SNAC

School Networks Alert Citizens Protection

Intellectual Output 1
Open Schooling Roadmap

Erasmus+

This project has received funding from the European Union's Erasmus + programme under grant agreement No.2018-1-EL01-KA201-047847

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Abstracts	The SNAC project develops and offers schools an Open Schooling Roadmap as a reference document to follow step by step during the lifetime of the project. The document is translated by the partners in their native language to shed a light for teachers and school heads in their countries. The Open Schooling Roadmap proposes a concrete overview of the implementation of open schooling approaches, offering a clear description of the necessary steps that schools will need to take in order to become hubs of responsible innovation. These hubs should bring together stakeholders, families, professionals from enterprises and civil and wider society with an aim to produce ideas and solutions that address socio-scientific issues and challenges around schools. Additionally, the roadmap focusses on the specific example of seismology education to support the implementation of the project activities as a state-of-the-art approach in the introduction of Responsible Research and Innovation (RRI) in the school settings.
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The SNAC Project

The European Commission and policy makers in each country should encourage each local school, no matter of its size or location, to take ownership of the issues their local society is facing. In order to achieve this, strong and sustainable community connections and actions must be established, enabling families, local stakeholders, businesses and school to bind together and support all forms of formal and informal learning. The whole community engagement is the key and it can be achieved through parental collaboration, curriculum connected to real world experiences and solving local problems. In this aspect, the School Networks Alert Citizens protection (SNAC) project aims to help schools to become open hubs of innovation, education, training and information to their local society. Through SNAC, schools should exploit educational innovation, the tools of discovery learning, technology, teaching natural, humanitarian and social sciences to study and handle local issues.

A SNAC open school will be in constant interaction with the local community and evolving as its equal social partner. This school is following the echo of the problems of the local community and reacts accordingly. It plans and implements projects that increase the science capital of the local society. In our vision students' projects are developing solutions for early warning systems, seismic activity monitoring and civic protection activities. Thus, societal actors interact during engaging with research and innovation process with the clear purpose to align both the process and its outcomes with the values, needs and expectations of European society. Developing awareness of this construct is considered of pivotal importance. Science education through inquiry and project-based learning methodologies are strongly related to the 21st century skills that current students and future citizens need to develop in order to become innovators by co-creation, collaboration and critical thinking.

In this context, the SNAC project aims to:

- transform schools to hubs of innovation and information about seismic activity and civil protection, that develop networks with local citizens and authorities, civilian protection agencies, local business, research and science centres and other local stakeholders;

- propose pedagogical practices based on inquiry-based methods that are more effective in science education;

- offer to teachers and school heads numerous engaging educational activities of STEM in which school students learn, practice and utilize themselves scientific instruments and methods while at the same time they need to communicate the outcomes of their work with the wider public;

- raise the students' awareness on their roles, responsibilities and attitudes as future scientists, researchers, engineers, and foremost citizens;

- promote both teachers' and learners' scientific and digital literacy and highlights aspects of civil protection, citizenship, civil responsibility and transnational cooperation;

- create a dedicated database with an easy to use front-end to enable seismological data collection and presentation from the current and existing network of school seismometers all over Europe;

- map the impact and effectiveness, both quantitatively and qualitatively, at student, teacher and school/institution level;

- guide and support anyone interested in SNAC's results, through a "Recommendations for Future use" Guide, containing show cases, best practices and cases of achievements beyond expectations.

SNAC will develop a network of 100 open school hubs in the participating countries. Each school of the network will be a hub, connected with local stakeholders, researchers and experts, as well as with other schools in the area or in the country. Many school hubs will be equipped with low cost seismometers (e.g. TC1 Seismometer, Raspberry Shake) or home-made devices, developed by the students in the framework of their project work or in the framework of students' contests, initiated by the project, which will acquire seismic data and, in very short time, provide this information to the local authorities. The students' projects will be based on the usage of the numerous data these low cost devices will acquire while the data from all schools will be available to larger audience through the dedicated project database.

Executive summary

School Networks Alert Citizens protection (SNAC) is a European Union project funded by the Erasmus Plus Program through the National Erasmus Agency of Greece under the grant agreement No.2018-1-EL01-KA201-047847.

The first intellectual output of the project is the "Open Schooling Roadmap". The Open Schooling Roadmap offers a clear description of the necessary steps that schools will need to take in order to become hubs of responsible innovation that bring together as many stakeholders as possible with an aim to produce ideas and solutions that address local issues and challenges. Additionally, it focuses on the specific example of seismology education to support the implementation of the project activities as a state-of-the-art approach in the introduction of Responsible Research and Innovation (RRI) in the school settings. The Open Schooling Roadmap offers a clear and step-by-step outline of how a SNAC school can embark on the process of opening up to its local community, through the use of RRI-enriched students' projects. The Roadmap should facilitate engaging students in real-life projects that are proposing innovative solutions, adopted to the local conditions by employing real-problem solving skills, dealing with seismic data that the students have acquired themselves, handling and studying situations and participating in meaningful and motivating science inquiry activities on earthquake disaster prevention and mitigation.

The first part of this output focuses on open school approaches. In this part, in addition to the definitions developed by the European Commission, the theoretical framework for open schooling approach is discussed in the light of different articles, project reports and sources in this field.

The second part describes the roadmap to explain the systems that enable a school to take the open schooling approach. The Roadmap includes 6 steps to create open schooling culture:

Step 1: Build an open schooling transformation committee and working groups

Step 2: Organize Professional Development Seminars for School Staff

Step 3: Build effective connections with stakeholders and other innovation hub schools

Step 4: Create a RRI based teaching and learning environment in the school

Step 5: Make assessment for quality check

Step 6: Reflect and share best practices using different media channels

In the last section, results, suggestions and future steps are discussed.

Project Glossary

Inquiry: Scientific inquiry is defined as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (*National Research Council*, 1996, p. 23). According to Bybee (1997), inquiry constitutes the heart of science as a discipline, and true scientific literacy cannot be achieved without employing inquiry skills. Although scientific inquiry has become very important for scientists and educators since 1960s, there is still not a definite consensus about a definition of inquiry-based learning in science education literature. Recently, different science educators define inquiry-based learning in terms and in combination of the following: "formulating questions" (Keys & Bryan, 2001; Zee, Iwasyk, Kurose, Simpson & Wild, 2001), "designing experiments" (Shimoda, White, & Fredericksen, 2001; Yerrick, 2000), "predicting outcome" (Songer, Lee & Kam, 2002), "gathering resource and data"(Byers & Fitzgerald, 2002), "analyzing data" (Donaldson & Odom, 2001), "transforming knowledge" (Bybee, 1997; Hamm & Adams, 2002), "hands on, minds on activities" (Crawford, 2000; Gibson & Chase, 2002), "communicating scientific arguments" (Bybee, 1997), "process of discovery" (Schwab, 1964), "making decisions about actions" (Hmelo-Silver & Nagarajan, 2001) and "authentic scientific practice" (Cartier & Stewart, 2000; Edelson, 2001) (cited in Atar, 2007).

