school based implementations to highlight (1) the part different process dimensions take in RRI processes and (2) the role a number of key stakeholders.

3.1.1 Process dimensions: principles of RRI

As mentioned, RRI process dimensions have been classified in different clusters. From those:

- **The Diversity and Inclusion** cluster entails the involvement of a wide range of stakeholders in the development of STEM related RRI processes, in order to expand and diversify the number of experts involved and perspectives included in scientific processes as well as for other reasons related to democratic processes.
- Within the **Anticipation and Reflection** cluster, two areas can be distinguished. While anticipation englobes a general understanding of the impacts of research and innovation in different societal groups and individuals, reflection is understood as the contemplation of motivations, purposes and potential implications of R+I.
- **Openness and Transparency** is essential to understand those conditions necessary to ensure accountability, liability and responsibility in the R+I process that will be just as necessary to ensure public trust.
- **Responsiveness and Adaptive** change incorporates two discernable dimensions. Responsiveness refers to the ability to take account of society's needs while Adaptive change involves the capacity to change prevalent behavioral routines, structures or systems, in response to changing circumstances.

3.1.2 RRI is multi-stakeholder cooperation

The engagement of different actors through inclusive, participatory procedures at all stages and levels of R+I is essential, too. In particular, the involvement of key groups of people will be necessary to tackle those challenging outcomes and multiple agendas that are continuously addressed in RRI:

- As **Policy Makers**, all those actors involved in any decision-making process that might have an impact in research and innovation (at any level, whether at European, national or local scale) will make the cut, including policy officers or research center directors.
- The **Research Community** is yet another vital group of RRI stakeholders, comprising all professionals involved in the diverse aspects of the research and innovation system, including researchers or research managers and innovators, just to name a few.
- Those working in the education field (again, including all capacities and levels) will form the **Education Community** stakeholder group. Not only teachers and students belong to it, but also science museums professionals, school directors or students' families.
- Likewise, **Civil society organizations** (whether individuals or organizations) are crucial in research and innovation. This group will be especially diverse, including NGO representatives or even media outlets.

- Finally, **Business and Industry** will also indispensable for the development of research and innovation, as the engines for the development of many research developments.

3.2 Inquiry and project-based learning methods as foundations for RRI at school

The integration of RRI principles in educative contexts can be strongly beneficial for students, as it supports them in the development of critical thinking and collaborative learning skills while accommodating multidisciplinary and stronger student engagement. Hence, it is essential to lay out principles that will help on the implementation of RRI in teaching and learning activities in schools. This can be done through a number of pedagogical methods such as inquiry based learning, structured research school projects or through reflections on ethical, legal and social aspects and basic socioscientific issues. A number of ways to do so are presented in the following.

3.2.1 Introduction of RRI concepts in study blocks

Teachers can facilitate the process and support the introduction of RRI concepts in the framework of school-based activities. For example, when they are proposing a group activity or a project, critical reflection processes could be established through the enactment of regular sessions focusing on group's processes, values, routines and final results. The RRI dimension of adaptive change could be incorporated by prompting students to make any necessary changes to their work plans and work methods, after the reflection process has taken place. When they are organizing project teams, students' critical considerations on gender balance and social inclusion can be triggered while learning about different roles and levels of expertise needed in collaborative endeavors and reflecting on its importance in real contexts. Teachers can dedicate some time to identifying and reflecting on key RRI-aspects related to the course lessons. This could serve as lessons around basic RRI principles. Reflection and discussion games could be used to trigger talks, debates or other deliberative processes about social and scientific issues or even about the ethical, legal and social aspects of a specific topic. Considerations on the sustainability, social desirability and ethical aspects of certain processes would also address the RRI areas of anticipation and refection and it could easily be implemented in classroom discussions. Identification of attractive research questions that students could solve through the utilization of scientific methods often used in research methodologies.

3.2.2 Stakeholders' engagement

The introduction of RRI principles in the classroom can also benefit collaborative planning and learning in school activities, especially if it involves the engagement of multiple stakeholders. In particular, the organization of events (such as workshops, exhibitions, open days or school fairs) with the aim of disseminating the results of a class activity or a school project supports the acquisition of communication and reflection skills and can be especially relevant for RRI processes if it involves stakeholders, such as parents, external experts and local communities.

3.2.3 RRI transversally in schools

Moreover, while RRI should be integrated at different levels of STEM education, including different school education stages (primary and secondary), it should also be incorporated in lifelong learning initiatives and in informal learning contexts like science centers, research centers, museums and thematic parks.

3.2.4 RRI in STEM

Finally, the introduction of RRI concepts in the classroom will most likely foster the development of receptive and open mind-sets in students which, in turn, will improve their understanding of the outside world and will prepare them to make better informed and evidence-based societal choices. Nonetheless, one must not forget that STEM education -in particular- has a critical role for the implementation of RRI principles, as it provides with the necessary knowledge and skills to empower today's students to become tomorrow's active citizens in nowadays knowledge society. In that sense, it is essential to make students better understand science and innovation as a whole as well as its relations with different aspects of society. STEM education should become a central environment where students are provided with the necessary scientific and technological knowledge, skills and methodologies to develop critical thinking on Research and Innovation. Besides, integrating RRI principles in STEM teaching will help make STEM careers more attractive and improve students' employability and career perspectives.

3.3 RRI-oriented educational practices

To start introducing RRI principles at organizational level, teachers and educational organizations can implement a self-reflection process to determine how RRI-oriented their practices are. This process is a continuous exercise that can be done between a small group of teachers developing lesson plans for a single class; at school council level and across curricula; at local level for a group of schools in the same district; and at a wider level, for example, within the activities of a national teachers' association or professional development courses. The process can be initiated as an informal activity, or proposed as an additional formal step of the school or local council's internal evaluation. Either way, it will require the involved parties to get familiar with the basic RRI principles as well as to bet set up in a format that enables discussion and participation, since integrating these aspects is not a checklist but rather a practice. It has to be noted that the RRI framework promotes a transparent, interactive process where innovators need to be mutually responsive. The OSOS approach is based on the fact that ideas generated through **individual, collaborative and communal activities** have a potent capacity to contribute to engagement and change. The layer of communal engagement is particularly important in terms of the societal level of the RRI, and the idea that innovators need to be mutually responsive within and beyond their communities. The idea of communal engagement (Chappell, 2008) acknowledges that when working creatively people exist in groups with shared identities which shape their ideas and thinking and which may be challenged by the thinking of other groups. This raises ethical questions which need consideration if these challenges are to be overcome (Craft, Claxton and Gardner, 2008) and people are to be genuinely engaged in scientific debates and questions via education.

Of vital importance to nurturing **empowerment and agency, dialogue, individual, collaborative and communal activities for change** and **ethics and trusteeship** are two more OSOS principles which finally resonate with RRI. The first is the importance of rigorous **Discipline knowledge.** This means science discipline knowledge but it is also embedded in the idea that there are different ways of knowing in the world, alongside those prioritized within the scientific realm which scientists must engage with in order to generate conversations between their ideas and those of the 'public' in order that a shared dialogue can be ongoing rather than a one way conversation. The second is the promotion of the idea of **professional wisdom.** At its heart, the OSOS approach values the idea that teaching professionals bring a wealth of often intuitive teaching and discipline knowledge and expertise; they cannot be viewed as 'information deliverers'. It is their professional wisdom that can make the science learning process creative and can engage children and young people in meaningful ways.

3.4 OSOS contribution: Pedagogical Principles in the Design of Open Schooling Activities

The OSOS coordination action aims to propose a generic framework for the design, development, implementation and evaluation (both short and long term) of Educational and Outreach activities that can be used to introduce the principles of Responsible Research and Innovation in science classrooms. The aim of the consortium is to formulate a common set of guidelines and recommendations on how scientific work can be used to provide an engaging educational experience through the exploration of "real science". Research on learning science makes clear that it involves development of a broad array of interests, attitudes, knowledge, and competencies. Clearly, learning "just the facts" or learning how to design simple experiments is not sufficient. In order to capture the multifaceted nature of science learning, the OSOS approach proposes a roadmap that includes a series of "Pedagogic Principles for the design of the Educational and Outreach Activities" and articulates the science-specific capabilities supported by the environment of the Open Schooling Hub. This framework builds on a four-strand model developed to capture what it means to learn science in school settings by adding two additional main strands incorporated for informal science learning, reflecting a special commitment to interest, personal growth, and sustained engagement that is the hallmark of informal settings.

Table 3.1: *The main Pedagogic Principles and the Educational Objectives for the design and implementation of Educational and Outreach activities for involving students in Research and Innovation process.*

Strands – Pedagogic Principles	Educational Objectives
Sparking Interest and Excitement	*Experiencing excitement, interest, and motivation to learn about phenomena in the natural and physical world.*
Understanding Scientific Content and Knowledge	*Generating, understanding, remembering, and using concepts, explanations, arguments, models, and facts related to science.*
Engaging in Scientific Reasoning	*Manipulating, testing, exploring, predicting, questioning, observing, analysing, and making sense of the natural and physical world.*
Reflecting on Science	*Reflecting on science as a way of knowing, including the processes, concepts, and institutions of science. It also involves reflection on the learner's own process of understanding natural phenomena and the scientific explanations for them.*
Using the Tools and Language of Science	*Participation in scientific activities and learning practices with others, using scientific language and tools.*
Identifying with the Scientific Enterprise	*Coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science.*

These Pedagogic Principles provide a framework for thinking about elements of scientific knowledge, innovation and practice. This framework describes a series of support functions that have to be deployed for the long-term impact of the proposed activities to be safeguarded. Such support actions could include support for: the integration and coordination of educational and outreach activities between groups across different research institutions; the science community and scientists interested in educational and outreach activities; the education communities interested in scientific content and applications; special events and activities that provide means and tools for web-based communication and collaboration. This framework provides a useful reference for helping teachers and outreach groups in the informal science education community articulate learning outcomes as they develop programs, activities, and events, and further explore and exploit the unique benefits of introducing scientific research in schools. Furthermore, such an action asks for knowledge areas integration, effective and closes cross-institutional collaboration, and organizational change in the field of science education. In the following we are presenting the key issues related with the proposed strands in more detail.

3.4.1 Sparking Interest and Excitement

The motivation to learn science, emotional engagement, curiosity, and willingness to persevere through complicated scientific ideas and procedures over time are all important aspects of learning science. Recent research shows that the emotions associated with interest are a major factor in thinking and learning, helping people learn as well as helping them retain and remember. Engagement can trigger motivation, which leads a learner to seek out additional ways to learn more about a topic.

3.4.2 Understanding Scientific Content and Knowledge

This strand includes knowing, using, and interpreting scientific explanations of the natural and physical world. Students who are visiting science centres and museums, research infrastructures and other science related places come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science. Students also must understand interrelations among central scientific concepts and use them to build and critique scientific arguments. While this strand includes what is usually categorized as content, it focuses on concepts and the link between them rather than on discrete facts. It also involves the ability to use this knowledge in one's own life. Effective outreach programmes and on-line labs could provide great tools for the teachers who have to cope with an increased number of student's questions on complex topics related with scientific research.

Engaging in Scientific Reasoning

This strand encompasses the knowledge and skills needed to reason about evidence and to design and analyze investigations. It includes evaluating evidence and constructing and defending arguments based on evidence. The strand also includes recognizing when there is insufficient evidence to draw a conclusion and determining what kind of additional data are needed. Many informal environments provide students with opportunities to manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world. In fact, most outreach and educational activities have to be built around the concept of exploration. Usually visitors (physical or virtual) are not given a correct scientific explanation of a natural phenomenon. Rather, they are presented with a phenomenon and then led through a process of asking questions and arriving at their own answers (which may then be verified against current scientific explanations). The generation and explanation of evidence is at the core of scientific practice; scientists are constantly refining theories and constructing new models based on observations and empirical data. Understanding the connections, similarities, and differences between the ways people evaluate evidence in their daily lives and the practice of science is also part of this strand (e.g., understanding the impact of individual and collective decisions related to light pollution, understanding the use of advanced technological applications to everyday life). Through trial and error students can begin to develop a deeper understanding of the world.

3.4.3 Reflecting on Science

The practice of science is a dynamic process, based on the continual evaluation of new evidence and the reassessment of old ideas. In this way, scientists are constantly modifying their view of the world. Students reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena. This strand also includes an appreciation of how the thinking of scientists and scientific communities' changes over time as well as the students' sense of how his or her own thinking changes. Research shows that, in general, people do not have a very good understanding of the nature of science and how scientific knowledge accumulates and advances[i]. This limited understanding may be due, in part, to a lack of exposure to opportunities to learn about how scientific knowledge is constructed and how scientific work is organised. It is also the case that simply carrying out scientific investigations does not automatically lead to an understanding of the nature of science. Instead, educational experiences must be designed to communicate this explicitly. Also compelling are the human stories behind great scientific discoveries.

3.4.4 Using the Tools and Language of Science

The myth of science as a solitary endeavour is misleading. Science is a social process, in which people with knowledge of the language, tools, and core values of the community come together to achieve a greater understanding of the world. The story of the discovery of Higgs boson (July 2012) is a good example of how scientists with different areas of expertise and from numerous nations around the world came together to accomplish a Herculean task that no single scientist (not even a large research laboratory) could have completed on his or her own. Even small research projects are often tackled by teams of researchers. Through participation in informal environments, non-scientists can develop a greater appreciation of how scientists work together and the specialized language and tools they have developed (among them the web that was developed at CERN to support international cooperation in research topics). In turn, students also can refine their own mastery of the language and tools of science. Using the tools of science, such as detectors and similar devices in a game-like approach to identify the particles that were produced from a collision, students could become more familiar with the means by which scientists work on their research problems. By engaging in scientific activities, participants also develop greater facility with the language of scientists; terms like *hypothesis*, *experiment*, and *control* begin to appear naturally in their discussion of what they are learning. In these ways, non-scientists begin to gain entry into the culture of the scientific community.

3.4.5 Identifying with the Scientific Enterprise

Through experiences in the framework of outreach and educational programmes, some students may start to change the way they think about themselves and their relationship to science. They think about themselves as science students and develop an identity as someone who knows about, uses, and sometimes contributes to science. When a transformation such as this one takes place, young people may begin to think seriously about a career in a research field, in an engineering firm, or in a research laboratory. Changing individual perspectives about science over the life span is a far-reaching goal of outreach and educational activities of the major research infrastructures. Sustaining existing science-related identities may be more common than creating new ones.

The strands are statements about what students do when they learn science, reflecting the practical as well as the more abstract, conceptual, and reflective aspects of science learning. The strands also represent important outcomes of science learning. That is, they encompass the knowledge, skills, attitudes, and habits of mind demonstrated by learners who are fully proficient in science. The strands serve as an important resource for guiding the design and development of the OSOS activities for schools and especially for articulating desired outcomes for learners.

4 Models of Open Schooling and School-based Innovation

4.1 Introduction

This Chapter is dedicated to the study of various open schooling models and their approaches in addressing the issue of school openness and change, affecting the school itself but also the local community. Some of the examples presented below are not direct applications of open schooling initiatives, but they certainly demonstrate how schools are trying to introduce innovation in their approaches and – according to our view – demonstrate the potential of local, national and international actions towards the development of an Open Schooling Culture:

- **educational resources generated in school settings according the local needs,**
- **holistic school approach and vision,**
- **effective introduction of RRI principles in the school operation,**
- **effective partnerships with external stakeholders and**
- **focused policy support actions.**

The consortium has developed a template (see Appendix 1) for the collection of the various models that are promoting the open schooling culture or they are focusing on specific characteristics and principles that the consortium considers as critical for the development of an open culture to the school. At the end of this chapter we are presenting in detail three initiatives that are integrating a series of key characteristics of the open schooling approach which we consider as key reference points for the development of the OSOS Open Schooling Model: A global initiative that sets as a goal to make students as change agents in their local communities (**Design for Change**), an international initiative that also aims to make young students catalysts of change in their communities (**EcoWeek**) and finally an initiative that aims to bring **MIT's unique "Mind and Hand"** learning approach beyond the campus to pre-Kindergarten through grade 12 (pK-12) learners and teachers around the world, demonstrating the key characteristics of the introduction of responsible research and innovation in school settings.

4.2 Educational resources generated in school settings according the local needs: The Open Discovery Space School Innovation Model

Open Discovery Space (ODS) aims at the introduction of innovation in schools for the purpose of improving school education as a whole. A major socially empowered digital infrastructure has been developed and currently supports more than 5000 schools and 15000 school leaders and teachers (see portal.opendiscoveryspace.eu). The ODS initiative is aligned with the objectives of the Opening Up Education Initiative (EC, 2013) by a) demonstrating effective community building between numerous school communities in Europe and empowering them to use, share and exploit the collective power of unique resources from advanced educational repositories in meaningful educational activities, b) demonstrating the potential of e-Learning resources to meet the educational needs of these communities through the implementation of a socially-empowered, multilingual portal and a monitored-for-impact use of digital materials that became available through its services in the framework of large scale initiatives, which provided feedback for the take-up of such interventions at large scale in Europe and c) documenting the whole process through the development of an advocacy roadmap that will include guidelines for the design and implementation of effective resource-based educational activities that could act as a reference to be adopted by stakeholders in school education.

Specifically, ODS focuses on the improvement of the means that novel educational content (such as lesson plans and scenarios) is produced, accessed, adapted, used and shared. ODS is providing tools and methods to support teachers to become change agents in their settings by promoting innovative teaching approaches that could lead to better educational outcomes.

4.2.1 ODS Description

According to the ODS Innovation Model, effective educational innovations proceed through three distinct phases: These are the Stimulation, the Incubation, and the Acceleration phase (see Figure 4.1).