Inquiry begins with gathering information through the use of human senses - seeing, hearing, touching, tasting, and smelling. Inquiry supports and encourages learner to question, conduct research, and make discoveries on their own experiences. The practice transforms the teacher into a learner with pupils, and pupils become teachers with us. Anderson (2002) states that inquiry is a good combination of learning, teaching, and doing science in a classroom and all components are interrelated with each other (Ark of Inquiry, 2018).

Open Schooling: Institutions that promote partnerships with families and the local community with a view to engage them in the teaching and learning processes but also to promote education as part of the local community development. We consider as an “open schooling” environment where (a) Schools, in cooperation with other stakeholders, become agents of community well-being, (b) Families are encouraged to become real partners in school life and activities, (c) Professionals from enterprise, civil and wider society are actively involved in bringing real-life projects into the classroom. Open Educational Resources provide a strategic opportunity to improve the quality of education as well as facilitate the policy dialogue, knowledge sharing and capacity building. Open Educational Resources are teaching, learning or research materials that are in the public domain or released with an intellectual property license that allows for free use, adaptation, and distribution (Sisnetwork, 2016).

Open School Culture: 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: students' 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 (Sotiriou et al., 2017).

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 organized: its structure, culture, and the use of space, place, and time. An Open Schooling Hub will be an open, inquiring, 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 the 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 (Sotiriou et al., 2017).

Open Schooling Roadmap: The consortium develops the Open Schooling Roadmap to support schools to reflect on, plan and undertake changes in education for 21st Century learning. Applying such an approach in local settings will clarify 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 closed cross-institutional collaboration, and organizational change in the field of science education. The whole process is described analytically and systematically in the "Open Schooling Roadmap" document that is one of the main deliverables of the project. This document is the first step in a journey of an educational reform that might take many years. 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 (Sotiriou et al., 2017).

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.

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, 2005).

Responsible Research and Innovation (RRI): The concept is explained by the European Commission (2014) as follows: "Responsible Research and Innovation (RRI) means that societal actors 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." Pupils who have an early opportunity to interact with a broad audience of stakeholders will be better prepared later as citizens to debate and think about scientific issues with an open and critical mind considering what have been mentioned as typical RRI aspects such as the global and sustainable impact of research findings and innovations in which positive and negative consequences are balanced, societal relevance, and the importance of participatory design and co-creation with end users (Sutcliffe, 2011).

Stakeholder: According to the Glossary of the Education Reform (2019), the term stakeholder in education typically refers to anyone who invested in the welfare and success of a school and its students, including administrators, teachers, staff members, students, parents, families, community members, local business leaders, and elected officials such as school board members, city councilors, and state representatives. Stakeholders may also be collective entities, such as local businesses, organizations, advocacy groups, committees, media outlets, and cultural institutions, in addition to organizations that represent specific groups, such as teachers' unions, parent-teacher organizations, and associations representing superintendents, principals, school boards, or teachers in specific academic disciplines. In a word, stakeholders have a "stake" in the school and its students, meaning that they have personal, professional, civic, or financial interest or concern.

1. THE OPEN SCHOOL ENVIRONMENT: THEORETICAL FRAMEWORK

In many reports published by the European Union, there are dramatic decreases in students' knowledge and skills related to science, technology and innovation. Many studies show that traditional teaching methods are not useful in teaching STEM (Science Technology Engineering Mathematic) courses; they affect students' interests and motivations in a negative way and, as a result, many students drop out from their schools.

The studies in the field of science education provide results indicating that citizens believe that innovations in science and technology can lead to urgent solutions for environmental, health and basic infrastructure problems (Sjøberg & Schreiner, 2010). The report on the "Maximizing the impact of EU Research & Innovation Programmes" published by the European Union recommends 11 key actions. Three of them are connected with the educational sector and are vital for the future of EU's Research and Innovation:

#3. Educate for the future and invest in people who will make the change.

Action: modernise, reward and resource the education and training of people for a creative and innovative Europe.

#8. Mobilise and involve citizens.

Action: stimulate co-design and co-creation through citizen involvement.

#11. Capture and better communicate impact.

Action: brand EU research and innovation and ensure wide communication of its results and impacts.

1.1. Educating European citizen for the future

Lamy (2017) indicates that Europe can have the most impressive talent pool on Earth, but it will fail to capitalise on this if the education system does not foster a more innovative and risk-friendly culture. Excellent research and innovation cannot be realized without excellent educational system. A fundamental reform of the role of education should systematically embed innovation and entrepreneurship in education across Europe, starting from the early stage school curricula. Schools should foster a culture that boosts self-confidence and provide to society environment that allows new ways to continue life-long-learning. In the future, everybody in society should be stimulated to be creative, from children to elderly, from employees to employers, from civil servants to start-ups (Lamy, 2017).

1.2. Mobilizing and involving stakeholders to science, technology and innovation

Adapting of the stakeholders in the broad perspective to scientific and technological research environments and to educational system will not only lead to a development of innovative ideas and products, but will also provide a change in the society. This will bring open science and open innovation and of course open schools to the next level and turn Europe into a continental living innovation lab (Lamy, 2017). Whenever possible, citizen science should be encouraged and citizens should be providers and users of data, produced by advanced level scientific researches. This will reinforce and give new meaning to the policy of open access to publications and data; this openness should enable citizens and citizen groups to participate in evidence-based policy and decision-making. This could give rise to new types of partnerships, such as "P4P"s or "P4.0s" where "people" are working together with the public and private sector (Lamy, 2017). The meaning of P4.0 is here People 4.0. The usage of new technologies in different sectors and companies such as Uber, the Taxi industry, Airbnb and hotel businesses have changed the way of people's habit. People 4.0 concept is directly related to these technologies. In SNAC project, it is aimed that stakeholders (people) and school staff will contribute to the teaching and learning environments using the new learning technologies such as web platform that was created by the OSOS project. This will help and support schools to transform into innovation hubs, where stakeholders and school staff work together to find alternative solutions for the problems in society.

1.3. Establishing capacity

The success and sustainability of the innovation in science and technology transformation depend mainly on the stakeholders' participation and contribution. The supporting community to any innovation process should be able to motivate and engage the citizens with appropriate challenges to attend and to give reactions and reflections when needed. The creation of new partnerships in local communities improves science education for all citizens. It is expected that in the short term the development of partnerships between schools, local communities and local industry should contribute to a more scientifically interested and literate society and students with a better awareness of and interest in scientific careers. In the medium term the activities should provide citizens and future researchers with the tools and skills to make informed decisions and choices and in the long-term this action should contribute towards the ERA objectives of increasing the numbers of scientists and researchers in Europe (H2020).

As a result of the reflections mentioned above, collaboration between formal, non-formal and informal education providers, enterprises and civil society should be 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 (H2020).

In order for this process to turn into a meaningful action, not only school and school staff but also citizens working in different sectors need to come together and cooperate in the school environment. This situation brings to education field a new concept: Open Schooling.

According to Horizon 2020 Framework programme, Open schooling, where schools, in cooperation with other stakeholders, become agents of the community's well-being shall be promoted; families shall be encouraged to become real partners in school life and activities; professionals from enterprises and civil and wider society should actively be involved in bringing real-life projects to the classroom (Horizon 2020).

Current 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. An open school that effectively introduces innovations in science education is an engaging environment not only for the students and teachers. Progressively it brings families, community groups, local businesses, international experts, universities, and other stakeholders into what we term an "Open School".

These initiative aim at transforming schools into open school premises and spaces serving the society –and vice-versa - society becomes an important partner that supports the schools (UNICEF, 2015).

1.4. Open Schooling Concept

The pedagogical framework of SNAC is based on two main pillars, the former is school openness to local communities and to society in general, the latter is project and inquiry-based methodology of teaching and learning. Both are essential elements of the open schooling concept as developed in the "Open School for Open Societies" (OSOS) EU funded project (http://www.openschools.eu). The OSOS project aims to develop an open schooling model to introduce and test it with 1000 schools across Europe. Although its focus is on science education, a similar approach can be accordingly adopted in SNAC with focus on earthquake study by seismometers installed in schools, civic protection, public awareness etc. It is in our plan and strategy to closely collaborate with OSOS - on one hand to capitalize on its outcomes, experiences and findings, and on the other hand - to utilize tools and concepts (e.g. community support platform, authoring tool), which were developed and successfully deployed during its implementation. The initial goal is to start developing a first community of practice than can be further developed and established with the support of the project partners with the long-term aim of self-sustainability (Mavromanolakis and Sotiriou, 2018).

1.5. Characteristics of an open school

In the context of SNAC, we define an open school which adopts the following main characteristics (Sotiriou, S., et al. 2017):

- Welcomes, encourages and promotes collaboration with non-formal and informal education providers, initiatives, parents and local communities to ensure engagement of all societal actors with focus on earthquake awareness and protection. In this respect, the school entity is not considered as an isolated self-contained closed system but as an active core component, to some extent autonomous and dynamic, in active interaction with the activities of out-of-school stakeholders.
- Becomes an agent or central point of community well-being. SNAC aims to support schools, teachers and their students to develop educational projects that are proposing solutions to the needs and challenges of their local communities emphasizing the fact that well-being is equivalent to living safely in general, with earthquake precaution measures being a particular vital element of it. The main approach will be to challenge and encourage students to explore themselves the notion of well-being by identifying and expressing what matters to them, what bothers them, what they can change or influence, how they can contribute or serve. In this process, not only they feel engaged and empowered but also, they develop and foster their attitude of responsible citizenship for the years to come.
- Promotes collaboration and partnership that foster expertise, networking, sharing and applying knowledge, research/survey findings that bring real-life problems or challenges related projects to the classroom. The project partners in SNAC, individually or collaboratively, have been developing and promoting innovative educational applications and approaches for schools for many years. Within SNAC, cross-sharing and co-creation will be enhanced and facilitated thus, further supporting the development of the 21st century competences through creative problem solving, discovery, learning by doing, experiential learning, critical thinking and creativity.
- Focuses on or promotes effective parental engagement. This characteristic builds on the general notion of knowledge capital of schools' communities and its two-way transfer, exchange and diffusion. In other words, knowledge or awareness acquired by students' projects developed in school is transferred to parents and on the other way around - parents' experience and expertise is engaged to influence effective change.

It is natural to expect that the schools, which express interest in participating in SNAC may not have developed these characteristics at the same level. Thus, SNAC proposes a roadmap as described in detail in this document in chapter 2 and teacher training programmes, which are the focus of Intellectual Output 2 and that will be offered as

practical guidance or support mechanisms and scaffolds to nurture the incubation of a change cycle for schools and teachers to facilitate the process in acquiring or developing the abovementioned characteristics.

1.6. Effective teaching and learning (project-based, inquiry-based pedagogy)

The main pedagogical approach adopted by SNAC is project-based teaching and learning along with inquiry-based methodology for STEM learning. One may draw distinctions between project, inquiry or problem-based learning, however in reality the differences are minor, and all have proven their efficacy in comparison to traditional lecture and worksheet-based forms of teaching and 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. The whole process gives students the opportunity to connect to real-life/real-world challenges, work across disciplines, learn to function and collaborate in teams, communicate their findings and solutions and to engage with their peers, experts and communities.

In the following section we discuss in detail the four-step process of Feel-Imagine-Create-Share as was first developed by the Design for Change movement and has been accordingly adapted by the OSOS project. This is the main process that SNAC proposes to teachers and students to follow in order to develop their projects. In addition to that, and for completeness, a generic inquiry-based model, based on five phases (Orientation, Conceptualization, Investigation, Conclusion and Discussion), that may be useful to follow in case of more STEM related educational activities or projects, will be presented also.

1.7. Feel-Imagine-Create-Share

Design for Change (https://www.dfcworld.com), in short DFC, is a global movement that aims to empower students and youth to say "I CAN" and inspire others by telling their own stories of change. The programme has introduced its unique curriculum in over 30 countries worldwide and promoted a design process as a way of encouraging students to create and develop solutions in their communities and to put into practice their own ideas to change the world starting from their own environment. The main concept is that 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 of all ages.

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 children learn while acting on real needs in order to improve it. 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.