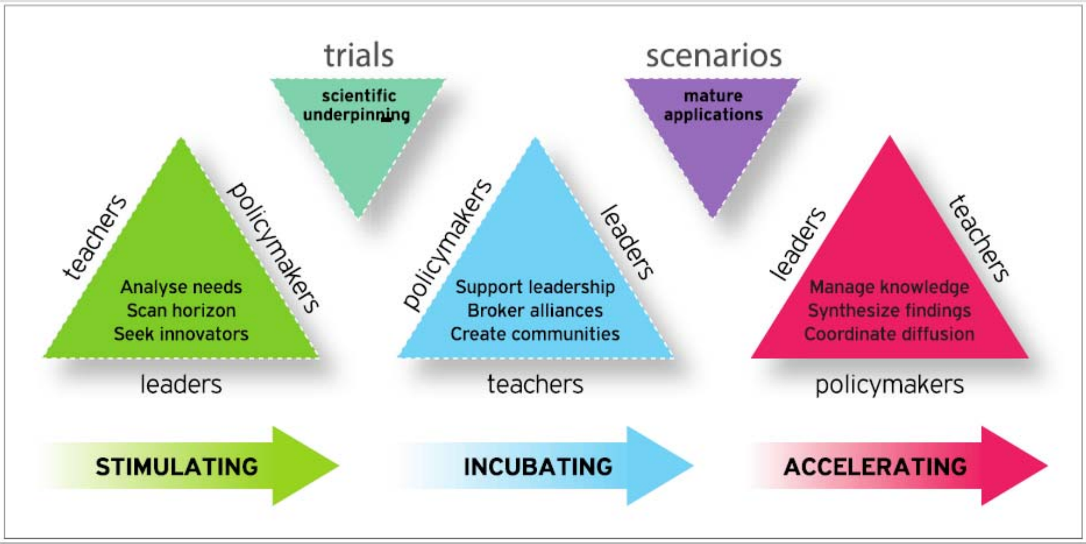


Figure 4.1: *The ODS School Innovation Model.*

- At the stimulation phase, schools are provided with a set of tools that are designed to support an appreciation of a school's needs and the devising of an *action plan*. The tools include: An e-maturity self-assessment survey for the school, that determines the degree to which the ICT and open learning resources (OER) are used in the school, the culture of the school towards ICT and OER, and whether there is a common vision about the development of the school in terms of innovation and technology; a self-assessment tool that measures a teacher's individual ICT competences. The tool has been developed based on the UNESCO ICT Competency Framework for Teachers. Heads of schools are invited to complete first their own competence profile and then encourage the rest of their schools' teaching staff to follow. This self-assessment process is clearly not of a competitive nature, but a means for the conducting of a needs analysis in the school; And finally, an action plan describing the vision and goals of the school, as well as the measures (activities, training, changes, etc.) that the school will undertake to accomplish them. It also addresses the aspect of collaboration and opening up of the school to networking and collaboration with other stakeholders (parents, regional directorates, policy makers, local councils, community organisations, etc.) and encourages staff to think about how to deal with any obstacles to innovation.

- The process of incubation is based on providing support, designing targeted interventions and implementing innovative practices in order to instill a culture that is open to change and spread a common vision for learning. During this pilot phase, new teaching and learning practices are tested and Open Educational Resources (OERs) are extensively used. So is the interaction among the teachers through an environment such as the ODS platform, and the development of thriving digital communities. Emphasis is also given on teacher training and professional development in national and international initiatives and pilot actions, such as the *ODS Summer and Winter Training Schools*, conferences and regional workshops. As far as the digital communities are concerned, a main task for the heads of schools is to identify ideas, practices and members of staff who can function as agents of change and innovation. A digital community should be responding to the school's actual needs, taking at the same time in account the requirements (and possible limitations) of the curricula.

- During the acceleration phase an educational change is intended to extend its reach and impact. Above all, this phase aims at spreading innovation. There are two kinds of processes in this phase: *dissemination* and *diffusion*. School principals and headmasters play a crucial role in both of them. Dissemination is a one-way process, where information is distributed through various means and channels. In ODS, information is shared through presentations, workshops, webinars, training events, meetings, websites, social media, etc. Diffusion is the process through which interventions are pulled into practice from within. For example, practitioners exchange information, arrange demonstrations, or coach each other. Diffusion is not necessarily an absolute criterion for measuring the success of an intervention, but its presence is an important indicator. It is a "spread within" which can be seen, for example, when reforms or norms of social interaction become embedded in school policies and routines or when teachers draw on those ideas and apply them in other aspects of their practice, which were not explicitly addressed by the intervention. Diffusion tends to be less common than dissemination. Here again, the role of school leaders is important in creating a positive atmosphere, exchange opportunities and openness among the staff that will gradually lead to the diffusion of an innovative practice.

4.2.2 Implementation: Methodologies, Tools and Metrics

ODS introduced an array of innovative methodologies, high quality educational tools and metrics to assist teachers in becoming autonomous designers of high quality educational content, as well as community builders with an interest in sharing innovative approaches to teaching and learning and champions of vibrant networks of peers. The overall architecture of the ODS social platform is presented graphically in Figure 4.2.

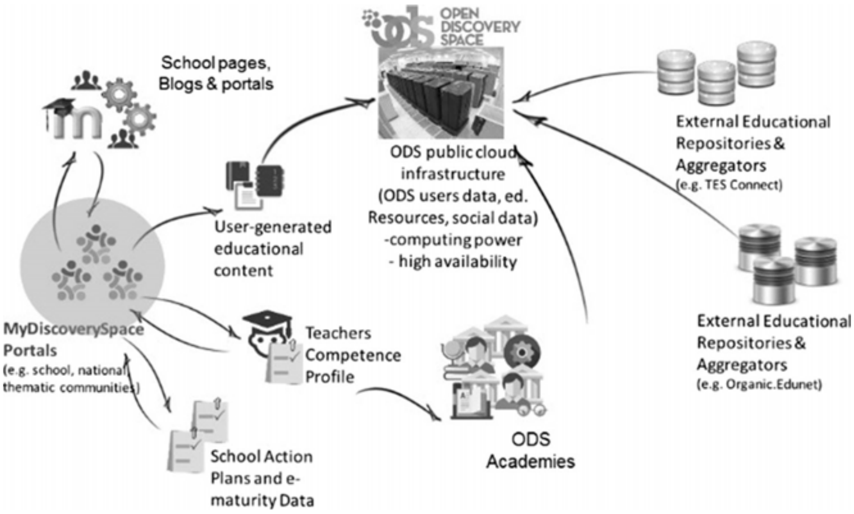


Figure 4.2: *The ODS infrastructure to support the realization of the model of innovation.*

Methodologies

- A comprehensive methodology for the introduction & facilitation of school innovation: ODS offers a thorough methodology for the introduction and the facilitation of school innovation in the form of a toolkit. It covers all areas of *stimulation, incubation* and *acceleration* and applies to a school, a network of schools and educational policy itself.
- A methodology to realize the vision of a school: ODS offers a methodology for the development of a **School Action Plan** with the use of a provided template and guidelines. School action plans provide a robust base for automating and facilitating the task of a periodic school self-assessment based on reliable criteria, such as teachers' professional development plans and school portfolios that may include information on school openness, teacher-generated content, collaborations, specific thematic targeted, all of them comprising the vision of the school.

Tools

- An advanced **search mechanism**: ODS offers an advanced search mechanism, giving access to over 800,000 resources, lessons plans and exercises to support teachers in planning their activities. These are resources that have either been aggregated by the 27 repositories (some of them part of large scale national initiatives) or have been created by users themselves, as part of national and international contests, the ODS schools' engagement with the portal and ODS-sponsored initiatives that involve major content contribution by experts in various fields.

- An advanced **authoring environment**: ODS offers an advanced authoring environment comprising of a complete set of tools and templates and the relevant methodology. It offers a unique opportunity to teachers to grow into agents of change in their schools through the creation of original and high quality education content.
- A social platform specially designed for teachers: ODS offers an **educational social platform**, particularly designed for schools, teachers, headmasters and parents, covering all aspects of classroom life and beyond. Features include school communities, digital libraries of resources and tools, blogs, discussions, events, news, activities, bookmarks, polls, connections with other users and notifications of all the above.
- A pilot student evaluation tool: ODS offers **a pilot student evaluation tool** aiming at assessing student performance, during the classroom implementation of Resource-Based Inquiry Learning Scenarios in STEM. The tool offers teachers a unique way of real-time monitoring of student and classroom activity when running STEM scenarios

Metrics

- Access to school metrics: **ODS offers a unique digital tool in the form of an electronic survey designed to assess the digital or e-maturity of a school**. The e-maturity questionnaire offers insights in areas such as 1) Leadership and Vision, 2) Curriculum, 3) School Culture, 4) Professional Development, 5) Resources and Infrastructure. Based on the historical data coming from the school, actionable analytics are provided. These data allow schools head teachers, governing bodies, etc. to monitor Key Performance Indicators (KPIs) and set targets for holistic improvement.
- Access to teacher competence metrics: ODS offers **a teacher self-assessment tool** that aims at building a dynamic competence profile for the user. This feature offers the opportunity to teachers to self-monitor their development over time. The tool is based on the UNESCO ICT Competency Framework for Teachers (2011). Through this type of self-assessment, focused assistance to the teachers could be provided, in order to identify competence gaps and help them draft their own personal development plans.

4.2.3 RRI approaches used

Though ODS did not make any specific RRI claims at the time of its introduction, certain RRI principles have featured prominently in its approach. In particular, in the realm of science education and its promotion as a pillar of European education, ODS offered innovative digital authoring tools that follow certain educational approaches such as Inquiry Based Learning (IBL) and Project Based Learning (PBL). It offered teachers the opportunity to design, adapt and share original educational material in the form of learning scenarios and lesson plans. In addition, ODS strived to create a community of peers who are enthusiastic about high quality open access educational material that is the work of collaboration in a trusted environment. This proved a rather successful community building exercise! A significant feature of the ODS social platform has been the behaviour of its users towards the sharing and, indeed, the creation of their own resources, using the portals' own authoring tools. One out of three registered users of the ODS Portal (36%) created and shared his/her educational resources in a community.

There has also been an effort to greatly increase the science role and capacity in primary and secondary education in the community of teachers. A popular activity of this community has been the Virtual Visits to CERN by ODS schools. CERN agreed to facilitate ODS schools which showed tremendous interest in this activity. A special facility in the form of an ODS online booking system had been created for this purpose to help ODS schools to arranged a virtual visit. In addition, specially designed resources in the Discover the Cosmos community also helped schools tie particular issues in particle research with national curriculums. Over 40 schools (a number of them being rural schools) had been facilitated by the ODS Discover the Cosmos community to conduct a virtual tour in the last year of the project. The popularity of virtual visits within the context of the Discover the Cosmos community tells a certain

story of the link between community building and the role of innovation in the classroom. CERN virtual visits attracted considerable attention from both participating schools and the local communities, given the recognition of certain discoveries at CERN and their implications for our fundamental understanding of reality. They demonstrated to fellow teachers, as well to other stakeholders the value of openness in education, as well as the role of ICT in delivering innovation and change. The success of virtual visits was also highlighted in the cases where national educational bodies and agencies urged their school communities to engage with ODS activities. This was the case in 4 occasions with considerable success. Ministerial departments in Greece, Bulgaria, Croatia and Serbia made official calls through various channels and networks for schools to join the ODS initiative. Another community in ODS that exhibit strong RRI features has been the My School Garden community that promoted the development of a school garden in the participating schools. The school garden is becoming a place of experimentation but also an area of interaction with external stakeholders, patents, local farmers and experts. It focused both on science education as well as of food security, sustainable agriculture and Bioeconomy. The community offered a wealth of lesson plans, scenarios, ideas, tips offered by experts and educators from around Europe with an emphasis on organic agriculture that has become increasingly important on the agenda of European countries committed to sustainable development.
School gardens are really outdoor classrooms where kids learn valuable lessons — not just about nutrition, but also about science and math, even business skills. In the context of ODS and in cooperation with Institute of Educational Policy in Greece nearly 100 gardens were developed in the countries schools.

4.2.4 Results – Evaluation

ODS proposed a school innovation model designed in the context of a major European Initiative, by pointing to the impact from its implementation in schools throughout Europe. Positive effects are apparent: During a time frame of 1 year, participating schools increased their e-maturity level by 8.61%. This was even more important for indicators such as ‘‘vision and leadership’’ and ‘‘professional development.’’ Access points to numerous resources may help teachers to find appropriate resources to acquire tools to cope with a variety of needs. A considerable number of teachers regard online ODS communities as a sufficient basis to exchange best practices (87 %) and use our portal’s tools for sharing OER. Schools may act as hubs of educational content production. Moreover, the significance of online communities of peers is made clear. In particular, there has been an emphasis on measuring and interpreting the way the school communities have grown, as well as the type and degree of involvement in various aspects of the ODS portal. At certain milestones, measures were obtained, such as the progress in the creation of new communities, member growth, the uploading and sharing of educational resources, as well as the relation of these to teacher professional development. The representation of participating countries clearly shows the advantages of large-scale interventions for national policy. A combination of support strategies and pilot studies that are adjustable and individualized, aiming to meet school needs and to systematically help schools to embed technology and innovation, is also on offer. The first indications are that, so far, these strategies have had positive results in engaging schools in the implementation of resource-based learning and innovative activities. Initiatives such as ODS show a positive impact on the most important pillars to reach classrooms and clearly support the characterization of OERs as catalyst for the introduction of innovation in educational settings (Sotiriou et al. 2016).

4.3 Holistic School Approach and Vision: Quality for Innovation Approach (Q4I)

The **Q4I project,** which started in December 2012, aimed to develop, test and mainstream a quality development approach for schools that includes a strong commitment to innovation and that is based on the participation of all key stakeholders: students, teachers and parents, employers and representatives of local community. The Q4I model is based upon formal change management models, but it is adapted to the knowledge and needs of school heads and teachers.

In 2013, the European School Heads Association (ESHA) reviewed the already existing formal change management models and drafted the following requisites for effective models:

- An effective change model needs to be applicable for all current innovations. Not just one, because school heads will not learn an innovation specific change model.
- An effective change model needs to be self-explanatory. School heads are unlikely to study a change model if this model is complicated
- An effective change model will only address the main issues of school leadership, has a start and an end and is part of an iteration process.

This feedback has led to the development of a change model that is graphically represented in Figure 4.3.

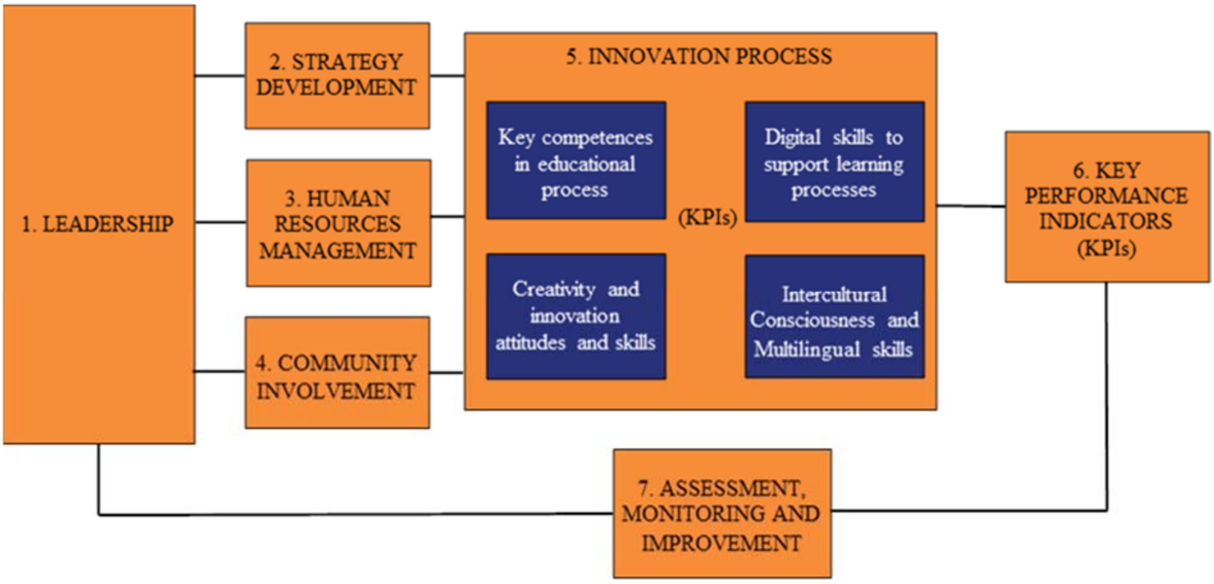


Figure 4.3: *Q4I model for school change and innovation.*

4.3.1 Q4I description

The first step in the innovation process is leadership. It takes a leader to develop a vision and initiate change. This could be a teacher or a school head. It may even be a policy maker or a parent that is involved in the school. The products of this first step are the description of the school's identity and its vision document. The vision document describes how future education will look like.

The second step is strategy development. How can the school reach its goals? It describes the pathways to reach the goals described in the school's vision document. All stakeholders will need to be included in this process in order to maximize the school's commitment to future change. ESHA research show that many innovation project fail because the innovation does not support the school's identity and strategy. It is perceived as ad hoc or not relevant to the learners.

The third step is human resource management. In order to change, the staff needs training and support. The HR section also includes addressing resistance to change. Resistance to change includes personal resistance to change (how does one person react to change) and organization aspects (are teachers allowed to make mistakes, is the school a learning organization, etc.). The third and final aspect is recruitment. Although not applicable in all European countries, it is advised for innovative schools to recruit innovative teachers.

The fourth step, community involvement is crucial to the success of the innovation process. The involvement of parents, policy makers and local businesses will support the innovation processes.

The fifth step, the actual innovation process can only be successfully implemented if the first 4 steps have been addressed successfully. According to the model, an innovation will be successful if the innovation underwrites the school's strategy, all staff are involved and supported and if the school's community is involved and supports the change.

The sixth step is the agreement on the performance indicators. These performance indicators are ideally shared by all the staff at the school and are part of the yearly evaluation discussions.

The seventh step is the actual measurement of the success. The progress will initiate a new innovation cycle.

4.3.2 An overview of features

The Q4I model is a simplified model that has been implemented by innovation networks. The models can be used together with other tools like the IGUANA project's tools (http://www.iguana-project.eu/assessment-tools) to address resistance to change. The models are designed to be applied by people who have no experience with formal change management models. The O4I model is based upon the "whole school approach". The first step of the model is to describe the vision of the school. The second step is to describe the strategy to realize the school's vision. This approach implicates that the whole school will be involved in the innovation and that the innovation will need to underline the school's vision. If the innovation does not support the school's identity, the innovation is likely to fail.

The model is applied by many schools. The strengths of the model are:

- **Simplicity:** it can be used by people who are not skilled to lead change processes.
- **Openness:** the model can be used together with approaches to address specific area for improvement.
- **Whole school approach:** innovation will not work if all staff members and the external community will choose to actively support the innovation.