DFC curriculum has greatly simplified design thinking principles for children, which led to widespread uptake. The framework of FEEL, IMAGINE, DO and SHARE builds empathy in children and engages them 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 are significant for them. Children become change makers. Teachers are able to experience the capabilities of their own children as they listen to their voices and ideas. The first step of DFC especially gets children to empathize and engage with a problem to imagine a solution and to act of change. Through sharing their story, students can inform the general public and inspire others to become change-makers as well.

As part of the DFC programme, 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 can work with all societal actors: with both private and government-run schools as well as NGOs that operate in rural or more remote areas. The program is free for schools and it runs independently at a country-level. While sponsors can contribute with 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. These are usually local activities that involve schools and community social stakeholders such as municipalities, non-governmental organizations, 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 to improve the situation.

As already mentioned, the development of strong communities of practice around the school-lead projects along with project-based pedagogical methods are the crucial elements for OSOS, focusing on science education, and for SNAC, focusing on earthquake awareness and citizens alert. In this context, OSOS adopted and adapted in the DFC process (see Figure 1) in guiding schools, teachers and students to develop their projects as follows (Sotiriou, S., et al. 2017):

- **Feel:** Students identify problems or challenges in their local communities. They can also select topics related to global challenges that may affect their communities in the future. Students observe problems and try to engage with

those who are affected, discuss their thoughts and ideas of solution 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 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.

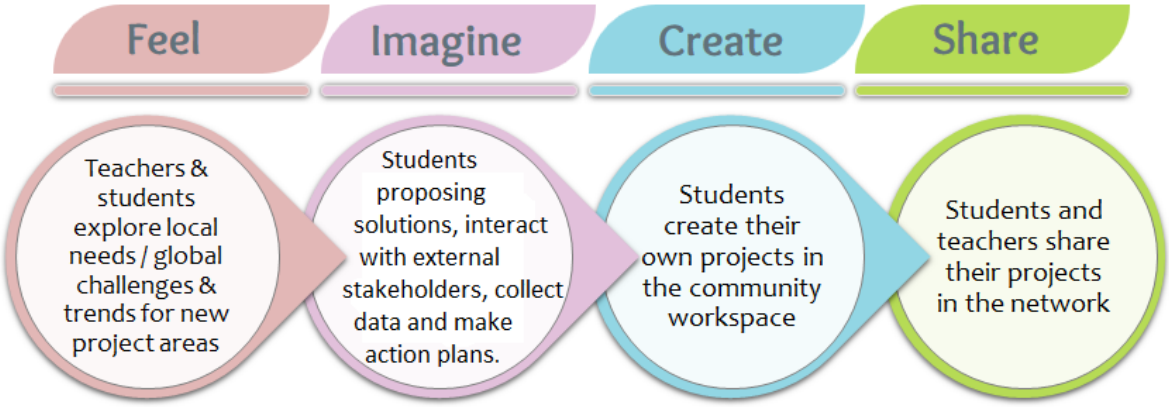

Figure 1. The four-step process of the DFC Model (based on the DFC model).

SNAC plans to utilize the OSOS community platform to offer students opportunity to develop their projects using this simple four-step process. OSOS has already developed and offered advanced community support and authoring tools for content creation by students and teachers following this four-step process. The aim is to help and enable teachers to become creators of educational activities, which will reflect on the real educational needs of their classrooms as well as will provide solutions to their local communities. Teachers will be able to adopt existing content, enrich it with numerous resources and tools in order to provide integrated solutions. SNAC fully embraces a similar approach which will be utilized and offered in its technical platform, training programme and educational activities.

1.8. RRI in the Framework of Open Schooling Approach

One of the main goals of the European Commission is to strengthen the relationship between science and society. On one hand, a robust effect science has on society can be mainly traced in the technological innovations and the associated improvements in our healthcare system and lifestyle. Of course, some of these innovations can negatively affect or be negatively received by society. An example of the latter relates

to the development of the golden rice which is a genetically modified plant created to overcome food shortage issues but met strong oppositions from anti-GMO movements. On the other hand, society distributes its economic resources on specific research and innovations which are considered to be beneficial and of essence for its citizens and overall function of society.

European Commission (EC) identified seven main challenges (connected with climate, energy, health, food, transport, inclusive and secure societies) our society faces. The contribution of science is vital for tackling these challenges and the active involvement of society is essential. All these challenges can be better addressed if "all societal actors understand the issues and their consequences and are actively involved in helping identify and monitor society's responses" (European Commission, 2015). Thus, it is not surprising that Responsible Research and Innovation (RRI) is an important priority in the Horizon 2020 programme. Societal actors which can be research institutes, educators, civil protection organizations, policy makers and the general public, can be involved in all stages of research and innovation in varying degrees. The RRI is a framework which aims in aligning the European societies' values, expectations and needs with all the stages of research and innovation governance; from the conceptualization and implementation stage to the outcomes and evaluation.

Therefore, RRI could be defined as "the attitude and ability to reflect on, communicate and discuss processes and outcomes of inquiry in terms of its relevance, consequences and ethics for oneself, others and society" (Ark of Inquiry, 2014). Based on this definition, RRI can be transferred in three main skills: reflection, communication and discussion. The first skill (reflection) concerns someone's' ability to think through the relevance, consequences and ethical issues that research and innovation have on society. The second skill (communication) is the ability to share that reflection with an audience, and the last skill (discussion) concerns someone's ability to discuss the societal relevance, consequences and ethics of processes and outcomes of research and innovation with others.

RRI Dimensions

RRI considers a **governance** approach to science and innovation (overarching dimension) which includes:

- The public **engagement** of a variety of stakeholders from science, industry, NGOs, politics, organizations etc. to dialogues and processes concerning current challenges.
- The **gender equality** and especially the under-representation of women. The results of research and innovation consider all the citizens – societal actors should be represented in a balanced matter.
- **Science education** and its significant role in preparing the citizens of tomorrow by providing them with the right tools and skills.

- **Ethics** for the insurance of high-quality and transparent research and innovation.
- **Open Access** to science. Through RRI, societal actors, who want to have a voice, affect or are being affected, should be called to openly participate in research and innovation processes to better tackle current societal challenges.