4.4 Effective Introduction of RRI Principles in the School Operation: The HYPATIA model

Gender equality is the 5th sustainable goal that is part of a universal, ambitious, sustainable development agenda, an agenda "of the people, by the people and for the people," crafted with UNESCO's active involvement in 2015. There are a number of rationales for striving towards a wider and more diverse recruitment of students in general and female students in particular. These include an economic rationale (If larger proportions of a student population achieve a higher degree of education, Europe will be better prepared to compete in the global knowledge economy), a diversity rationale (education must support and welcome a diversity of student experiences, interests and aspirations), an equity rationale (education is perceived as a result of a democratic process where everyone has equal possibilities for achieving the benefits they produce), an empowerment rationale (The knowledge the students gain through education enables them to make informed choices about their own lives and the society surrounding them) as well as even an environmental rationale (in a global perspective, the environmental threats (e.g. loss of biodiversity or climate change) facing the world today requires a deeper understanding of STEM. In the age of sustainable development all individuals should have the opportunity to contribute to find new sustainable solutions (Sachs, 2015). The challenges of today's educational systems are many when it comes to achieving gender equality in schools, in the classrooms. The most pertinent challenges HYPATIA identified are for one thing that science is often pictured as gender-neutral. However, it is becoming increasingly clear that science, technology, engineering and mathematics are not gender-neutral practices. Rather, STEM can be understood as a set of culturally and historically situated human practices of knowledge and thought (Allegrini, 2015); as such, 'scientific knowledge, like other forms of knowledge, is gendered. Science cannot produce culture-free, gender-neutral knowledge' (Brickhouse, 2001 p. 283).

Another challenge for formal education is that, teaching is often structured in a way that reflects a number of explicit or implicit assumptions about what constitutes a standard student, the so-called implied student.

Finally, a challenge we need to face in contemporary school is the assumption that girls and boys belong to distinct, internally homogeneous groups based on their biological sex that 'creates a stereotype of girls and boys that fits no one in particular' (Brickhouse, Lowery, & Schultz, 2000, p. 442). Rather than the simple translation of biological difference, gender should be approached as a complex category that individuals make themselves recognizable through and perform in various ways (Allegrini, 2015; Due, 2014; Sinnes & Løken, 2014).

4.4.1 HYPATIA description

Hypatia is Horizon2020 funded project that is carried out by 19 partners from 15 countries. The focus of the project is mainly on science centers and museums as hubs around which all the relevant stakeholders are brought together. They act as bridges linking science and society, formal and informal education and bringing together all the key players in the challenge of addressing gender balance in STEM: young people, education, research, industry and policy makers. In the framework of the project schools are acting as one of the three pillars of the HYPATIA approach and several activities are built around formal education system. Here it is described the Hypatia theoretical framework as has been developed by the University of Copenhagen in Denmark. We are also describing the approaches we take into account for gender and promote gender inclusion in the science education activities developed and disseminated in the project. Hypatia specifically targets gender inclusion at several levels: **the institutional level, the interactional level, and the individual level**.

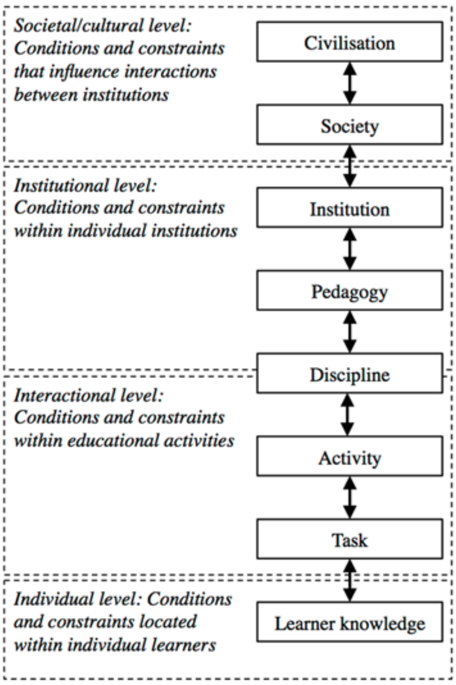


Figure 4.4: *HYPATIA model for gender inclusion.*

4.4.2 Implementing a framework for institutional science education

The planning and implementation of science education activities within institutions does not take place in a vacuum. Science educators, whether they work in schools, science centres, research institutions, or industry, carry out their planning and implementation work within a complex environment that constrains and conditions their work in a variety of ways. This means that the science education programmes that take place in these settings are the results not only of the careful planning and implementation of the science educators, but also of the various constraints and conditions that influence their work (Achiam & Marandino, 2014). The constraints and conditions that influence science education efforts may be explicit, but the constraints may also be implicit, such as for example an established 'way of doing things' that remains tacit among educators but still strongly conditions the way they design education programmes.

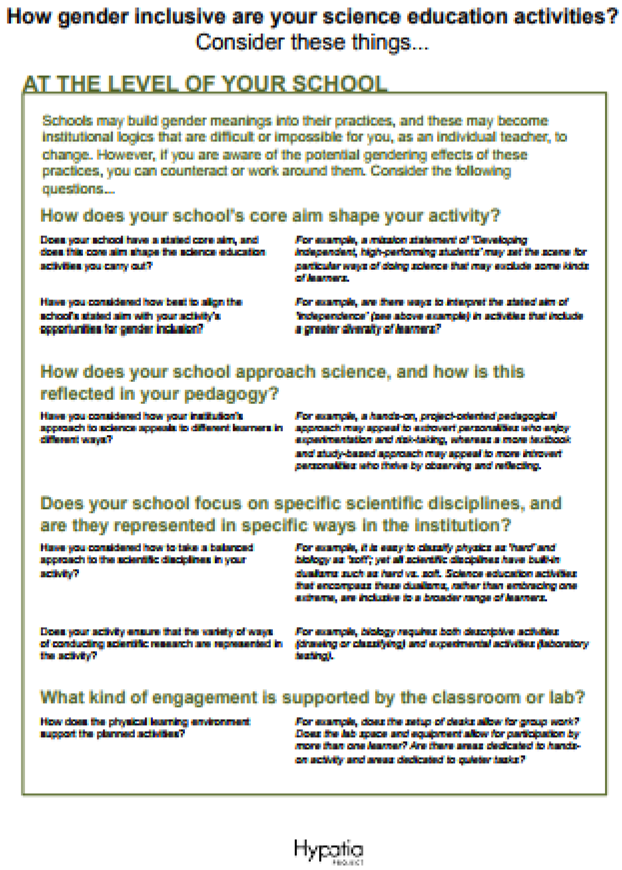
The **societal/cultural level**: At the societal/cultural level, we find conditions and constraints that originate outside the institution. For example, schools are dependent on government subsidies; these subsidies are often given on the condition that the institutions and their activities align with the conditions set out by the government or ministry in question.

The institutional level: At the institutional levels of the hierarchy, we find the conditions and constraints that originate within the particular institution in question. The type of institution will often have a defining influence on the kinds of activities undertaken; e.g. a science activity in school might be developed with the ultimate aim of furthering students' learning progression within a specific curriculum area. These conditions and constraints are often, but not always, located beyond the control of institutional science educators.

The interactional level: The specific ways in which an institution organises and presents learners with scientific activities strongly influence the ways in which learners participate. For example, an activity arranged in the form of a typical classroom affords certain types of interactions between participants and constrains others, just as an activity arranged in the form of a laboratory experiment allows some actions between participants (e.g. shared hands-on activities, experimentally comparing variables) and prohibits others. In other words, the specific format of the interaction that is designed by the institution influences the way science is disseminated within it.

The individual level: The individual level refers to the constraints and conditions that originate or manifest themselves in relation to the learners' individual knowledge, values, experiences, etc. For instance, we can imagine how a learner with a strong sense of empathy may prefer group work, while a learner with a strong capacity for acting might find individual tasks attractive. These preferences strongly co-determine the ways in which the individual learner can participate in the education activity, and should therefore be considered and addressed by the institutional science educator.

HYPATIA has broken down these levels, created a set of questions and analysis of these levels and a set of proposed activities (so called modules) that include instructions for educators and description of the activities that may run in schools and can address the issues of gender equality.



How gender inclusive are your science education activities?
Consider these things...

AT THE LEVEL OF YOUR SCHOOL

Schools may build gender meanings into their practices, and these may become institutional logics that are difficult or impossible for you, as an individual teacher, to change. However, if you are aware of the potential gendering effects of these practices, you can counteract or work around them. Consider the following questions...

How does your school's core aim shape your activity?

Does your school have a stated core aim, and does this core aim shape the science education activities you carry out?	*For example, a mission statement of 'Developing independent, high-performing students' may set the scene for particular ways of doing science that may exclude some kinds of learners.*
Have you considered how best to align the school's stated aim with your activity's opportunities for gender inclusion?	*For example, are there ways to interpret the stated aim of 'independence' (see above example) in activities that include a greater diversity of learners?*

How does your school approach science, and how is this reflected in your pedagogy?

Have you considered how your institution's approach to science appeals to different learners in different ways?	*For example, a hands-on, project-oriented pedagogical approach may appeal to extrovert personalities who enjoy experimentation and risk-taking, whereas a more textbook and study-based approach may appeal to more introvert personalities who thrive by observing and reflecting.*

Does your school focus on specific scientific disciplines, and are they represented in specific ways in the institution?

Have you considered how to take a balanced approach to the scientific disciplines in your activity?	*For example, it is easy to classify physics as 'hard' and biology as 'soft'; yet all scientific disciplines have built-in dualisms such as hard vs. soft. Science education activities that encompass these dualisms, rather than embracing one extreme, are inclusive to a broader range of learners.*
Does your activity ensure that the variety of ways of conducting scientific research are represented in the activity?	*For example, biology requires both descriptive activities (drawing or classifying) and experimental activities (laboratory testing).*

What kind of engagement is supported by the classroom or lab?

How does the physical learning environment support the planned activities?	*For example, does the setup of desks allow for group work? Does the lab space and equipment allow for participation by more than one learner? Are there areas dedicated to hands-on activity and areas dedicated to quieter tasks?*

Figure 4.5: *A breakdown of the HYPATIA model for a school setting.*

4.4.3 Description

HYPATIA is a European initiative. It is currently being implemented in 14 countries within the Hypatia project (target group teenagers 12-18). This project is still running until august 2018. In each country, a hub has been developed lead by a science center and museum. The hubs consist of members of formal education systems, ministries, schools, gender experts, industry representatives and policy makers. Youth panels with teenagers have been created in these countries, co-developing the project outcomes together with the other stakeholders and influencing decisions and processes.

4.4.4 Tools and Infrastructure

Toolkit: 15 Good practices (GP) have been selected from an initial pool of activities proposed by the partners and improved according to this framework and the criteria developed by UCPH to form the project Modules and toolkit (http://www.expecteverything.eu/hypatia/toolkit/). A number of these practices are meant to be used in school settings. All activities aim to involve different stakeholders mainly industries, schools, museums, teenagers as well as parents. The toolkit is translated in 14 languages.

Theoretical framework: The framework can be downloaded online: www.hypatia.eu/resources. The framework briefly described above may be used as a basis for a school to create a gender equality plan in different levels.

4.4.5 RRI approaches used

The Hypatia model is clearly linked with one pillar of RRI that is the topic of Gender equality. It proposes a framework and a series of activities that may be Implemented for an organization interested to implement it.

4.5 Effective Partnerships with External Stakeholders: Urban Advantage (UA)

Based on a project developed and led by the American Museum of Natural History in New York, the Bloomfield Science Museum Jerusalem (BSMJ) has initiated and leads a consortium of informal science education institutions in the city of Jerusalem to support teachers in new student assignments in science and technology in collaboration with the Israeli Ministry of Education, the municipality and industries. Based on the new initiative for developing 21st century skills in student-centered learning approach, the Israeli Ministry of Education has decided to launch a new national program based on PBL learning in science fairs in schools – both at regional and national levels - for all 6th and 9th grades. The aim of the consortium is to support teachers' needs to learn new pedagogical skills on how to introduce and support their students in open-ended challenges. Six organizations - including the Jerusalem Zoo, the Botanic Gardens and the Central Science Youth Laboratories - are collaborating on the pedagogical development of tool kits and teachers' training, student support, as well as family programs. Such a model provides a good infrastructure for addressing all mentioned issues of the Grand Societal Challenges. The students' assignments relate to issues concerning the whole community, such as health, environmental and nutritional issues.

4.5.1 UA description

The aims of the Urban Advantage model are:

- To foster a better understanding of scientific research /Engineering problem solving.
- To promote the choice of Science and Technology studies in high school.
- To instill the concept of research and problem solving as an opportunity for each student to connect to this subject, and to provide a scientific/technological challenge.
- To create a broad infrastructure for cooperation between all institutions in the formal and informal education systems.

The model is based on **an innovative collaboration between the public school system and institutions dealing with informal science education**. The underlying concept of Urban Advantage is to focus on a specific assignment in the Curriculum – the Science Research Project, as one that best illustrates the nature of scientific endeavor and the principles of learning as they relate to the “21st century skills”.

Urban Advantage is based locally in the city of Jerusalem, taking advantage of the local urban establishments dealing with informal science education. The main actors involved in the model are: researchers and engineers, teachers, students and parents, local and national government and six institutions dealing with informal scientific and technological education: The Bloomfield Science Museum, the Belmonte Science Laboratory Center, the Meyerhoff Youth Center for Advanced Studies, the University Botanical Garden, the Biblical Zoo and the Jerusalem Bird Observatory.

4.5.2 Tools and Infrastructure

Each of the six partner institutions in the Jerusalem Urban Advantage offers a Science Assisting Package (SAP) available to participating schools. Each SAP provides teachers and students with the guidance and support needed to work on research and problem-solving projects. It enables a long-term involvement with the teachers and the students, provides a platform for presenting the projects and creates an impact on the entire school and the parents in the course of the work process. The SAP includes:

- An Introduction to Research / Introduction to Engineering classroom Activity
- A list of topics and ideas for carrying out further projects
- The loan of designated equipment as needed for carrying out projects
- Support, supervision, and consultancy for teachers and students with regard to content and technical issues
- Science festival – activity for the families of students participating in the project.

4.5.3 Implementation

In 2015 The Jerusalem education authority with the Bloomfield Science Museum Jerusalem launched the program. Year 1 was dedicated to development, pilot and operation with a small number of classes. The Municipality-funded program was conducted with the assistance of six institutions under the supervision of the Ministry of Education, in 40 9th grade classrooms with a total of 1000 students.

4.5.4 RRI approaches used

The Urban Advantage model makes direct reference to RRI elements:

- **Gender Equality:** The project is directed towards all students, not only the students in the scientific classes. The students work in groups on a subject they chose to investigate. The group work enables students with different subjects of interest to be exposed to, and take part in, a science and engineering project. It also encourages students in learning to work together and communicate their ideas effectively. The students' inquiries are as open-ended as possible, with no "right answers".
- **Governance:** The project is based upon a partnership of informal scientific and technological education with local and national government and policymakers.
- **Open Access:** One of the features of the Urban Advantage project is that each partner institute opens its gates to the groups of students and invites them to come every week and work on their projects using the institutions resources and experts, after school hours.
- **Science Education:** The core program of the Ministry of Education regarding Science and Technology studies in Israel requires all 6th grade students (in elementary schools) and 9th grade students (in junior high schools) to carry out a scientific research or engineering problem solving project. The inquiry and problem solving based learning is regarded as one of the most important ways to internalize the principles of scientific and technological thinking and attainment.

Many studies emphasize the advantages of integrating informal learning environments and using in-school experts into the school curriculum. The proliferation of urban establishments dealing with informal science education has proved beneficial. They have been incorporated into the school program, providing a unique opportunity to leverage STEM studies among students. The Municipality intends to gradually expand the program over the next couple of years, to include all 9th grade classes in West Jerusalem and in East Jerusalem. The program will eventually be expanded to include 6th grade classes as well.

4.5.5 Results and evaluation

Evaluating the application of the Urban Advantage model is done in two ways: a quantitative measure - the number of schools, classes and students participating in the project each year, and qualitative measure – Questionnaires and interviews with the teachers supporting the students. The overall trend of the measurements is positive, including an increase in the number of participants in the project and positive feedback from the teachers. Improvements are to be made to the teachers' training and to the support that the informal science education institutions provide the teachers. The teachers need extensive support to impart the process of research and problem solving (e.g. source of ideas for projects, help with scientific and technological content, and direct support for student). The SAP provided by the institution has to meet all needs arising in schools. Teachers have also asked to start the project earlier in the school year, so that students will more time to benefit from advantages offered by the supporting institutions.

4.5.6 Conclusions and recommendations

The Urban Advantage in Jerusalem was adopted from the New York City model. Like New York, Jerusalem is endowed with many institutions of informal Science and Technology education. Institutes of higher education such as the Hebrew University and Hi-tech industry abound. Together they constitute an infrastructure with great potential for supporting the education system. Any city or region wanting to adopt a similar project has to have a similar infrastructure. Adoption of the Urban Advantage model in Jerusalem required partnership with the relevant institutions, the Jerusalem Municipality, and the Ministry of Education. To achieve the aims of the project it is important to invest in high level professional teaching and learning.

4.6 Focused Policy Support Actions: The National Thematic Week

The IEP is a tactician scientific institution that supports the Minister of Education on issues that regard primary and secondary education, as well as the transition from secondary to higher education. The purpose of IEP is the scientific research and study of issues that are mentioned in the previous paragraph and the ongoing scientific and technical support of the planning and implementation of educational policy on those issues. The IEP is also developing innovative projects in order to support the implementation of the educational policy. During the current reform effort in Greece towards more open school environments IEP has designed and implemented the "Thematic Week" Initiative. IEP's flagship project concerns work that took place in lower secondary education schools (13-15 years old students) in Greece during the last academic year (2016-17) is the thematic week: "Human Body and Identity".

The main goal of this initiative is the engagement of school community (students, teachers, parents) with educational activities and processes concerning three specific fields relevant to health education (nutrition, prevention of addictions and gender identities). It took place during a school week from February to May. The teachers decided how to arrange their hourly schedule and reformed the weekly school program. The schools / teachers organized:

- lectures and workshops with various experts from organizations (NGO's, Universities, Public Health Services (Hospitals, Prevention Centers), Municipalities' services and the Ministry of Education (school counselors, coordinators for health, environmental and cultural education and school psychologies).

- Lesson plans relevant to the curriculum and the specific themes that had been chosen

The Institute of Education Policy developed a platform to support teachers and schools in planning implementation and evaluation of this initiative. The thematic week is a policy action that supports the open schooling approach. The general principles and objectives are presented above, while the completion of the evaluation and the general assessment is still in process. The thematic week is characterized by the principles of responsible research and innovation. IEP has set the basis and the framework for the principles and rules required on the implementation of innovative actions, programs, and surveys in schools.

4.7 International Open Schooling Initiatives

In this section we are presenting in detail three initiatives that are integrating a series of key characteristics of the open schooling approach which we consider as key reference points for the development of the OSOS Open Schooling Model: A global initiative that sets as a goal to make students as change agents in their local communities (**Design for Change**), an international initiative that also aims to make young students catalysts of change in their communities (**EcoWeek**) and finally an initiative that aims to bring **MIT's unique "Mind and Hand"** learning approach beyond the campus to pre-Kindergarten through grade 12 (pK-12) learners and teachers around the world, demonstrating the key characteristics of the introduction of responsible research and innovation in school settings.

4.7.1 Students as Change Agents - Design for Change

Design for Change is a global movement that aims to empower students to say "I CAN" and inspire others by telling their own stories of change. The program has introduced its unique curriculum in over 30 countries worldwide and promotes design process as a way of encouraging students to create and develop solutions in their communities.

Design for Change (DFC) is a global movement whose aim is to offer children and young people the opportunity to put into practice their own ideas to change the world from their own environment by:

- Learning by doing a Service to the community.
- Investigating the causes of forest degradation is a learning activity.
- E.g. commitment to the reforestation applying the studied, is service-learning.

Design thinking, a solution-based and user-centered approach to tackling problems, allows students to become active learners who guide their own education. Since its founding in 2009, DFC has worked to introduce design thinking in the education sector in a way that is accessible for children. DFC weaved students' own stories back into education by designing a year-long curriculum. Students **begin to develop the design mindset while engaging in real-world problems**, in turn **activating and developing skills and attitudes, such as a sense of well-being, problem-solving, and other 21st century skills**. The curriculum is designed to be plugged into existing school calendars and enhance academic learning. In the learning-service, the students identify in their immediate environment a situation with which they are committed, developing a solidarity project that brings knowledge, skills, attitudes and values into play. It is an educational practice in which boys and girls learn while acting on real needs in order to improve it. Some relative examples:

- In the project "Adopt a River", children and adolescents commit to protect a river stretch. In this way, they deepen their knowledge and apply them in their efforts to stop environmental degradation.
- In the "Food Collection Campaign" project, adolescents improve their knowledge and attitudes about nutrition, hunger and inequity, designing and carrying out their own campaign in the neighborhood in collaboration with the Food Bank.

The experiences address many of the Grand Societal Challenges, i.e. health, secure societies, clean energy, green transport, environment and other relevant issues. Examples:

- High school students organize and conduct a blood donation campaign in the neighborhood, working with the Blood Bank.
- Elementary students build clay nests to install them in strategic points of the city, so that the swallows can nest there again.
- Young apprentices of painter, they are inspired in the artistic work of Joan Miró to return to the infantile schools of the neighborhood a looked and happy aspect.

Every year, teams from around the world submit social change projects using the Design for Change framework. An Ambassador Team is selected to attend an all expenses trip to the DFC Global Conference that brings together teams from across the world to share and celebrate their projects, and most importantly, inspire others.

Description of the Model

The DFC Model is guiding students to develop their projects following a four-step process:

- **Feel:** Students identify problems in their classrooms, schools, and communities. Students observe problems and try to engage with those who are affected, discuss their thoughts in groups, and vote on an idea.
- **Imagine:** Students envision and develop creative solutions that can be replicated easily, reach the maximum number of people, generate long-lasting change, and make a quick impact.
- **Do:** Students develop a plan of action to effect change. This includes planning, implementing, and later recording the process.
- **Share:** Students submit their stories to DFC through text, photos, video, or slideshows and are encouraged to do so with other schools in the community and local media, as well.

DFC curriculum has simplified design thinking principles for children. The framework of FEEL, IMAGINE, DO and SHARE builds empathy in children, for them **to engage as active participants in their communities**. It redefines failure as prototyping and gives them the confidence to be innovative and find creative solutions for problems that bother them. **Children become change makers**. Teachers are able to experience the capabilities of their own children as they listen to their voices and ideas. Feel gets children to empathize and engage with a problem, they imagine a solution and do the act of change. Through sharing their story, they inspire others. FIDS provides a structured curriculum to teach and assess key 21st century skills.

Figure 4.6: *The Design for Change phases for the development of the students' projects.*

As a part of the DFC program, children have chosen to tackle a number of issues plaguing their communities, such as waste management, school infrastructure, health awareness, special needs, personal hygiene, learning aids, and gender equality. DFC works with all actors: with both private and government-run schools as well as NGOs that operate in tribal or more remote areas. The program is free for schools and run individually at the country-level. While sponsors contribute initial funding and materials, each program runs independently. DFC conducts design thinking workshops for teachers, provides technical support with websites and the online community, and selects and shares inspiring stories from participants. DFC won a Rockefeller Foundation Innovation Award in 2012. Design for Change is one of the 10 Champions of the LEGO Foundation and Ashoka's Re-Imagine Learning Challenge.

These are usually local activities that involve schools and community social stakeholders such as municipalities, ONGs, associations, etc. It is a project based approach, where schools address a societal need in their community and develop a project to find a solution or improve the situation.

Tools and infrastructure

DFC has an international platform to publish challenges and stories: https://challenge.dfcworld.com There is also a map to localize stories: http://www.dfcspain.com/historias-dfc/ This platform makes all stories available: http://stories.dfcworld.com/. Search facilities include: year, country, language, category (miscellaneous, health, environment, education, social) and story type (video, photo, document).

Results and evaluation

Research conducted in the framework of The GoodWork Project has reaffirmed the impact of the DFC curriculum on the development of skills like **collaboration, creative thinking & empathy**. Ongoing research suggests that the confidence developed through the project improves academic scores as well. Their latest effort, the 8th grade curriculum, has the potential to provide students with exposure to important student development areas (empathetic thinking, problem-solving, confidence) in the context of DFC 's principles. In order to ensure that the curriculum works for this purpose, The Good Project is currently assessing the impact of the 8th grade curriculum on students over the 2016-2017 school year. ASSET (Assessment of Scholastic Skills through Educational Testing), India, a scientifically designed, skill-based assessment test conducted by Educational Initiatives has been also used to determine the impact of design thinking curriculum on academic scores of the participating students.

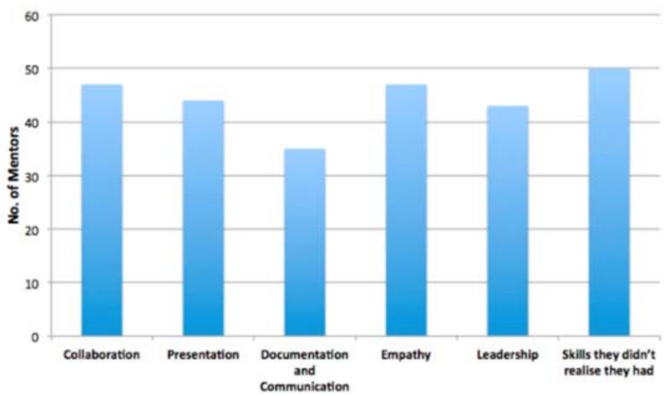


Figure 4.6: *Skills Assessments (based on teachers' opinion) in the framework of the DFS programme.*

Teachers share that facilitating DFC projects help them discover strengths of their students, develop faith in their capabilities and get to know what the children think and feel about the world around them. According to them, children feel more responsible and confident. DFC is advocating for inclusion of design thinking in education. DFC team currently prototyping a 30-hour DFC curriculum for eighth grade students in schools across India, USA, Brazil, Taiwan, Spain and Philippines. The country partners are translating the curriculum and spreading its reach. Research is being conducted simultaneously to study impact of learning design thinking on social-emotional well-being, academic outcomes and teacher pedagogy. This will make a strong case for linkages between social emotional well-being and academic outcomes, promoting a pedagogy based on empathy & creativity.

4.7.2 Students as Catalysts for Change - ECOWEEK

ECOWEEK welcomes universities, student groups municipalities and NGOs to host ECOWEEK design programs and workshops to educate and train students and young professionals in co-operation and sustainable design, to engage in placemaking and interventions in the public realm. ECOWEEK workshops are design and hands-on design-build projects in real sites, which, in addition to their educational and training value, leave a positive impact on the ground. ECOWEEK programs inspire and empower young students and professionals to become catalysts for change.

ECOWEEK non-profit organization was founded in 2007 with the mission to raise environmental awareness, awareness on climate change and to promote the principles of sustainability. ECOWEEK has developed a model of connecting academia to society, academic research and design excellence to real-world challenges seeking solutions, and to empowering young professionals and students to act for the benefit of local communities. The model is based on many decades of accumulated experience – both professional and academic – by ECOWEEK founder Dr. Elias Messinas architect and senior lecturer, and academic and professional partners in Europe and around the world. ECOWEEK has developed an outreach in 17 countries and has established a network of active and socially and environmentally aware students and professionals in 56 countries.

The ECOWEEK model is inspired by leading academic programs for architecture and design students, in particular the **Yale School of Architecture Building Project**, and the **Auburn University Rural Studio**, and collaborative practices such as **MASS and Architecture for Humanity** (Open Architecture Collaborative).

Architecture

ECOWEEK workshops hosted professionals from around the world, who challenged students to design new buildings, address the refurbishment of existing buildings – such as public schools, abandoned structures, historic structures, conversion of industrial buildings to residential, office and public uses. Two examples of projects where students designed a passive solar house of zero emissions in Athens, and refurbished two public schools in Thessaloniki with passive solar elements. Workshop teams worked with experts Daniel Wicke (Rural Studio), Brian Mark (Mott McDonald Fulcrum), Alexandros Tombazis (Meletitiki), Zerefos and Tessas Architects, and others.

The ECOWEEK model in creating better public spaces through placemaking, fulfilling the targets of the global UN-HABITAT program 'Transforming Cities through Placemaking & Public Spaces' a partnership with Project for Public Spaces (PPS). The ECOWEEK model makes references to several of the Grand Societal Challenges set by the EU, namely:

- **Wellbeing:** by addressing local problems in a focused manner, ECOWEEK activity applies improvements to the public space, and thus improves the wellbeing of communities locally, in an 'acupunctural' way.
- **Sustainable agriculture:** ECOWEEK activity includes introducing urban agriculture in cities around the world, teaching students about the challenges and solutions, making them ambassadors of new practices.
- **Secure, clean and efficient energy:** ECOWEEK projects address energy issues and teach students to apply renewable energy solutions integrated in their design solutions, to make energy production local, renewable, and accessible.
- **Climate action, environment, resource efficiency and raw materials:** ECOWEEK activity places environmental and climate change awareness high on the agenda, teaching students to design solutions for resilient urban communities, to integrate environmental protection in their work, and to understand efficiency in the use of resources and raw materials, by emphasizing recycling, reclaiming, and reusing in their design solutions.

Methodology

The ECOWEEK Open Schooling model is modular and the phase framework can be repeated in short or long term programs. ECOWEEK has implemented the model in more than 200 sites in 28 cities in 17 countries, activating more than 4000 students and young professionals. The model can accommodate changes and variations in context and issues, and can support quick initiatives or in-depth long-term processes. The ECOWEEK model takes two principle forms: short term one-week activity, and long-term activity (spanning several months).

The methodology and rationale derive from the architectural design process: **starting from identification and study of existing conditions, and getting acquainted with the site, the local community, local strengths, potential, and problems.** This phase requires one or more meetings with the stakeholders and visit to the site. These meetings can take a variety of formats – co-design, 'world café', common workshop, etc. – in order to get maximum input to support the planning process. Drawing an initial program, and studying the challenges at hand requires acquiring tools and knowledge, and if necessary, involving additional outside experts. Finally, **the team goes into an intense creative and innovative planning and design development of alternatives, solutions and proposed ideas, guided by experts and local leaders.** The proposals and solutions are then presented and discussed with the community and local stakeholders, and are fine-tuned prior to implementation. Implementation involves a community effort, drawing together different stakeholders who apply their skills, acquire new skills, and take responsibility of the site upon completion for future maintenance. The process, which is as important as the final outcome, strengthens the team and the community, builds bridges of communication and cooperation, opens up horizons and eliminates borders, helps participants to understand their potential and the opportunities opened up by collective and methodical activation with a common goal.

The process follows an interdisciplinary path, involving students of different disciplines and stakeholders from the local community. Involving the local community depends on the type and location of the project. For example, planning mid-scale interventions in an elementary public school in Agios Nikolaos in Greece, it involved the planning team of architecture students, their tutors, the school teachers, students, and parents, a local contractor, local businesses - that contributed materials and tools - and close collaboration with the local municipality to enable identification, communication and coordination with the different stakeholders.

The successful model in Greece, has been repeated in other occasions, including another elementary school in the same city in Greece, a public park in Valle Aurelia in Rome, Italy, and a university campus in Prishtina, Kosovo, where the participating students were both the users and planners of the project.

A recent long-term project to upgrade the interiors of two institutions in Athens that host children and youth, have required from ECOWEEK, in addition to the immediate stakeholders, applications to foundations for funding, and addressing legal issues – with legal advisers – in the donation of services to these public institutions.

Pre-workshop with pupils

Process and Tools
Tools and infrastructure required for the implementation of the ECOWEEK Open Schooling model per phase:

Phase 1 – Logistics and Coordination
Tools needed include communication tools, project management tools, online sharing platforms and access to high-speed internet. A website may be needed early on to communicate the project to the team and stakeholders, and for future dissemination, crowd-funding, fund-raising, etc. May involve travel. Early communication with local authorities, and authorization, coordination and approval of project is key in a smooth process. Local authorities legitimize the program, make referrals to local leaders and local stakeholders, and assist in practical issues with regard to the choice of site, making on-site work possible, storage, materials, and other practical aspects. Point of contact with the city is also key to expediting the process at a good pace. From our experience till now, setting up a network of key people early on, may be the most important key to the success of the program.

Phase 2 – Identification
Will involve travel. Premises to host the work team. Access to internet and date on the site – history, facts, aerials, maps, etc. Meeting(s) with local authorities, site briefing, lecture on site and wider picture of urban evolution of the area. Site visit(s), site analysis, understanding of urban conditions, physical, environmental and social analysis.

Phase 3 – Community involvement
Convenient and accessible meeting place with appropriate furniture, work tools – markers, paper, projector – documenting tools – camera and recording device, computers. Community involvement

may take place in several occasions, each time involving different community members – leaders, children, women, etc. – matching the meeting format according to the occasion and need: moderated discussions, hands-on workshops, 'world café' meetings, questionnaires, group site visits, co-design, and more. The community is involved in the early stages of the project, is involved in the program forming, in the early design stage, it is presented the final proposals and is involved in the implementation and upkeep.

Phase 4 – Design
Tools and resources include: Premises for the team to work, Computers, Access to library / internet resources, Materials for building physical models, Software for drafting, 3-d modeling, photo processing, Access to basic environmental data, and software.

Phase 5 – Community presentation
Requires appropriate premises with projector, screen, and sound system. Design revisions may be necessary.

Phase 6 – Implementation
- Inquiry of available materials and tools by the local authorities and local businesses
- Storage, handling and transportation of materials and tools.
- Professional support and supervision.
- Available water and electricity, Coordination of team and volunteers.
- Documentation of process – camera, recording.

The opportunities for 'bridging' between the school and the real world are continuous and extend throughout the duration of the project. Through the experience of ECOWEEK such processes, which are often complex and demanding, are made possible and are successfully handled and completed. ECOWEEK prefers to work with available tools, with off-the-shelve free software, and with locally available resources, so that tools and infrastructures are affordable, accessible and do not delay the process.

RRI Approaches Used
ECOWEEK model addresses RRI in the relationship of stakeholders and innovators in the following way:
Engagement: The activity is based on a participatory model, where different stakeholders are engaged on a common project. They include students, professionals, expert consultants, active members of the community, representatives of the community board(s), with representatives of the general public. The project is guided by environmental and social sustainability goals in decision making and in accepting one solution vs. another.
Gender Equality: The activity is inclusive and open for all. In practice, women comprise more than 50% of the participating youth and professionals, as the mostly involved professions of design and architecture are dominated by women by over 60%.
Science Education: The activity engages in an educational and training process that offers experience and practical tools and examples to learn from. Further, hands-on experience and exposure to real-life challenges, enriches the participants' understanding, and makes them open to new knowledge in their profession and other related professions needed for the activity.
Open Access: All activity materials are posted online, and are freely accessible by the public. In addition, publications and articles are catalogued and made accessible for educational purposes free of charge.
Ethics: Guided by social and environmental principles, and aiming to non-profit activity, the programs abide by high ethical standards at all levels – from the participants, stakeholders and local community, to addressing decisions in public space and respecting of the commons.

Governance: Activity is synchronized and coordinated closely with both policymakers and the representatives of the local community, therefore living no space for harmful or unethical developments of the conducted research and activity. On the contrary: the activity is aligned with the local community aspirations and needs and addresses real issues in public space to serve better the neighborhood and community.

Evaluation and Results

ECOWEEK programs are complemented by a series of actions that gather feedback, prepare material for dissemination (exhibitions, internet, catalogues) providing materials on the program which are freely accessible online for students, professionals and the general public. ECOWEEK's evaluation tools are mainly based on questionnaires completed by participants at the end of the program and feedback on social media. Long term results are received later on, either from communities communicating about maintenance or further development of the project, or students making career decisions that take into consideration social and environmental issues, clearly influenced by their experience at the ECOWEEK program.

4.7.3 Focus on Student Empowerment - The Mind and Hand Initiative

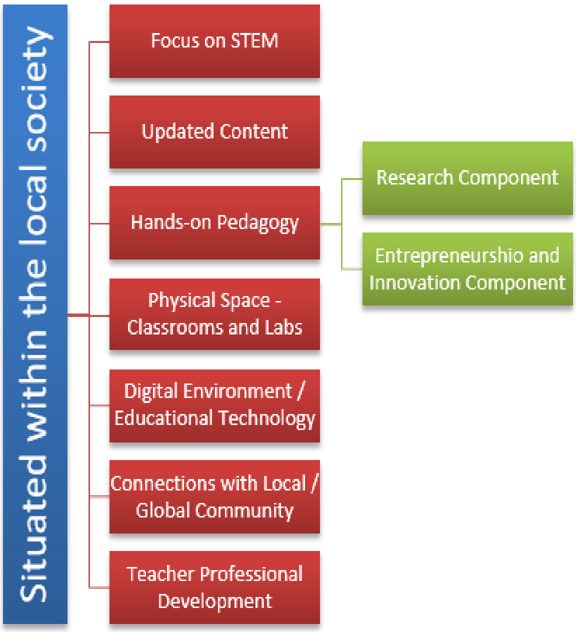
As one of the world's pre-eminent science and engineering universities, MIT is working to inspire pre K-12 students in STEM (Science, Technology, Engineering, and Mathematics) subjects. To provide further support and coordination MIT has recently established the pK-12 Action Group. The new pK-12 Action Group is a new effort that will bring MIT's unique "Mind and Hand" learning approach beyond the campus to pre-Kindergarten through grade 12 (pK-12) learners and teachers around the world. MIT's current engagement in pK-12 includes over 100 diverse activities for learners and teachers, in different domain areas that can be represented in a framework characterized by informal and formal learning, inspirational content, policy and finance, and professional development for educators. The pK-12 Action Group is launched with the idea of applying and disseminating the results of MIT Integrated Learning Initiative (MITili). MITili is a multi-disciplinary center for research in teaching and learning. It will drive fundamental research on learning to improve approaches to teaching and educational technologies on campus and online. MITili will draw from fields as wide ranging as cognitive psychology, engineering, neuroscience, economics, health, arts, design, and architecture.