Figure 2: The Six Dimensions of the Responsible Research and Innovation (RRI)

1.9. Inquiry-Based Model

Inquiry has been a well-known teaching and learning science education method in many countries for the last decade. However, there is no clear definition about what inquiry entails. Actually, the term “inquiry,” meaning, “search for truth,” appears frequently in writings by philosophers but not so often in the work of social science researchers. The earliest known philosophical writings are thought to have been written around 1500 B.C. Then, as now, philosophers wrestled with questions about the nature of existence, knowledge, morality, reason and purpose or meaning (Michael, 2002). It is clear that there are many contributions from the longstanding dialogue about the nature of learning and teaching, in particular from the work of Jean Piaget, Lev Vygotsky, and David Ausubel (Cavas et al, 2013). Wells (2001) argues that "Inquiry is not a ‘method’ of doing science, history, or any other subject, in which the

obligatory first stage, in a fixed, linear sequence, is that of students formulating random questions to investigate.
Pedaste et al (2015) define the inquiry phases in five distinct phases: Orientation, Conceptualisation, Investigation, Conclusion and Discussion (Figure 3).

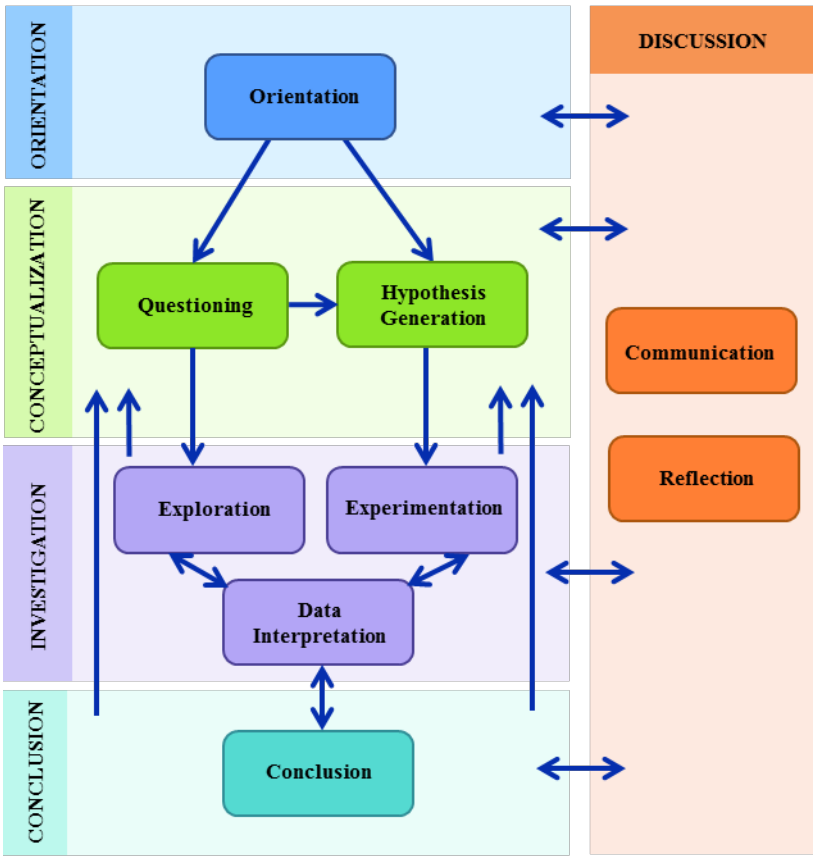

Figure 3. Phases, and sub-phases of Inquiry-based learning and their relations. Excerpted from ''Phases of inquiry-based learning: Definitions and the inquiry cycle'' by Pedaste et al, 2015.

Orientation phase: The main aim of this phase is to stimulate curiosity about a topic and provide pupils with opportunities for defining a problem statement. As a teacher, your main aim is to find issues and topics which are relevant to your pupils.

Conceptualisation phase: This is the phase during which research questions and/or hypotheses are stated. As a teacher, you need to encourage your pupils to define research questions or hypotheses.

Investigation phase: The Investigation phase is based mostly on hands-on activities. It is a process of gathering empirical evidence to answer the research question or verify hypotheses.

Conclusion phase: In this phase, research findings from the Investigation phase are reported and justified by the results of the investigation. As a teacher, your role is to

encourage your pupils to communicate with their peers to present their findings and results of their investigation.

Discussion phase: This phase of inquiry is directly connected to all the other phases. It consists of communicating partial or completed outcomes as well as reflective processes to regulate the learning process (Ark of Inquiry, 2018).

More information concerning inquiry-based learning is provided in the "Intellectual Output 1: Pedagogical Framework" of the "Schools Study Earthquakes" (http://sse-project.eu/).

1.10. Teachers' roles in SNAC

In the literature there is an abundance of proposed guiding principles for teachers who are supporting the vision of open schooling in their everyday practices. In the case of SNAC, we consider more specifically the study of Martinez et al. 2014, which identified six main strategies and pedagogical practices common across the schools committed to adopt an open culture and to offer related learning opportunities to their students. Their analysis found that, in order to prepare students for success in their endeavours, teachers must 1. Empower students as learners, 2. Contextualize knowledge so it is coherent, 3. Connect learning to real world experiences, 4. Extend learning beyond the school, 5. Inspire students by customizing learning experiences and 6. Purposefully incorporate technology to enhance and complement (not automate) learning.

In other words, teachers are constant and persistent mentors rather than solely instructors. The educational approaches and activities they develop and implement in their school environment and beyond offer students plethora of opportunities to understand, collaborate, communicate, plan and organize their own work, solve problems, create ideas, products and services, and use new technologies in their pursuits. In the following we quote and elaborate on each principal role focusing on its relevance to SNAC.

1. Empowering students as learners: Teachers who focus on the open schooling approach see their first responsibility as empowering students as learners. For this reason, they use pedagogical approaches (project-based and inquiry-based learning) that help students become self-directed and responsible learners rather than passive followers. The cornerstone of their main role is helping students develop an understanding of learning as a complex and ongoing process that entails seeking feedback, revising work and regularly reflecting on what one has learned, found and achieved, as well as on the choices and decisions made throughout the learning process.

2. Contextualize knowledge so it is coherent: Teachers are involving students in projects that are relevant to them and to the local communities. Furthermore, teachers

from different disciplines collaborate across multiple subjects to design integrated interdisciplinary learning activities to connect their otherwise separate subject-specific content.

3. Connect learning to real issues and settings: Teachers focus on connecting classroom learning to real-life issues and settings in order to make it more meaningful for students. Teachers explore, develop and exploit opportunities for students to experience workplace conditions, situations and expectations that address or exemplify real world challenges and problem solving.