Figure 4.7: *Framework guiding MIT Pk-12 Initiatives*

Inspiration and Engagement

In collaboration with ODL, MIT aims to provide universal access to high quality education for pre K-12 schools, teachers and students. We aspire to create a new pipeline of future engineers and scientists for fields vital to the future. We believe it is essential to capture the imagination and curiosity of students from the start of their education: to introduce even first and second graders to cutting edge concepts with modules designed to engage their inventiveness and creativity, while at the same time building a solid foundation in critical 21st-century skills.

Figure 4.8: *The K-12 Open School Model*



Focus on STEM

MIT is considering STEM skills to be absolutely critical to the future. MIT is envisioning STEM to be a cornerstone to the future of K-12 education, however in order to achieve truly reformed STEM education MIT highlights that STEM content introduced might need to be complemented with significant chances in regards to the pedagogy and the research culture adopted and supported by each school. Furthermore, true to the MIT spirit, it is suggested that STEM projects get also occasionally introduced within an entrepreneurial or business context to provide even greater connection to the real world.

Content Development

MIT is already working to enhance classroom learning with video segments that enliven subject matter with gifted “guest lecturers” and intriguing case studies by taking advantage of resources such as LiNC (Learning International Networks Consortium), BLOSSOMS (Blended Learning Open Source Science or Math Studies), and MIT OpenCourseWare’s (OCW’s) Highlights for High School, or co-designing new content from these seed repositories. However, supporting the Open School culture, MIT acknowledges the great need for new technology to be developed that will further support sharing but, even more important, offer instant content and pedagogical validation of educational resources. Up to this date the advent of Internet has dramatically increased sharing of information, and of course of educational content, however the great lack of a mechanism that would validate the disciplinary accuracy, as well as the developmental and pedagogical appropriateness, sometimes leads teachers to more confusion as they are trying to navigate through a plethora of invalidated resources.

Pedagogy

When it comes to pedagogy MIT understands that there is no one set pedagogy that can work as a panacea to all cases, but many different methods that appear so far to be bringing positive results. With this in mind, ODL suggests various pedagogies to teachers and faculty, but the common ground is that they are all well aligned with the Mens at Manus mentality. As a general guideline active learning, project/design/task based learning, and problem-based learning are suggested to be at the forefront of teaching. It is also highly suggested that problems/projects selected for each course to be placed with in a context that would be highly relatable to students, or even selected by the students themselves. In addition to that, ODL is highly supportive of the blended learning model. Working on this direction ODL has already created a website where educators can find more information in regards to proposed learning mechanisms. Although the content is addressed to MIT faculty, the methods can also be applied to the precollege level. As a starting point Professor Sanjoy Mahajan created the "Essentials to Instructional Design" document in June 2015, through which faculty and teachers get briefly introduced to:

- David Merrill's *First Principles of Instruction* task-based teaching model,
- The *Four-component Instructional Design* model, and
- The *ICAP Framework* (Interactive, Constructive, Active/Passive)

In addition to these instructional frameworks ODL also introduces and provides research-based findings in regards to the following 5 instructional practices, as they "have been shown to facilitate student learning and are useful for in-class and online learning" (ODL, 2017)

- **Retrieval practice (the "testing effect"):** The ability to recall and remember knowledge increases if it is periodically retrieved.
- **Spaced and interleaved practice:** Spacing out repetition is more effective for learning than is studying an idea over a single period (even if it is longer than each of the many repetitions)
- **Worked and faded examples:** When non-experts are learning new concepts, it is more effective for them to study solutions to solved problems than to attempt solving problems
- **Active learning:** Instruction that requires students to engage cognitively and meaningfully with content results in better learning than instruction where students are solely exposed to information passively
- **Pre-/Post-testing:** Assessing understanding of the most important concepts and tasks in a course at the beginning and end of the course allows instructors to determine what students know when they start the course and how much they learned in the course. At this point it should be noted that although most of the times we refer to the whole pre-collegiate educational system as K-12, it is understood that the very young ages (K-3) require different developmentally appropriate pedagogical approaches that should be examined separately.

The Research Component

Taking a close look at all MIT K-12 initiatives it becomes obvious that research, as an additional form of instruction, is highly suggested. Hands-on STEM is the core of the MIT preferred instructional model, but implementing that through research related projects places an additional value. At that point it should be noted that research projects should not just be decided by the teachers or by external collaborators. Students should be constantly encouraged to come up with their own problems, pose their own questions and actively be supported to look for the answers themselves. In most cases that might mean more time for exploration, but the teacher should be prepared to provide time and resources for that, while also working towards having students accept and embrace failure, as this is an integral part of the scientific method. The Edgerton Center at MIT offers workshops for kids but also to teachers on how active research can be combined with hands-on learning to be incorporated in the K-12 classroom. According its mission "The Edgerton Center's hands-on science and engineering challenges educate and inspire kindergarten through 12th-grade students, aiming to increase their curiosity and desire to pursue these fields in their future". As Professor Ed Morriarti said, when asked to describe how learning in the Edgerton Center occurs, "*no state-of the art content or high-end Lab will work unless we focus on* ***student empowerment****.* ***The student should be an active contributor to the learning process.*** *In the Edgerton center students are constantly encouraged to suggest their own projects and research questions, and look for the answers using their own reasoning process. Most of the times I don't even know the answers to their questions and that's ok! We learn together*" (MIT Edgerton Center, 2017)

The Entrepreneurship and Innovation Component

Although Entrepreneurship is not usually included in most traditionally designed curricula, MIT places a particular value on this component and proposed that it can be introduced at an informal learning mode at the high school level. Working on this direction MIT Launch acts as the first node in a network and invites high schools to participate into the MIT Launch School Clubs Program. Launch provides materials and mentorship support to high schools throughout the school year to allow students to develop entrepreneurial skills and mindset by launching startups. This is not a business plan contest. The aim is to create a real startup – to solve a real need in a differentiated way. The focus is on taking action, learning from results, and making changes to improve chances of success. By creating a network of educators MIT Launch is aiming to change the way students learn and solve problems. To do so, and in perfect alignment to the Open School culture, MIT Launch asks for "*a champion of a high school (a student or teacher) to spearhead development of the club by implementing the materials and recruiting members, plus attending webinars to learn implementation of the MIT Launch materials.*" (MIT Launch Summer, 2017)

Working on the same path, the Lemelson-MIT InvenTeams™ aims to inspire the next generation of inventors. Lemelson-MIT InvenTeams™ are comprised of high school students, educators, and mentors that receive up to $10,000 each to invent technological solutions to real-world problems of their own choosing. (Lemelson-MIT Program, 2017)

Physical Spaces – Classrooms and Labs

Design of the physical classroom space and of the labs is critical to the educational experience as it is most of the times that the classroom setup drives the pedagogy and supports the necessary student interactions, especially when the teachers aims to implement active hands-on pedagogies and blended learning. A classroom model particularly design to support such instructional models at MIT is the Technology Enabled Active Learning (TEAL) classroom. Although the TEAL classroom was first designed in 2005 by MIT faculty to be used for MIT residential classes, it is now considered an exemplar classroom model that has already been adopted by many other universities as well as K-12 schools. TEAL classes feature:

- **Collaborative learning**—students working during class in small groups with shared laptop computers
- **Desktop experiments** with data acquisition links to laptops
- **Media-rich visualizations and simulations** delivered via laptops and the Internet
- **Personal response systems** that stimulate interaction between students and lecturers

Discussing the logic behind the TEAL classroom its designers say "*Scientists and engineers work in groups as well as alone. Social interactions are critical to their success. Most good ideas grow out of discussions with colleagues. This subject encourages collaborative teamwork. As students study together, help their partners, ask each other questions, and critique their group homework and lab write-ups. Teach each other! Students learn a great deal by teaching others*." (TEAL, 2016)

Labs are also reinvented in an approach to embrace a more open, hands-on, multidisciplinary education model. In a new school MIT envisions labs that will break the Silos created by traditional disciplines and embrace "cross contamination". E.g instead of a school having 3 different small labs for Physics, Biology and Chemistry, a classroom model inspired by the TEAL classroom setting could offer student tables in the middle and also offer open lab benches representing these 3 traditional disciplines around the class. Furthermore the "**Makerspace" is a Lab model**, supporting hands-on instruction that gains great popularity, and shows encouraging results over the last years. According to MIT Project Manus, makerspaces are usually one of three types. They all have similar maker tools, but their community elements differ, and they are purposed and managed in a different way, although many spaces are hybrids, primarily of one type but have elements of another type (MIT Project Manus, 2017):

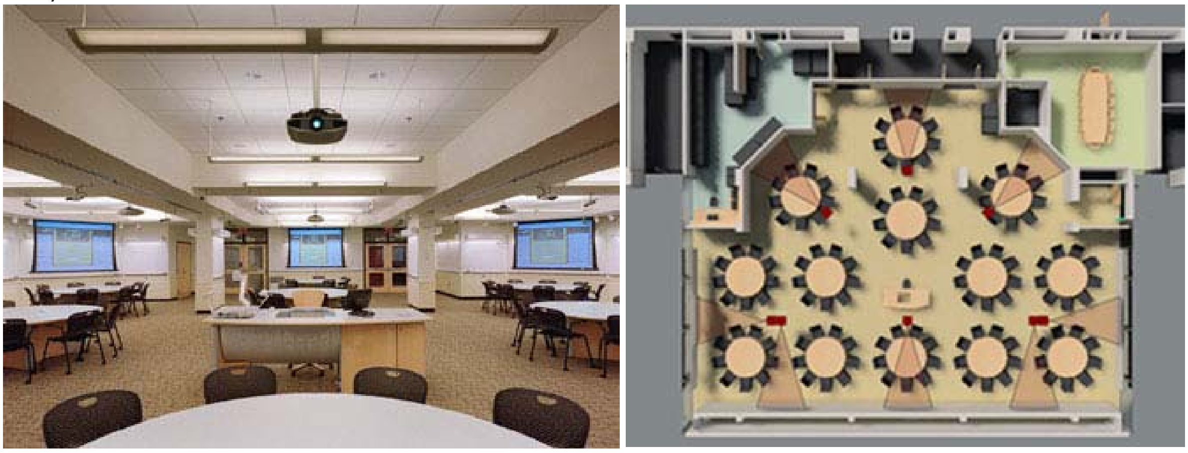


Figure 4.9: *TEAL classroom supporting team engagement (side and top view)*

- **Machine shops** - Spaces that specialize in training/mentoring/making on creation of complex systems and/or fine-detailed components. Interaction with staff (skilled machinist educators) is their key value, so they specialize in quality of maker education/work vs. quantity of students served.
- **Project makerspaces** - Spaces that primarily support class projects. These spaces usually contain more resources to facilitate collaboration, i.e. meeting space and open working space. The key value of these spaces is in their ability to integrate specific resources that enable programmed, curriculum-based learning.
- **Community makerspaces** - Prioritizes fostering unrestricted making via a community effort. The community serves as stewards of the space/resources and educates users in safe making practices. The key value of these spaces is the communities' ability to facilitate access to more users, particularly early/novice users.

At the K-12 level, as described and introduced by the MIT Edgerton Center, Makerspaces can foster emphasis on creativity, collaboration, and community in which students can learn, experiment with new tools, develop skills, and become innovators and designers. They can exist as a corner within a classroom, as a portable cart, as a room that is part of a school library or computer lab, or as a stand-alone shop or facility. Makerspace programs can provide significant benefits to a school community in terms of student engagement, empowerment, and content learning as well as 21st century skills. The design and implementation of a makerspace are critical to its success. While exciting digital tools may draw students in, it's the empowered learning that keeps students engaged. Makerspace leaders should consider activities, training, and academic integration to be at *least* as important as the tools and materials.

Digital Environment/ Educational Technology

MIT has been at the forefront of developing and applying learning technologies in the classroom. Faculty, staff, and students have pioneered technologies that enhance visualization, facilitate knowledge mapping, crowd-source review of assignments, integrate games into learning, conduct experiments via remote laboratories, and advance the digital humanities. As digital learning technology has moved from the early adopter phase into one of broader experimentation and acceptance, ODL seeks to encourage and enable educators to use online learning platforms and other digital tools, such as those described below, through knowledge dissemination, training, and support.

- Interactive, online tutors
- EdX platform

- Technology-enabled classrooms
- Mathlets
- NB PDF Annotation Tool
- Annotation Studio
- Clickers: personal response systems
- Undergraduate contributions to digital tools for the classroom
- Crowdsourced grading
- Light board for lecture video capture
- Self-service: voice-over PPTs & screen capture videos
- Additional innovations

In addition to the aforementioned tools suggested by the MIT ODL, that can be considered as more generic, as they can be used in a variety of courses and disciplines, more specialized digital tools, educational content, simulators and educational games are have been developed by MIT faculty and staff working on K-12 related projects (ODL, 2017).

- **MIT Blossoms :** BLOSSOMS video lessons are enriching students' learning experiences in high school classrooms from Brooklyn to Beirut to Bangalore. Our Video Library contains over 100 math and science lessons, all freely available to teachers as streaming video and Internet downloads and as DVDs and videotapes.
- **Highlights for High School:** MIT OpenCourseWare's (OCW's) Highlights for High School features MIT OpenCourseWare materials that are most useful for high school students and teachers.
- **MIT K-12 Videos** is an educational outreach media program under Strategic Education Initiatives in the MIT ODL. They produce original digital media and live programming that seeks to sparks curiosity and a love of learning, open the door to the science / technology / engineering / math (STEM) world, and promote STEM-literacy among the general public.
- **Education Arcade:** We're all about transforming kids into creators and explorers. We provide fun and accessible ways to explore real and virtual worlds, experiment with technology and use games to build math and science skills. The games, simulations and tools we develop in the Education Arcade are designed with the educator in mind. They use technology to create powerful learning environments in schools, in the home and in the community.
- **Scratch:** is a free programming language and online community where you can create your own interactive stories, games, and animations. Scratch helps young people learn to think creatively, reason systematically, and work collaboratively — essential skills for life in the 21st century.

Living in a digital era, it is now common knowledge that a plethora of new educational resources get developed everyday, and MIT highly suggests that teachers should keep exploring and experimenting with them, however, as the majority of those have not been validated neither for the accuracy of content that is presented nor for the pedagogy and assessment that is implied, they should therefore be introduced in class after careful consideration.

RRI approaches Connections with Local/Global Community

Developing and maintaining connections with the Local and Global community is absolutely critical when attempting to create an Open School culture. These connections may occur at many different levels

- **Connecting with the school:** Students and teachers are encouraged to work in multidisciplinary project. These projects may involve students from the same or different cohorts.
- **Connecting with the local community:** As student are encouraged to work on solving real life problems, collaborations can be formed between local schools, research institutions, museums, the local industry, and other local agents. This type of collaboration can happen both ways, as external agents may be addressing the schools in order to solve an existing problem, or the students may

identify problems in their own community and seek to collaborate with external partners in order to come up with realistic solutions.

- **Connecting with the global community:** Students and teacher can use Information and Communication Technologies (ICT) to further expand their connections. Global connectivity allows for students to develop global awareness, provides them with a global perspective, and assists them to compare their experiences and their solutions to problems with the rest of the world.

Teacher Professional Development

The continuum of K-12 transformation cannot occur without a deep commitment and substantial investments on teacher professional development. With that in mind MIT is already offering programs through the Teaching and Learning Lab (TLL) and the Scheller Teacher Education Program (STEP) that prepare teachers to internalize and apply new concepts and techniques. It is however expected that when discussing an Open Schooling model, the K-12 administration will place significant efforts into cultivating a continuous teacher development attitude, not just by providing external mentorship to the teachers, but by **encouraging open sharing of resources and experiences (both positive and negative) within the school and beyond.**

Situating the School in the Society

While MIT has an extended know-how on developing education on many different levels, starting from the development of a small new module for a course or a new educational software application, to the development of whole new Universities, there is always one common factor to keep in mind. The local legislation, as well as the local culture and norms, have to be studied and understood in great depth before any new development should take place, especially when there is an attempt to introduce an educational component to a new region, State, or country. This does not mean that there should not be attempts to break the local barriers and to introduce new ideas, on the contrary education developers are highly encouraged to closely work with the departments of education, and school districts in order to carefully work on successful adaptations that might be needed, and to better situate the new, possibly "disruptive", school into the local community.

The STEAM Studio Paradigm

The STEAM Studio Education project (Grave, 2017) is the most holistic approach to an MIT inspired Open High-school today. "*STEAM Studio Education Foundation is a Massachusetts-based non-profit organization. Foundation members and advisors are experienced in K12, higher education (Harvard, MIT, Tufts, UMass Lowell), industry, and the Arts."* Although the STEAM Studio Education in not an MIT Project, there are very strong ties to the MIT community, as David Birnbach, one of the key founders of the STEAM Studio is an MIT lecturer at the MIT Sloan School of Management, and the whole school has been designed to infuse "*the learning principals from MIT's Edgerton Center and Media Lab to create the next generation engineers, scientists, and innovators*." At this point it should be noted that although the STEAM Studio Education is the most holistic model of an MIT inspired Open High-school, this Project is still under development, and is expected to be implemented as a new elective program offered by a well-established high-school in Massachusetts in Fall 2018.

The STEAM Studio Learning Model and Curriculum

STEAM Studio is expected to offer high school students an exciting approach to learning as it infuses the learning principals from MIT's Edgerton Center and Media Lab, namely working with Projects, Peers, Passion and Play.

The curriculum blends the mind of a scientist/technologist with that of an artist, enabling students to explore the captivating area where STEM, the Arts, and the future intersect, and it is based on a strong foundation in STEM, Arts and the Humanities. As described on the STEAM Studio website the curriculum is based on Integrated Core Courses, Crash Courses, and Action Learning Labs.

Figure 4.10: *The STEAM Studio Learning Model*

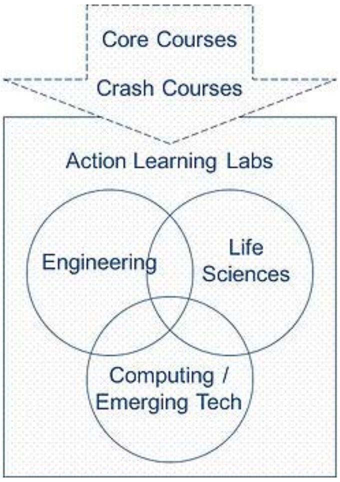


Figure 4.11: *The STEAM Studio Curriculum*

Integrated Core Courses (year-long) unite academic subjects with industry and career pathways. Students apply academic principals to real-world challenges. Course example: Physics & Engineering: Motion by Design, where students apply principles of physics and engineering to an iterative cycle of product design. Course culminates with competition-ready, semi-autonomous devices presented as marketable products designed to serve a specific purpose in the students' local community.

Crash Courses (6-12 weeks long) introduce a variety of short courses that give students the knowledge and skills needed to explore exciting fields (e.g. computational thinking, bioengineering, internet of things, design thinking, coding Amazon Echo & Google Home, electronics, creative writing, making wearables, architecture, bio-inspired robotics). "Core Courses are interdisciplinary and year-round. Sample courses (adopted from University of California's Curriculum Integrated Initiative) include English and Digital Media Arts; Engineering America: US History and Engineering, The Technology of Biology; Geometry and Computer Visualization, Physics and Engineering: Motion by Design." (Grave, 2017)

Action Learning Labs. (3 hours every other day). Modeled after MIT Sloan's Action Learning methodology, students participate in three labs, where they apply classroom learning and engaging in real-life projects: deep dives into current topics that provoke imagination, ignite passion, and improve their lives and the lives of others – in their communities and across the world. Labs are expected to start by teachers and students discussing a question, idea or technology, but the STEAM Studio developers mention that in order "to make the experience as rich as possible, we aim for big questions, stimulating ideas, and unexplored technologies that can lead students in many productive directions – within and across labs."(Grave, 2017)

The Engineering Lab, a "maker space" where students leverage science and technology to engineer solutions that lead to better lives for our citizens and society.

The Life Sciences Lab, where students tackle exciting projects at the forefront of science, including biological engineering, new media medicine, wireless health, genetics, bio-design, brain and cognitive sciences, and computational biology.

The Computing/Emerging Tech Lab, where students get immersed in the exciting world of computing – and explore how new technologies will shape our world (e.g. cloud computing, internet of things, data science, virtual/augmented reality, machine learning, cybersecurity).

A Typical School Week

In a STEAM Studio School students will follow a rotating "Week 1" and "Week 2" schedule, with core courses and action learning labs meeting 5 times over 10 school days (Grave, 2017).

Week 1: Students take interdisciplinary core courses on Monday, Wednesday, Friday. On Tuesday and Thursday, students take Performing Arts classes/workshops (90 min) and work on engineering, life sciences, and computing/emerging tech projects in the Action Learning Labs (3 hours)

WEEK 1					
	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Period 1	Phys Ed / Wellness	Coaching/Advising	Phys Ed / Wellness	Coaching/Advising	Phys Ed / Wellness
Period 2	Foreign Language	Performing Arts	Foreign Language	Performing Arts	Foreign Language
Period 3	Technology of Biology	**Action Learning Labs**	Technology of Biology	**Action Learning Labs**	Technology of Biology
Period 4	Engineering America	- Engineering - Life Sciences	Engineering America	- Engineering - Life Sciences	Engineering America
Period 5	Functional Design Through Algebra	- Emerging Tech.	Functional Design Through Algebra	- Emerging Tech.	Functional Design Through Algebra
Period 6	English & Digital Media Arts	*with integrated Crash Courses*	English & Digital Media Arts	*with integrated Crash Courses*	English & Digital Media Arts
After School	Athletics, Community Service, Optional Studio / Learning Lab Time				

Week 2: Students take core courses on Tuesday and Thursday. Monday, Wednesday, Friday are devoted to Performing Arts and the Labs. (Grave, 2017).

WEEK 2					
	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Period 1	Coaching/Advising	Phys Ed / Wellness	Coaching/Advising	Phys Ed / Wellness	Coaching/Advising
Period 2	Performing Arts	Foreign Language	Performing Arts	Foreign Language	Performing Arts
Period 3	**Action Learning Labs**	Technology of Biology	**Action Learning Labs**	Technology of Biology	**Action Learning Labs**
Period 4	- Engineering - Life Sciences	Engineering America	- Engineering - Life Sciences	Engineering America	- Engineering - Life Sciences
Period 5	- Emerging Tech.	Functional Design Through Algebra	- Emerging Tech.	Functional Design Through Algebra	- Emerging Tech.
Period 6	*with integrated Crash Courses*	English & Digital Media Arts	*with integrated Crash Courses*	English & Digital Media Arts	*with integrated Crash Courses*
After School	Athletics, Community Service, Optional Studio / Learning Lab Time				

Approach to Learning

According to the STEAM Studio developers, the teachers will be employing three approaches to learning - exposure to many concepts, taking responsibility for one's own learning, and practice – that provide students with a well-rounded education that gives them the basics, opens their eyes to the possibilities, and gives them the chance to translate their ideas into working forms.

The first theme is that **students should be exposed to as many concepts and fields of study as possible**. The goal is to open students' eyes to a world of possibilities and interests - and help them learn something about a large number of fields so they can make well-informed career decisions and lead richer lives. The academic programs:

- Show students how to apply subject-matter knowledge in different fields of study while providing a glimpse of different professions (apply English to the Digital Arts, apply Math to Architecture, apply Biology to Engineering)
- Teach students practical skills they can use throughout their academic and personal lives
- Enable students to try different fields of study to discover which ones they like and may want to pursue in the future

The second theme is **the notion of taking responsibility for one's own learning**. This means shifting the reason for learning from "because I have to" to "*because I want to*." It means students setting their own educational goals. ("*I'd like to learn more about this subject because it interests me*.") It means students making their own educational plans. ("*I'd like to learn this field next and then branch into that field*.")

The third theme is **the notion of putting ideas into practice**. "Practice" is a term borrowed from the professional world. Doctors have a practice. Lawyers have a practice. Architects and designers have a practice. In these fields, and in Design Colleges around the country, "practice" means taking what someone has learned in the classroom and applying it to Creation and Problem Solution. It is a way of making learning concrete and putting it to practical ends (Grave, 2017).

Teacher Community

Teachers collaborate daily, and engage in weekly workshops to discuss ways to refine/advance the curriculum, ensure continuity between courses and action learning labs, and discuss new ideas, and teaching methods. Teachers also have access to an online Teacher's Forum, where they can post classroom/project successes and learnings – in written, photo, and video formats. These artifacts are shared with colleagues, so everyone can learn from any one teacher's approaches and experiences. Teachers frequently engage in outside activities, including lectures and seminars at area universities, monthly round-table discussions with engineers, scientists, and technologies at partner companies, and visits to other schools - to observe their approaches and learn from their best practices.

The STEAM Studio Implementation

STEAM Studio is a model for a new generation of academies within existing public high schools located in Gateway Cities. The STEAM Studio team is currently collaborating with vocational/technical schools and district high schools to create STEAM Studios as *academies within their existing schools* - in Massachusetts and throughout the US. First classes that will operate under the STEAM Studio model are expected to begin in Fall 2018.

5 The OSOS Open Schooling Model: From Scenarios to Practice

In the previous chapters we have presented the development of the Open Schooling concept from the re-schooling OECD scenarios (2001-2004) to the most recent initiatives at national or international level that are focusing on rethinking how schools and on empowering students to act as catalysts of change and as developers of innovative educational activities and projects. These are also the driving forces of the OSOS approach that aims to describe a generic process that schools have to follow in order to introduce an Open Schooling Culture in their settings. This chapter includes two main parts. In the first part, we will describe in short, the two driving forces of the OSOS approach. In the second part, we will describe in detail the OSOS Open Schooling Model while at the same time we will present the influences from the initiatives that were presented in Chapter 4. It has to be noted that the strategies for the implementation of the OSOS Open Schooling Model will be presented in the Deliverable D2.2. For this reason, we will not focus on the specific issue in the following paragraphs.

5.1 The Driving Forces of the OSOS Open Schooling Model

5.1.1 Rethinking How Schools Work

There is a focused movement to reinvent the traditional classroom paradigm and rearrange the entire school experience — a trend that is largely being driven by the influence of innovative learning approaches. Methods such as project based and inquiry learning (Sotiriou & Bogner 2011, Sotiriou et all, 2017) call for school structures that enable students to move from one learning activity to another more organically, removing the limitations of the traditional timetable. The multidisciplinary nature of these contemporary approaches has popularized the creative application of technology and fostered innovative designs of school models that link each class and subject matter to one another. As learning becomes more fluid and student-centered, some teachers and administrators believe that schedules should be more flexible to allow opportunities for authentic learning to take place and ample room for independent study. Changing how learning takes place in classrooms is also requiring shifts in the business models of schools, which are increasingly becoming more agile and open to trying new approaches.

This trend is largely a response to the overly structured nature of a typical school day, which some believe hampers learning.[10] Traditionally, bells have signified the beginning and end of each day, ushering students from one class to the next. In many ways, the bell symbolizes the separation of disciplines, making a clear statement that each should be kept disparate. In the past few years, many teachers have made progress toward bolstering interdisciplinary learning, also commonly referred to as integrated studies. Edutopia describes this model as combining “curriculum from two or more disciplines, allowing students to see how ideas are connected.” They point to collaboration, critical thinking, and knowledge retention as three positive outcomes for students. Technology use is at the heart of this design as activities such as integrating 3D printing in science classes and media production into humanities courses become more pervasive.

> The goal is for students to understand the various intersections between any subject matter, acquiring a skillset that is desired in the contemporary workforce.

5.1.2 Shift from Students as Consumers to Creators

A shift is taking place in schools all over the world as students are exploring subject matter through the act of creation rather than the consumption of content. A vast array of digital tools is available to support this transformation in K-12 education; indeed, the growing accessibility of mobile technologies is giving rise to a whole new level of comfort with producing media and prototypes. Many teachers believe that honing these skills in learners can lead to deeply engaging learning experiences in which students become the authorities on subjects through investigation, storytelling, and production. Other components of this trend include game development and making, and access to programming instruction that nurtures learners as inventors and entrepreneurs. As students become more active producers and publishers of educational resources, intellectual property issues will become a key component of K-12 curricula.

There is growing support for empowering learners as creators that demonstrate their mastery in forms that surpass traditional tests and worksheets. Emerging instructional frameworks are encouraging teachers to use digital tools that foster creativity along with production skills. This trend also implies that teachers are increasingly becoming creators, too, and are therefore in the position to lead activities that involve developing and publishing educational content. Large scale initiatives as Open Discovery Space (Sotiriou et al, 2016) have helped teachers streamline the process of creating, editing, and publishing educational materials. Such tools offer a way for teachers to develop digital lesson plans that are in line with the needs of their classrooms. As teachers become more comfortable using media, they can offer better guidance to their students.

5.2 Supporting Schools to become Sustainable Innovation Ecosystems

According to the Brookings Institution, scaling schooling innovations is an especially wicked challenge because it is a matter of absence over presence. They argue that it is a problem related to the conservative culture of schools that are always reluctant to support innovative practices and approaches. According to the HORIZON 2015 K-12 Report (NMC, 2015) experts on the topic surmise that these types of innovations often fail because teachers struggle against the odds; their formal education has not prepared them to implement novel instructional approaches, and strong support systems for effective professional development are scarce. The problem is not the absence of innovation experts claim, but "*a trend that leads agencies — both public and philanthropic — to provide seed funding to new ideas rather than scaling projects and models that already work*" (NMC, 2015, p.30). As a result, pockets of isolated innovation do not make the kind of broad impact that will affect systemic change at the institutional, social, or political level. According to the report, any effort to scale innovation should be focused on supporting advocacy and organizing communities around existing models, creating a united voice that is heard through social platforms and other outlets. "*The difficulty lies in capturing the impact of social movements in a way that funding agencies can digest*" the report concludes (NMC, 2015, p.30). But how this united voice can be created?

In fact, there are many parameters and conditions for the school transformation process:

Increase Mass	• Before schools can embark on change they need a clear **vision and leadership**. More specifically school leaders need to create a shared vision for **how science education best can meet the needs of all learners and to develop a plan that translates the vision into action**. This vision and planning processes should be based on **holistic view of the current innovation** status of the school. This transparent overview will allow for more targeted planning to address the specific issues that each school is facing, thus optimizing the efforts to overcome them. The vision begins with a discussion of how and why a community wants to transform learning. Once these goals are clear, science and research findings can be used to open new possibilities for accomplishing the vision that would otherwise be out of reach. A series of system changes can then occur: When carefully designed and thoughtfully applied, **innovative projects can accelerate, amplify, and expand the impact** of effective teaching practices. However, to be transformative, teachers need to have the **knowledge and skills** to take full advantage of the process and the outcomes of these project-based activities. In addition, the roles of teachers and teachers' trainers, parents, and learners all will need to shift as scientific inquiry enables new types of learning experiences. • Building **teacher and leader capacity** is vital to successful transformation. A successful change strategy requires professional development, feedback and support for teachers along with a well-researched monitoring and evaluation system. **Organizational capacity**, **strategic planning** and **quality assurance** are crucial parameters during the transformation journey.

Increase Density	• An extended (beyond the school) **community of practice** can provide a structure for fostering growth, sharing experiences and best practices and enhancing learning goals. **Partnerships and capacity building** for change are equally important at this stage. For example, a **public-private education partnership** has the potential to be a significant catalyst for systemic change. **Science Centers and Museums** could also catalyze the transformation process by bringing in their open and creative culture. **Outreach groups of research organizations** could offer unique insides on how science works as well as on how scientists work. **Communities and local business as well as industrial partners** can contribute to the school openness at this level. The selection of the partners has to be done according to the innovation action plan and the real needs of the school.
Increase Temperature	A wealth of recent research in cognitive psychology and the neuroscience of learning presents new pathways to efficient and meaningful education: leveraging such techniques as blended-learning scenarios, hands-on exercises, games-based-learning and other research-based interventions and techniques allows schools to operate more effectively. From whole-of-school transformation to innovative learning solutions, open and creative environments can cultivate effective and engaging learning. A commitment to **personalized learning** includes providing solutions that empower all students. **Inclusion, accessibility and sustainability** should be included in the key functionalities of the educational activities in the Open Schooling Hub. In the framework of the proposed educational activities the consolidation of good practice will be achieved by: • ***Bringing into the classroom a unique collection of digital resources and tools that are based on real-world problems.*** The resources will involve students in finding their own problems, testing ideas (from small to big ideas in science), receiving feedback, and working collaboratively with other students or practitioners beyond the school classroom. The *eLearning* tools will provide scaffolds that enhance learning, support thinking and problem solving, model activities and guide practice, represent data in different ways, and form part of a coherent and systemic educational approach. • ***Giving students and teachers more opportunities to evaluate the quality of their own thinking and products for feedback, reflection, and revision***. • ***Giving students and teachers the opportunity to interact with working scientists, receive feedback from multiple sources*****.** • ***Building local and global communities*** where teachers, teacher trainers, education policy makers, parents, students, practicing scientists and other interested members of society are included in order to expand the learning environment beyond the school walls and expand opportunities for teachers' professional development. This will include helping teachers to think differently about students and learning, reduce barriers between students and teachers as learners and creates new partnerships among teachers, students and parents.
Increase Reflectivity	**Responsive and creative use of the outcomes of the projects which will be developed in the framework of the process** is a powerful way to improve curriculum and assessment outcomes for students, teaching practices and for the school as organization. **Technology-enabled assessments and support mechanisms based on analytics** support learning and teaching by communicating evidence of learning progress and providing insights to teachers; school leaders, policy makers; parents; and, most importantly, the learners themselves. These assessments can be embedded within learning activities to reduce interruptions to learning time. For example, the organization of the inquiry activities in the framework of the students' project preparation allows for the introduction of methods to analyze the effects of the implementation of such activities that fostering complex problem-solving abilities. (detailed description of the approach is presented in Deliverable D6.1).