4. Extend learning beyond the school: In addition to connecting to the real world and real-life challenges, teachers seek ways to extend learning beyond the school in a range of settings. Establishment and development of relationships with local community groups, institutions, organizations and initiatives can offer students access to rich content and additional resources for authentic and contextualized learning experiences.

5. Inspire students by customizing learning experiences: Teachers are intentional in establishing strong relationships with students for the purpose of finding what will engage their interest to pursue their own learning. When and where possible, teachers choose to offer flexible projects to both customize learning and provide inspiration for all students. In this way students feel free and gain confidence in directing their learning to subjects and issues that matter to them.

6. Use technology in service of learning: Teachers selectively and purposefully incorporate technology and online educational resources and tools to enhance and complement teaching and learning, rather than automate or substitute it.

1.11. Tools for Open Schooling

To facilitate the uptake of the open schooling concept among schools and teachers, SNAC plans to utilize existing tools that are already well-developed and implemented with proven efficiency. These are tools that aim to assist community building, educational design and content authoring, self-reflection and assessment support. We describe them in the following sections.

Community building portal

The SNAC project aims to utilize the services offered by the Open Discovery Space (ODS) portal (http://portal.opendiscoveryspace.eu/) which is the 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 5000 European Schools from 20 European Member States. The ODS services were further enhanced and expanded by the Inspiring Science Education (ISE) and Open School for Open Societies (OSOS) European projects, their respective interlinked portals are in

https://portal.opendiscoveryspace.eu/en/ise and in https://portal.opendiscoveryspace.eu/en/osos. The portal offers various features and functionalities for a school and its teachers to create and manage communities, share resources, create and edit student projects. Namely one can a. create profile, b. create community, c. create modules inside community, d. join community, e. manage community, f. share resources in community. The portal offers also an integrated authoring tool with which one can create, edit and publish students' projects. For each of these functionalities there already exist detailed manuals which are online and publicly available at http://portal.opendiscoveryspace.eu/en/training-academies.

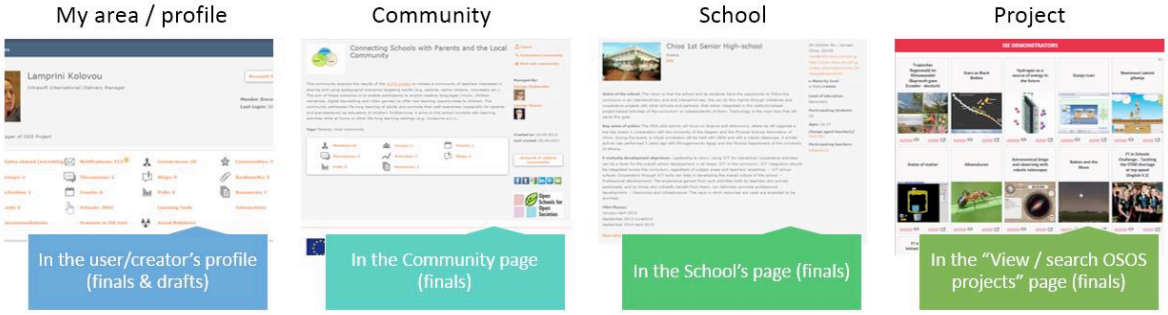

Figure 4: Snapshots of different areas in the portal where are located the educational projects that a user or other members have created and shared.

Educational design and authoring tool

One of the main objectives of the SNAC project is to realize effective teaching and learning by providing students with opportunities to independently and collaboratively explore and acquire knowledge. Students can apply what is learned to different contexts, in order to demonstrate that the learning outcomes have been achieved. Developing effective educational design requires careful planning and structured thinking in order to maximize students' potential for success. Students learn best when they are actively engaged: when they interact with their peers, teachers and educational resources, when they are reflective and have opportunities to apply this knowledge. Successful design therefore needs to ensure that students are given opportunities to take an active, interactive and reflective role in their studies. The portal provides teachers with a set of functionalities and integrated well-structured tool that allow them to easily become developers of educational activities. The tool encompasses two different authoring environments: one for teachers and another for students.

In the teachers' environment, each community member, i.e. teacher or in general educator will be able to personalize existing online resources and share them with other community members. The process they have to follow is guided by a flow of steps as depicted in Figure 5.

Figure 5: Process to follow for authoring a new project by the teachers.

The process consists of seven distinct steps which are as follows: 1. Visit/enter portal, 2. Select a school, 3. Visit a community, 4. Select to create a new project, 5. Enter basic information, 6. Edit guidelines to each phase, 7. Share the final link with the students. The following figure depicts the editor frame where a teacher can edit the guidelines for the students for each phase of the project.

After completing the process of creating a new project, for efficiency and convenience there are several locations in the portal where the teacher can find it, depending on its status as “draft” or “final”. The draft projects are presented only under the profile of the creator, the final ones are located simultaneously in multiple pages, namely, under the profile page of the user, under the projects page of the community where the project was created, in the page of the school of which the teacher is registered in the portal and in the overall page of the portal where all the final projects are presented. In this way educational projects can be easily shared, searched-for and found at multiple levels.