The challenge is to provide schools with an **integrated framework** fitting all the pieces together: introducing and helping to sustain a culture of change, providing tools and resources for innovative projects, supporting community and capacity building, providing mechanisms to monitor and assess the progress at different levels. This is the foreseen role of the Open Schooling Model that can facilitate the school innovation process, acting as an innovation ecosystem for school leaders, students and teachers, parents, policy makers and industry partners. The OSOS approach has been designed and applied in practice as a three-step process (based of the framework that has been developed in Open Discover Space Policy Support Initiative), aiming to **Stimulate**, **Incubate** and **Accelerate** the uptake of innovative RRI practices in school communities and national policies. Figure 5.1 presents the proposed innovation approach in its final format, having been slightly adapted after implementation in 400 schools across Europe (Sotiriou & Bogner 2011, Sotiriou et al, 2016). The main activities and the objectives of each phase are described in the following:

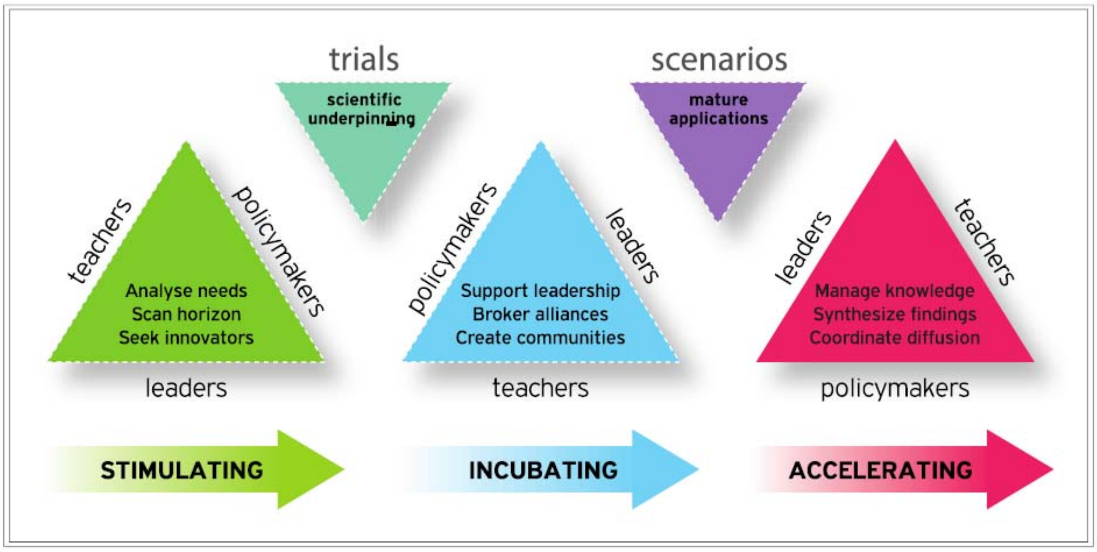


Figure 5.1: *School Innovation Diffusion approach (based on Sotiriou et al. 2016) that forms the basis for the Open Schooling Hub model in the framework of OSOS project.*

The **stimulation phase** is focusing on the analysis of the school needs and has the aim to identify areas in which the school can best demonstrate innovative approaches and projects. The development of a critical mass of **Change Agents**, innovative teachers who will share the vision of the school leader to take the school to the next level, is of major importance at this phase. At this level, initial innovative scenarios are being implemented to pioneer future-oriented practices and to experiment with scientific data and resources as well as with innovative technological services and practices. At this phase, the **OSOS project will offer a rich database of creative initiatives with access to numerous resources, guidelines and support** (also online through webinars and hangouts) as well as examples for the coordination of action plans offering funding opportunities for the realization of the school action plans focusing on teachers' professional development and the adoption of an Open Schooling Development Plan for the participating schools. The ESHA recommendations in section 4.3 (based on the experiences from the implementation of the Q4I model) has put emphasis on all staff members working with an innovation model. Obviously, each school should strive to include all members in a journey for change. Yet resistance to this change is always a possibility and OSOS will provide a set of actions that address the issue. ESHA has recommended the use of the Organizational Innovation Capacity Assessment Tool (IGUANA, 2013) to address resistance to change. MIT school innovation initiative (see Section 4.7.3) also puts emphasis on a deep commitment and substantial investments on teacher professional development. With that in mind MIT is already offering programs through the Teaching and Learning Lab (TLL) and the Scheller Teacher Education Program (STEP) that prepare teachers to internalize and apply new concepts and techniques in the school transformation process. It is however expected that when discussing an Open Schooling model, the K-12 administration will place significant efforts into cultivating a continuous teacher development attitude, not just by providing external mentorship to the teachers, but by **encouraging open sharing of resources and experiences (both positive and negative) within the school and beyond.** Apart from their training, in order for teachers to introduce innovation in their everyday routine, they will have to perform a change in behavior and to adapt a new culture and philosophy. In order for the OSOS approach to assist this change, we must introduce a solid theoretical framework and underline the main actions that need to be taken. In a review paper (Lawson and Price, 2003), McKinsey management experts identify four key prerequisites for accelerating and establishing change in the school environment:

- **A purpose to believe in:** “I will change if I believe I should” The first, and most important, condition for change is identifying a purpose to believe in. In our case, we must persuade teachers of the importance of scientific literature in terms of social value, importance to their students and personal achievement through learning and teaching these important subjects. We must carefully craft a “change story” underlining the benefits that the project can offer to all the involved actors. Furthermore, we must cultivate a sense of community, making the teacher feel part of a cohesive multi-national team. This sense of belonging will prove very important for motivating teachers and asking them to take then next, possibly “painful” steps, of learning new skills.
- **Reinforcement systems:** “I will change if I have something to win”. From a pure behavioristic point of view, changing is only possible if formal and informal conditioning mechanisms are in place. These mechanisms can reinforce the new behavior, penalize the old one or, preferably do both. In our case, we can use informal reinforcement patterns in order to make teachers commit more to our project. A short list of such methods could include competitions, challenges, promoting the best teacher created project or lesson plan, offering e.g. the participation to a summer school as rewards.
- **The skills required for change:** “I will change if I have the right skills”. A change is only possible if all the involved actors have the right set of skills. In the case of the OSOS project, we should make sure that our training program is designed in such a way that teachers acquire all the skills they will need, both technical and pedagogical.
- **Consistent role models:** “I will change if other people change”. A number of “change leaders” will need to be established, acting as role models for the community of teachers. These very active and competent teachers will be a proof of concept for their colleagues that the change is indeed feasible, acceptable and beneficial for them. To achieve that we will have to identify the high flyers among the participating teachers and pay special attention into motivating them, supporting and encouraging them.

All four will specifically be addressed in each implementation phase of the OSOS project. Additionally, the consortium team will collaborate closely with teachers to develop a set of support services (WP3) which help teachers to implement the necessary changes, to develop the diagnostics and intervention skills necessary to best plan and then diffuse of innovation in their own contexts. An effective training approach will provide the starting point for equipping teachers with the competences they need to act successfully as change agents, developing a language/terminology necessary to describe the dynamics of change processes, and making them able to recognize different forms of resistance and addressing it in their own context. At the same time, it will provide a common basis/experience for “connecting” teachers across schools, within and across national boundaries – engaging them in an ongoing exchange of experiences across school, regions and countries.

The **incubation phase** aims to diffuse innovative practices in numerous areas (curriculum, parental engagement, interactions with actors outside from the school) of the school operation. It aims to encourage the uptake of project-based and resource-based learning practices and to engage a wider school community (by involving more teachers in the projects and initiatives, technical staff, parents, community members, local industry) in implementing innovative projects in various curriculum areas, as well as to reflect on the use of tools, resources and practices through the systematic assessment methodology that will be set in place to act as a reference system for the school development as an Open Schooling Hub. This phase aims to create the steady and supportive development of new learning techniques and methodologies, leading to sustained improvement. The development of strong communities of practice around the school-lead projects is regarded as a crucial element in the success of proposed interventions. At this phase, the **OSOS offers numerous tools for the school communities. Apart from community building and support tools numerous content creation and content delivery tools will be available for students and teachers.** The aim is to help them to become **creators of educational activities** which will reflect on the real educational needs of their classrooms as well as they are providing solutions to their local communities. The approaches used in the framework of DFC Initiative, the RRI Tools project and the HYPATIA project will act as references in the design of the students' empowerment techniques that will be used. They will be able to adopt existing content, enrich it with numerous resources and tools in order to provide integrated solutions to the local problems. The OSOS team will adopt the DFC Model (see Section 4.7.1) in guiding students to develop their projects. This includes the following four-step process (adopted from the DFC four-step process):

- **Feel:** Students identify problems in their local communities. They can also select topics related to global challenges. Students observe problems and try to engage with those who are affected, discuss their thoughts in groups, and make a plan of action, based on scientific evidences.
- **Imagine:** Students envision and develop creative solutions that can be replicated easily, reach the maximum number of people, generate long-lasting change, and make a quick impact. They are coming in contact with external actors, they are looking for data to support their ideas and they are proposing a series of solutions.
- **Create:** Students are implementing the project (taking into account the RRI related issues) and they are interacting with external stakeholders to communicate their findings.
- **Share:** Students share their stories with other schools in the community and local media.

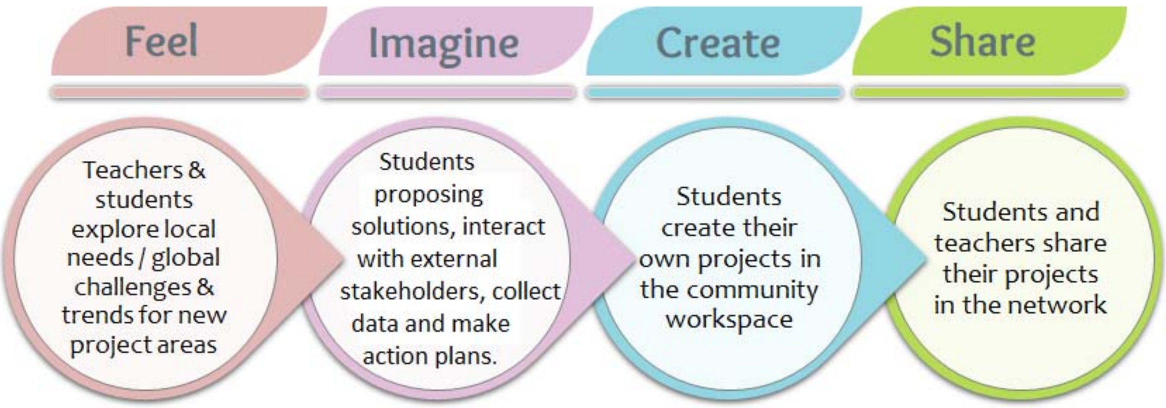


Figure 5.2: *The OSOS platform will offer students the opportunity to develop their projects following a simple four step process (based on the DFC model).*

Localized assessment approaches will estimate the impact on both, individuals and schools as an organization, as well as on the development of effective cooperation with organizations like universities and research centers, informal learning centers (e.g. museums and science centers), enterprises, industries and the local communities. The OSOS project aims to validate its approach with the very large school communities (see Figure 5.3) who are currently using the services offered by the Open Discovery Space (ODS) socially empowered portal (http://portal.opendiscoveryspace.eu/) (main outcome of the major European initiative funded by European Commission's CIP-ICT Policy Support Programme) (Athanasiades et al, 2014). ODS portal is currently used by **5.000 European Schools** from **20 European Member States.** The use of ODS services (combined with the functionalities of the Inspiring Science Education (ISE) tools) has resulted to substantial growth in digital maturity (e-maturity) of the participating schools, even for schools which were considered as e-mature when they joined the network. The participating school communities became core nodes of innovation, involving numerous teachers in sharing educational content and experiences (Sotiriou et al, 2016). Schools that were involved in ODS and ISE large scale initiatives have developed innovations locally, and while the consortium sought to understand what works across the innovation programme as a whole. In the framework of OSOS the project team, using the extended experience from the large scale pilots over the last years, will design and **implement localized approaches and strategies** in different countries and in the different school settings (These strategies will be described in detail in Deliverable D2.2). Through these localized strategies the consortium aims to provide schools and their staff with new ways for the use of technology: not simply to automate processes but to inspire, to engage, and to connect. It will provide a powerful framework for school leaders to engage, discuss and explore: how schools need to **Evolve, Transform and Reinvent**; how schools will facilitate open, more effective and efficient co-design, co-creation, and use of digital content, tools and services for personalized learning and teaching; how schools can become innovation incubators and accelerators. The consortium will set in place a **community support mechanism** (**WP3**) to facilitate the work of the different stakeholders involved in the process.

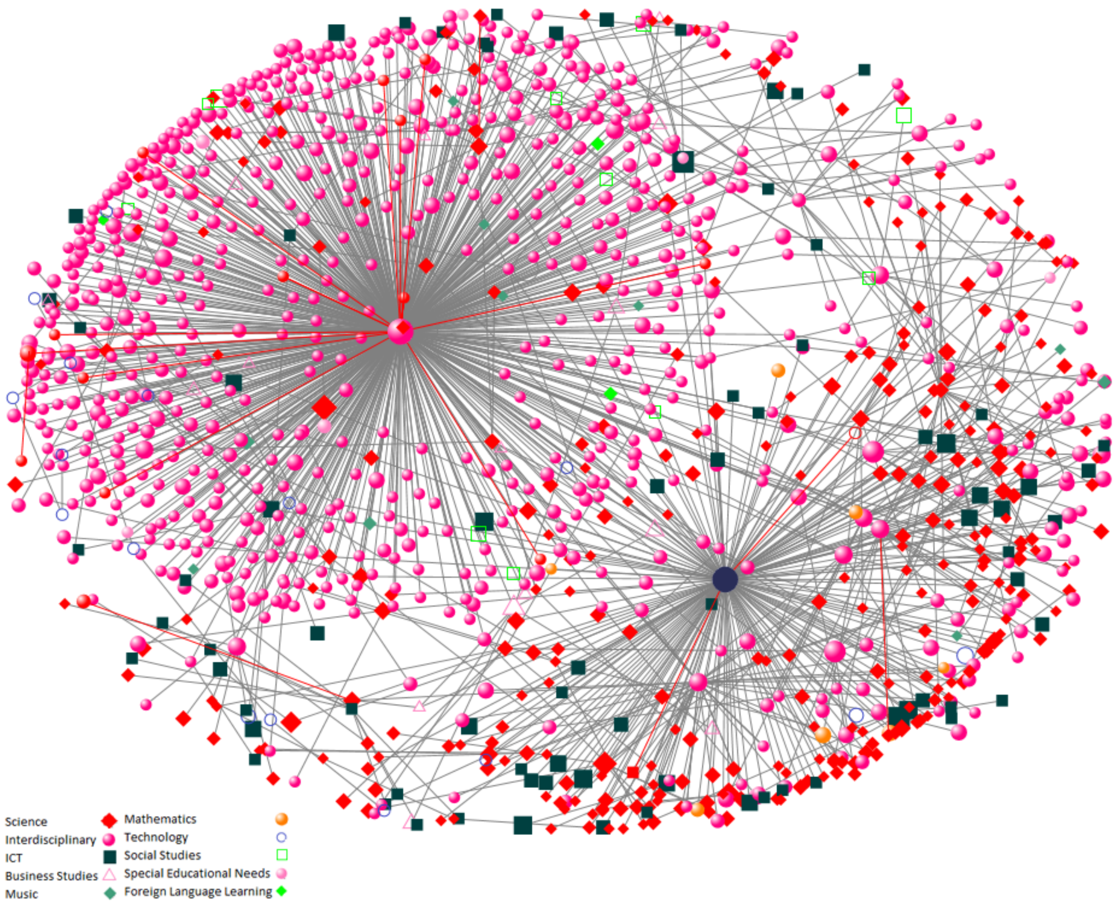


Figure 5.3: *OSOS project will capitalize on the ODS/ISE school communities which currently involve 5.000 schools from all over Europe. The graph presents the thematic communities that have been developed by these schools. One can see that the communities are dominated by science and interdisciplinary projects which can form a unique space for implementation of the Open Schooling Activities.*

The objective of the **acceleration phase** is to accelerate the educational changes regarded as effective and to expand them to significant parts of the school, always keeping in mind the school's main needs (as defined in phase one). Attention is given to exploiting knowledge management techniques (sharing what is known within the participating school communities); synthesizing evaluation and accelerating diffusion within national agencies (to reach more users). Insights from the use of the OSOS support mechanism, data from the school communities, the development of the teachers' competence profiles, the content that was created and delivered locally, the interaction of the communities and their members will create a unique data base for future recommendations and for the identification of best practices. **The OSOS proposed best practices will help innovative schools to proceed more and develop their innovative ideas to new localized projects that could provide new solutions for the school and its community,** for bringing the gap between formal and informal learning settings and creating new opportunities for personalization at different levels (student, teacher, school). At this level, innovation has to be the norm in the school operation that will act as **an Open Schooling Hub**, an environment that shares a culture that imports external ideas that challenge internal views and beliefs and, in turn, exports its students – and their assets – to the community it serves.

Table 5.1: *The OSOS approach can facilitate in an integrated way the "chain reaction" of school innovation and openness by providing the critical mass of innovative practitioners, engage them in communities of practice, support their work with numerous tools that will enrich their practices and provide them with systematic reflections on the impact of their interventions. The Table presents the key components of the Open Schooling Support Mechanism (WP3).*

	Increase Mass	**Increase Density**	**Increase Temperature**	**Increase Reflectivity**
Simulation Phase	Teachers Guidelines, School Leaders Tool Kit	Community Building Tools, Community Support Mechanism	RRI Tools and Guidelines (Partners Initiatives)	School Profiling (openness and RRI culture), Open School Development Plan
Incubation Phase	Teachers Academy, Parents Tool Kit, Outreach Groups School Kit	Community Building Tools, Community Support Mechanism	OSOS Scenarios of Use (Incubators of Innovation)	Open School Development Plan (re-visited), School Innovation Profile (re-visited), Open School Plan Recommender
Acceleration Phase	Teachers Academy & Parents Tool Kit, Outreach Groups School Kit	Community Building Tools, Community Support Mechanism	OSOS Best Practices, European Open Schooling Map (Accelerators of Innovation)	Open School Development Plan (re-visited), School Innovation Profile (re-visited), Open School Plan Recommender

Table 5.1 presents the OSOS tools (provided by the OSOS support mechanism, WP3) that will be in place to spread a RRI culture (following the three-step innovation diffusion approach) throughout every single school of the OSOS network. The OSOS tools are categorized in four different but complementary areas according to their impact to the innovation process which is represented as a "**chain reaction**": we need **to "increase the mass" of the innovators**, we need to **bring them together to exchange ideas and experiences ("increase density")**, we need **to motivate them by providing them with tools according to their educational needs ("increase temperature")**, we need to **reflect on their practices** and **provide guidance for future actions**. In Figure 5.4, we are graphically representing the parameters and the conditions for the school innovation process and the support mechanisms that OSOS initiative will set in place to support this process: The OSOS Open Schooling Model. Figure 5.5 presents the contributions/influences of the Model by the initiatives presented in Section 4.