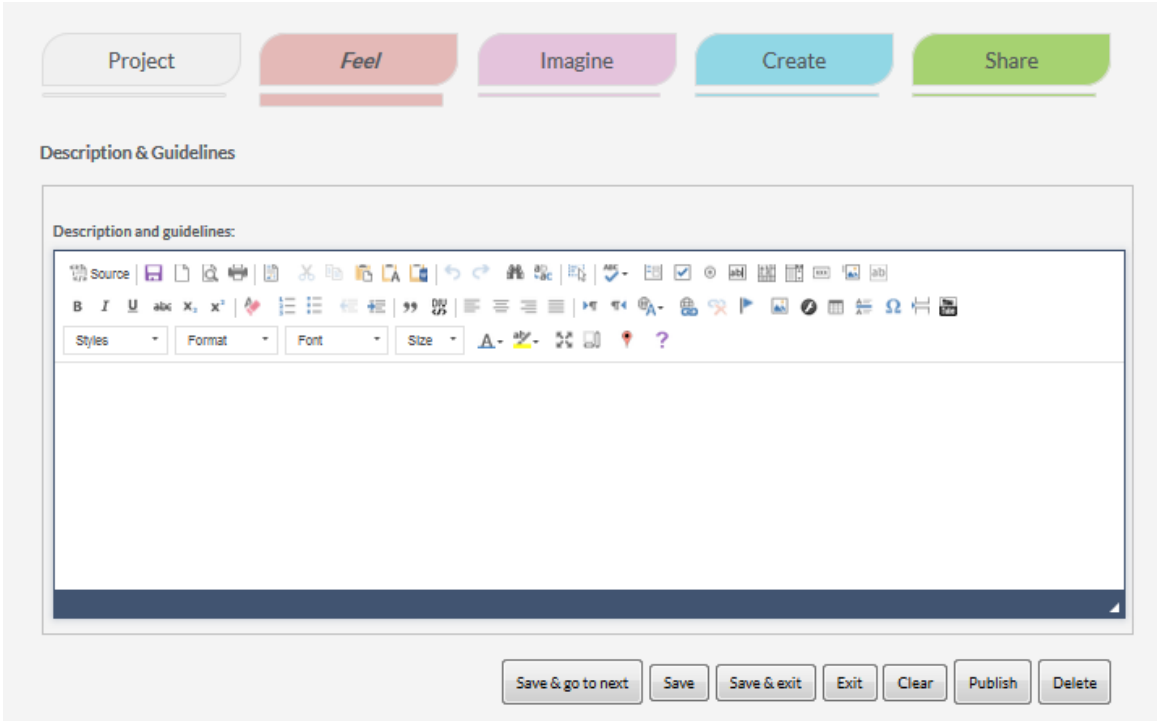

Figure 6: Authoring environment for teachers, editing the guidelines for the students for each phase of the educational project.

Utilizing the common project link that teacher has created, students with anonymous nicknames and access code generated only by the teacher will also be creators of projects and educational activities which will reflect on their real educational needs of their classrooms as well as providing solutions to their local communities. Students will identify community problems (Feel), envision and develop creative solutions that can be replicated easily (Imagine), implement the project (Create) and finally share their stories with other schools in the community (Share), therefore following the four-step process of the DFC model we adopted and described in previous sections (see 1.7 and relevant figure therein).

Figure 7: Process to follow for authoring a new project by the students.

The aforementioned tools aim for community building and support, for educational design and authoring, delivering and sharing of educational content. They will facilitate the spread of the open school concept and RRI principles as approached by SNAC throughout every school network. A complementary tool provided by OSOS is also considered that will assist schools, teachers and students to assess and reflect on their practices and provide guidance for future actions. This is the so-called OSOS Self-Reflection tool which will be described in the following.

OSOS Open School Development Plan

This tool can be used at the beginning of your efforts of integrating the open-schooling framework. It consists of three main parts (1. School details, 2. Insight – Where are we now, 3. Vision – Where do we want to go) which include open-ended questions to help you create and present to the school staff a clear picture of the school's current status and future goals regarding this innovation process. This tool can help schools develop and commit to a specific vision and strategy to become an Open School and also facilitate the periodic school self-assessment (Sotiriou et al., 2018).

It is noted that the term "OSOS accelerator(s)" used in this document, refers to innovative activities which focus on social responsibility or connect different activities into interdisciplinary learning scenarios. The SSE and SNAC projects are considered to be accelerators. Other examples of accelerators are available in the OSOS portal: https://portal.opendiscoveryspace.eu/en/osos/accelerators.

OSOS Self-Reflection Tool for Schools and Teachers

The self-reflection tool was introduced in OSOS in order to measure the organizational change of each school based on three levels, the management level, the process level,

the teacher professional development level (Sotiriou et al. 2018). Each level includes 8 aspects, as shown Table 1, that cover in each level relevant issues like leadership and vision, processes and how they are implemented as well as the school staff competences and how they are included in the strategy of each school. The aspects include also RRI characteristics that the school needs to integrate in its structure and development plan. In more detail, the management level refers to the school management. It describes how the school works or should work following the specific strategies, setting goals, developing a common vision, monitoring the overall process, introducing reflective procedures and adopting the strategy based on the feedback received, as well as managing the resources available. The process level refers to the processes and the activities that the school is implementing in the framework of the project and beyond. In this level the school is assessed on whether is using the proposed pedagogical methods and the community building tools offered by the project. The outcomes of the assessment here also inform the project team on how to develop services that could facilitate the school transformation process more effectively. The teacher professional development level refers to the opportunities for professional development that the school as an organization is offering. The project team examines if these professional development activities are focused and systematic, if innovative approaches are used, if the school is taking advantage of external opportunities like the ERASMUS+ and eTwinning programmes to secure funding, if the knowledge gained through these activities is shared among the members of the school community and if the school has established mechanisms to assess the impact of these activities to everyday teaching.

Table 1: Organizational Change Levels

	Management Level	**Process Level**	**Teacher Professional Development Level**
1	Vision and Strategy	School Leaders and Teachers Shaping Learning Systems	Teacher Awareness and Participation
2	Coherence of Policies	Creating an inclusive environment	Setting Expectations
3	Shared Vision and Understanding	Collaborative environments and tools (co-creation, sharing)	Professional Culture
4	Education as a Learning System	Implementing Projects	Professional Competences, Capacity Building and Autonomy
5	Responsible Research, Reflective Practice and Inquiry	Parents and external stakeholders' involvement in school's activities/projects	Leadership Competence
6	Motivation Mechanisms	Reflect, Monitor, Debate	Collaborative learning (mobility actions)
7	Plans for Staff Competences	Learning Processes adaptation	Collaborative learning (ICT Competences)
8	Communication and Feedback Mechanism	Established collaboration with local, national institutions	Use and reuse of resources

For each one of the 8 aspects in each level the school has to choose one statement that correspond to the actual situation at the time. Each statement corresponds to a school typology of enabled, consistent, integrated or advanced as described in Table 2 and show the school's readiness to adapt an open schooling culture.

Table 2: School Typology

ENABLED	CONSISTENT	INTEGRATED	ADVANCED
Schools that are at an initial stage of incorporating educational innovation in the classroom and beyond	Schools that have achieved a certain level of innovation and openness through specific measures, educational ICT tools, best practices, but they still consist of isolated cases without a network of other schools and external partners to facilitate the process	Schools that have achieved a high degree of innovation and openness and they have already established cooperation with community stakeholders and other external partners	Schools that are considered rather extreme cases of schools that offer a glimpse to the open school of the future

The school representative through the OSOS portal, will have access to the OSOS Self Reflection Tool (Figure 8) and will fill in each of the statements that correspond to the school's status.