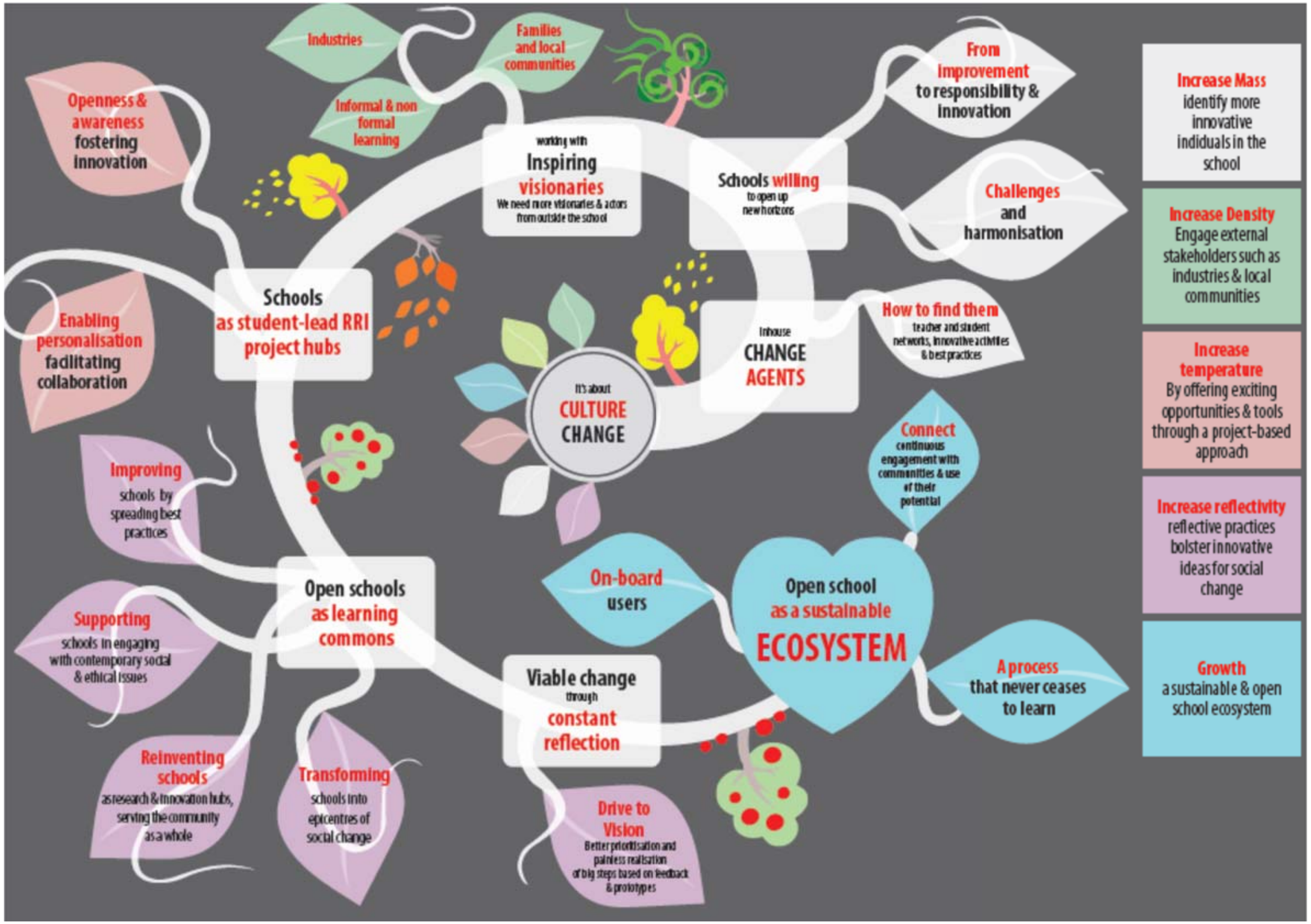


Figure 5.4: *The full cycle of the school transformation with the support of the OSOS support mechanism. The process starts with the Change Agents who are becoming Inspiring Leaders of the school community. The OSOS support mechanism offers open, interoperable and personalized solutions meeting the local needs, supports school leaders capture innovation, to decide on the appropriate strategy to diffuse innovation to the school and through constant reflection is guiding them towards the transformation of the school to Open Schooling Hubs and finally to sustainable innovation ecosystems.*

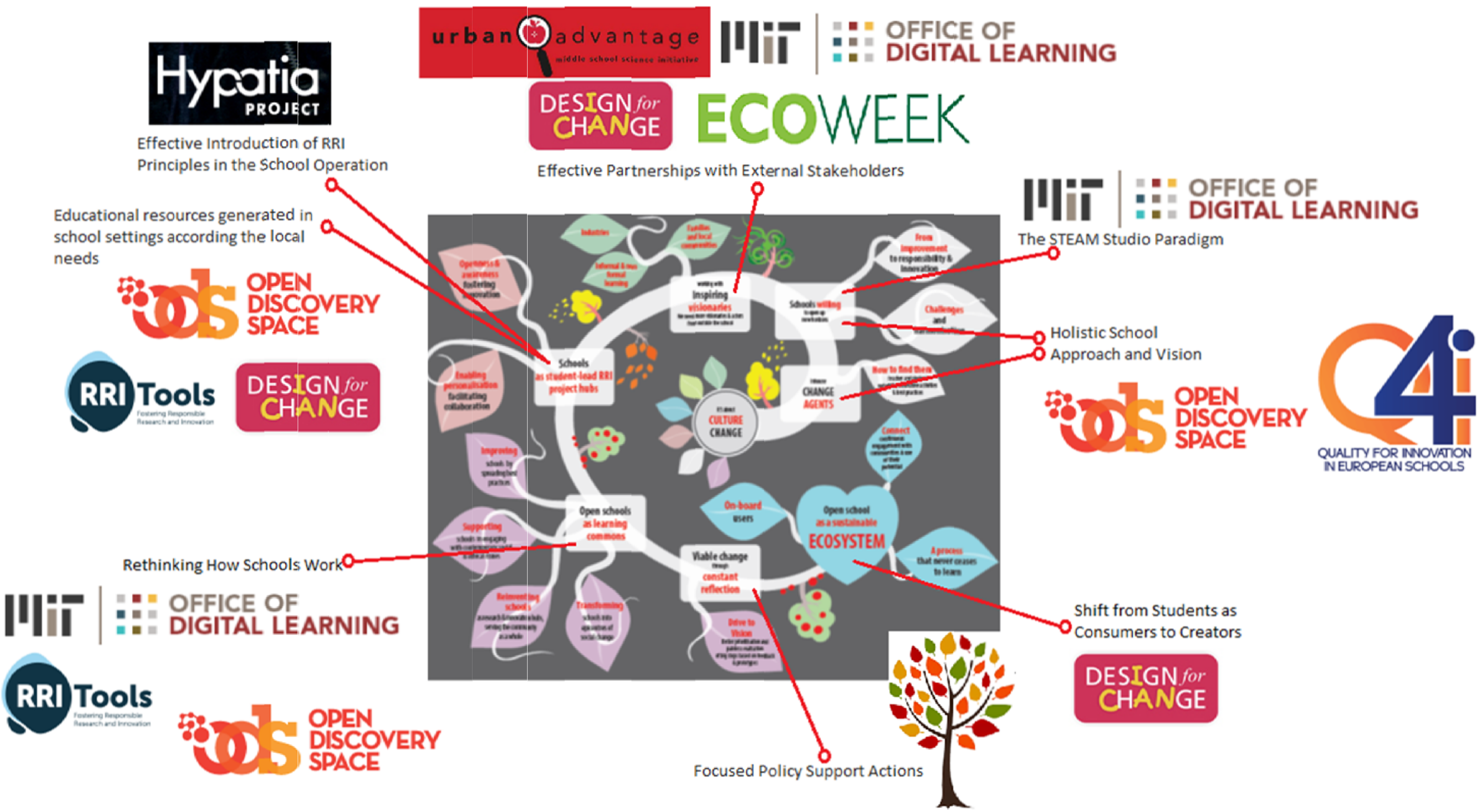


Figure 5.5: *The full cycle of the school transformation with the support of the OSOS support mechanism and the contributions/influences from the school innovation initiatives presented in Chapter 4 with emphasis to the main driving forces of the Open Schooling Culture (Vision and Leadership, effective interaction with external stakeholders, introduction of the RRI principles, school-generated resources from students and teachers and policy support).*

5.3 Viable Change: Sustainability as a route to the future

The OSOS Open Schooling Model put emphasis on creating viable change to school settings that lasts and expands. The OSOS Open Schooling approach aims to create strong school networks which are ready to share their experiences with others. It is built on numerous national and international initiatives and provides a unique resource for a school reform towards a more effective school environment. Thinking about the future or even performing isolated experiments is not enough for decision makers in education. It is also necessary to conceptualize how to change current systems in specific powerful ways. System thinking in action (Fullan, 2005) addresses sustainability and the need to change context. How do contexts or systems change? They do so over a very long period of time. System change evolves as a result of major alterations in demographics, technology, and other social forces. But we want to accelerate the development of good changes like the spread of professional learning communities. The key to this involves conceptualizing sustainability and using leadership to change context or the environment by a) **increasing leaders' participation in wider contexts** and b**) helping to develop leadership in others so they can do the same**.

After about 5 years of working on European-wide reforms (including the Opening-Up Education Initiative by the EC, 2013), the OSOS consortium noticed the following phenomenon: Individual school head-masters became almost as concerned about the success of other schools in their areas as they were with the success of their own school. This is a direct result of being engaged in a larger purpose and getting to know other schools through walk-throughs and other lateral capacity-building strategies. These strategies might involve small clusters of schools working together to improve literacy or principals and teachers conducting walk-throughs of a school or schools to provide critical feedback to the staff. Their world-views and commitments increased to encompass the larger system, but at the same time, they helped change the very system within which they work. They literally changed their context. **The key to sustainability is to change context**: "Sustainability does not simply mean whether something will last. It addresses how particular initiatives can be developed without compromising the development of others in the surrounding environment now and in the future". Sustainability is about changing and developing the social environment. **The OSOS Open Schooling approach is not about the proliferation and the development of single schools; it is about creating new environments across the system through tri-level development, at school level, at the community level and at national level.** The following eight items (Fullan, 2005a) are elements of sustainability and part of the writ large agenda:

- **Public service with a moral purpose is an explicit commitment** on the part of the system to endorse and pursue an agenda for raising standards and closing the gap.
- **Commitment to changing context at all levels** involves the realization by leaders at all levels that they are changing the culture of schools and districts.
- **Lateral capacity-building through networks** means identifying and investing in strategies that promote schools learning from each other.
- **Intelligent accountability and vertical relationships focus on developing great self-review capacity** in the context of transparent external accountability.
- **Deep learning** means that the system is continually pushing the envelope to address the fundamental learning goals of thinking and problem-solving skills, teamwork, and learning across the curriculum.
- **Dual commitment to short-term and long-term results** requires system leaders to realize that they must pursue simultaneously short-term increases in student achievement and mid- to long-term results. They must lay the foundation for the long-term learning of all students.
- **Cyclical energizing** emphasizes that "achievement at all costs" is self-defeating. Capacity must be built over time. Periods of intense development must be coupled with opportunities to recoup. Sustainability is about energy more than it is about time. Thus, monitoring and stimulating energy are key.

- **The long lever of leadership**—leaders fostering the development of other leaders by widening their sphere of commitment and participation—is an integral part of this agenda. In this sense, the main mark of a school principal at the end of his or her tenure is not just his or her impact on the bottom line of student achievement, but equally on how many good leaders he or she leaves behind who can go even further. This is the long lever of leadership. Leaders also need to help provide wider learning experiences through networks, clusters, paired schools, and other lateral capacity-building strategies.

Learning from each other concept is a very crucial point in moving this ambitious agenda forward. We know this but need to address it explicitly with respect to tri-level reform. School cultures improve when teachers within the school learn from each other on an ongoing basis. Communities cultures improve when schools learn from each other, and when local communities learn from one another. When schools or their communities want to know where to start reform, they would be wise to conduct site visits to other schools or communities that are further down the road. During a site visit, teams from the visiting school or it community prepare questions for the host school and then gather data to address these questions. They then examine their findings and identify specific actions to take. The current organization of the ERASMUS+ programme for schools' cooperation and exchanges offers unique opportunities for this to happen even at an international level. This is an example of continuous learning that includes seeking out better information and learning from one's own experiences and from the experiences of others. In addition, member states engaged in tri-level reform need to learn from each other (both within and across countries). The learning principles are no different, just applied on a larger scale. Paying attention to the growing knowledge base, problem solving and learning through reflection, cultivating networks of interaction, and enlarging the world view are all part and parcel of increasing capacity and changing.

Finally, it would be a **fundamental misunderstanding of systems theory to assume that the system should change first**. Each of us is the system; there is no chicken and egg. We must connect with others to change whatever parts of the system we can. Whenever one is acting to promote professional learning communities, there should be an obligation to connect it to larger issues—bigger dots, if you will. Waiting for others to act virtually guarantees preservation of the status quo. If individuals are proactive, they stimulate others and make it more likely that the system will begin to change, resulting in new breakthroughs.

6 Conclusions and Future Steps

Working with more than 5,000 schools across Europe in the framework of numerous European initiatives and Policy Support Actions (e.g. Inspiring Science Education, Go-Lab, Pathway, Ark of Inquiry, RRI Tools) over the last five years has helped the OSOS consortium to define a systematic framework for the development of an Open School Culture in European schools. An Open School culture imports external ideas that challenge internal views and beliefs and, in turn, exports its students – and their assets – to the community it serves. Such an engaging environment makes a vital contribution to its community: student projects meet real needs in the community outside of school, they are presented publicly, and draw upon local expertise and experience. The school environment fosters learner independence – and interdependence – through collaboration, mentoring, and through providing opportunities for learners to understand and interrogate their place in the world. An Open School Culture recognizes the important part that students can play as peer enquirers / researchers, and welcomes their active involvement.

In this deliverable, the OSOS consortium is presenting the development of the Open School concept from the initial OECD scenarios back in 2001 to global current initiatives that are empowering schools to become hubs of innovation in their settings. The guiding forces of the OSOS Open Schooling Model are discussed and analyzed. The OSOS Open Schooling Model describes a three-step process, aiming to Stimulate, Incubate and Accelerate the uptake of innovative RRI practices in school communities and national policies. It describes the full cycle of the school transformation with the support of the OSOS support mechanism. The process starts with the Change Agents who are becoming Inspiring Leaders of the school community. The OSOS support mechanism offers open, interoperable and personalized solutions meeting the local needs, supports school leaders capture innovation, to decide on the appropriate strategy to diffuse innovation to the school and through constant reflection is guiding them towards the transformation of the school to Open Schooling Hub and finally to sustainable innovation ecosystems.

Following the delivery of the current work (D2.1) the consortium will focus on the description of the OSOS Strategies (D2.2) for the implementation of the OSOS Open Schooling Model in the different school settings across Europe. These documents will form the basis of the Open Schooling Roadmap (D2.3). The proposed open schooling process will be implemented and monitored during the whole period of school involvement in the pilot activities. The aim of the Open Schooling Roadmap is to give a concrete overview of what is known so far about the implementation of open schooling approaches in general and to incorporate these insights into the proposed Open Schooling Model. Applying the OSOS Open Schooling Model in local settings will make it clear that schools have much to gain by fostering connections between formal and informal learning, between existing providers of education and new entrants. The roadmap will be an evolving set of guidelines that will be informed from the implementation findings and it will be delivered in three versions, the initial version that will support the schools that will be involved in the first phase of implementation, the interim version that will be available for the large scale implementation and the final version that will be the main outcome of the project.

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8 Appendix 1

Co-funded by the Horizon 2020
Framework Programme of the European Union

Open
Schools for
Open
Societies

WP2

Open Schooling Model Template

GLOSSARY

Open School Culture: An Open School culture imports external ideas that challenge internal views and beliefs and, in turn, exports its students – and their assets – to the community it serves. Such an engaging environment makes a vital contribution to its community: student projects meet real needs in the community outside of school, they are presented publicly, and draw upon local expertise and experience. The school environment fosters learner independence – and interdependence – through collaboration, mentoring, and through providing opportunities for learners to understand and interrogate their place in the world.

Science Capital: Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job). Science capital is unevenly spread across societal groups.

Responsible Citizenship: Responsible Citizenship views citizenship as a total practice of responsibility between individuals and their political, social, economic and natural environment. It goes beyond formal relationships of rights and duties between the citizen and the state, and stretches the spatial, temporal and material boundaries of citizenship to those of the global economy. Since Responsible Citizenship extends citizenship responsibilities to an expanded notion of equity and caretaking and gives more weight to universal principles of democracy, human rights and global commons, some scholars claim that this new version of citizenship has the potential to challenge and change the underlying structural, root causes that led to environmental and social justice problems in the first place.

Project-Based Learning: Project-Based Learning is the main pedagogical approach of the **Open School Culture**. Whilst teachers will draw distinctions between project, inquiry, and problem based learning, in reality the differences are minor – particularly in comparison to more transmissive, lecture or worksheet-based forms of learning. Great projects grow from inquiries in order to solve problems. Students found them highly engaging because they are conducting work that is meaningful, to them and their families or communities. Learning begins with a problem to be solved, and the problem is posed in such a way that children need to gain new knowledge before they can solve the problem. Rather than seeking a single correct answer, children interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. They relish the opportunity to make adult-world connections, work across disciplines, and in extended blocks of time.

RRI. Responsible Research and Innovation:

Responsible research and innovation is an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation. Key issues that should be taken into account:

- Ethics
- Gender Equality
- Governance
- Open Access
- Public Engagement
- Science Education

Grand Societal Challenges:

Policy priorities of the Europe 2020 strategy address major concerns shared by citizens in Europe and elsewhere:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;

- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

During the first phase of the project we will need to identify approaches and methods used by schools and other educational institutions to open schools to the local communities. We will need to identify the key characteristics of these approaches that could be adopted in the project approach. Partners of OSOS project are bringing to the project significant expertise in the field. In this framework it is important to share with the WP2 team their experiences from the field. Please use the form below to describe the main characteristics of the process that your institution is implementing or describe initiatives (both from formal and informal learning sector) that you are considering that are important to be used as reference in the development of the OSOS open schooling model.

1. Introduction
Provide a general description of your model for opening up the school to the society: Its rationale, its basic concept and focus. Make reference to some examples from the field. Make reference to any relevant national initiatives the approach was/is a part of. Make sure that concepts which particularly tied to local educational policies are properly analyzed. *Furthermore, please provide information on whether the Open Schooling Model makes reference to one or more of the Grand Societal Challenges set by the European Union.*

2. Description (phases, main actors)
Please provide more detailed information of the Open Schooling Model. Which are the main aims and the expected outcomes? Is it used locally or at national level? Is it a national or an international initiative? How long does it take to implement the model as a whole? Does it include phases? Does it adopt a modular approach? Please also discuss the involvement of other actors: parents, museums, enterprises, NGOs, organizations. What is their role and in which way do they cooperate with schools.

3. Tools and Infrastructure
Please provide information on the different tools and infrastructure that are used to support the implementation of the Open Schooling Model. Please refer to community building, professional development (for teachers and school heads) and self-assessment tools for the schools involved. How the school opening is supported by these tools? Are these tools acting as "bridges" with the outside world? *Were they specially designed for this Model?*

4. Implementation
Please refer in detail to the basic phases of your Open School Model. In relation to school education, phases are usually tied with piloting and implementation within academic years. A typical 3-stage model for introducing a new element in education could last for 3 or more academic years, depending on how much it is trying to test or change. *Please also refer to any particular implementation strategies. For example, does your model follow the same path in both Primary and Secondary education or there are different implementation strategies for each type? Are there differences in relation to the type of schools (special education, vocational, academies, independent schools, music schools, art schools, sport schools, etc.)?* *Please provide information in which way the concept of Open School Culture is introduced. In which way Project-Based Learning, the main pedagogical approach of the Open School Culture is used in the participating schools.*

5. RRI approaches used
Does the Open Schooling Model make reference to concrete RRI elements and approaches in schools? *Why were these concepts chosen?* *In which way are they used?* *Is the model supporting the development of the community science capital? Please provide examples.*

6. Results – Evaluation
Please offer a discussion of any type of results that you may have as part of an evaluation of the application of the Open Schooling Model. If there any measurable results, for example indicators demonstrating improvement in particular categories, please offer a detailed analysis of the methods involved.

7. Conclusions and Recommendations
Please provide a general assessment of the Open Schooling Model. In which way is it transferable?