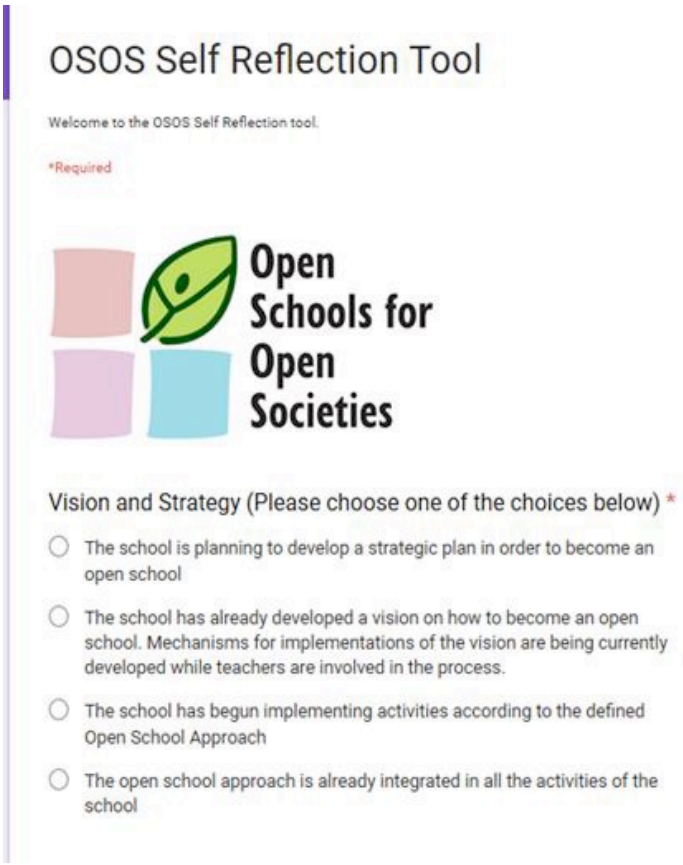

Figure 8: Highlight from the online entry page of the OSOS Self-Reflection Tool.

After the completion of each of the required section, the school will get a report that will include the answers in each one of the sections as well as the results of the reflection about the status in relation to its openness along with proposed guidelines for further advancement.

Instruments or questionnaires for complementing assessment

SNAC encompasses an approach that is based on the open schooling model and the RRI principles with the aim that these will be adopted by schools and teachers for providing effective teaching and learning to their students. In this context SNAC will develop and document an evaluation methodology in order to assess to what level this is achieved by the end of the project. This is the scope of Intellectual Output 4, entitled "Evaluation methodology and analysis of results". Herein we discuss briefly already existing assessment instruments that the project may consider adopting and adapting accordingly for assessing various aspects of students' behaviors and attitudes in the course of the project. These include aspects such as motivation towards science, motivation towards learning in general, and cognitive load (for more details and references therein see Sotiriou et al. 2018). This may complement or support the evaluation methodology of SNAC with respect to content or concept knowledge and attitude change.

Science Motivation Questionnaire: it consists of the following five factors, indicating the strength of the main motivational component that influence self-regulated learning. Factor 1: intrinsic motivation; Factor 2: self-efficacy; Factor 3: self-determination; Factor 4: career motivation; Factor 5: grade motivation. In the context of SNAC this survey may investigate: to what extent specific activities influence the students' science motivation, could the motivation to learn science be raised, are there gender differences.

Intrinsic Motivation Inventory: it is a general and multidimensional survey, complementary to the above focusing on whether and to what extent a specific educational activity or approach influence the students' general motivation towards learning.

Level of Cognitive Load: this rating scale measures students' perceived difficulty before and after an implementation of an educational activity. Students must report themselves the amount of mental effort they invested in the intervention, therefore they are asked to estimate their perceived difficulty of the individual items immediately after they had finished or completed a task. The rating scale has to be provided, explained, and illustrated just before the beginning of an educational activity. The results of this survey may be examined whether they are correlated or influenced by the students' motivation as assessed with the above instruments.

2. SNAC ROADMAP FOR SCHOOL INNOVATION

2.1. Defining the Roadmap

Innovation can be simply defined as a "new idea, creative thoughts, new imaginations in form of device or method". Such innovation takes place through the provision of more-effective products, processes, services, technologies, or business models that are made available to markets, governments and society (Wikipedia, 2018). It is difficult and demanding process to bring innovation to such environments. Nevertheless, innovation is crucial to the continuing success of any organization.

The introduction of innovations in schools, especially the internalization of the open schooling approach in the school environment requires systematic planning and implementation processes.

SNAC project, built on the concept of Open Schooling, aims to perform an extended proof of concept experiment to:

a) transform schools in South Eastern Mediterranean countries into local hubs of education, innovation and information about earthquakes and disaster prevention, connecting them with local authorities, local civilian protection agencies, local business, research and science centres and other local stakeholders in the process and

b) engage students in real-life projects that propose innovative solutions adopted to the local conditions by employing real problem-solving skills, handling and studying situations, and participating in meaningful and motivating science inquiry activities on earthquake disaster prevention and mitigation.

The objective of this combination is, on one hand to increase children's and students' interest in science and how it affects everyday life and, on the other, to stimulate teachers' motivation on up-taking innovative teaching methods, subjects and practices to enrich and renew the science curriculum. The SNAC project also provides increased opportunities for cooperation and collaboration between schools across different areas and countries and encourage relationships between stakeholders of both formal and informal education. Teachers are key players in the renewal of science education and being part of a network allows them to improve the quality of their teaching and supports their motivation. Networks can be used as an effective component of teachers' professional development, can be complementary to more traditional forms of in-service teacher training and stimulate morale and motivation which then is passed to learners and has long-term implications for the individuals and for the society.

In this framework the proposed project promotes open education and innovation in schools and their communities. It also promotes the development of key competences for students who are developing projects and activities serving their communities and presents innovative whole-school approaches, which are supporting teachers'

professional development through collaboration, networking and good practice exchanges.

In order to reach objectives, defined in the SNAC project, a specific roadmap has been prepared to bring innovation to the participating schools. The roadmap includes six steps which school staff can follow to realize “open schooling” innovation.

Figure 9 presents a roadmap model in order to create open schooling culture. The six steps are defined as:

Step 1: Build an open schooling transformation committee and working groups

Step 2: Organize Professional Development Seminars for school staff

Step 3: Build effective connections with stakeholders and other innovation hub schools

Step 4: Create an RRI based teaching and learning environment in the school

Step 5: Make assessment for quality check

Step 6: Reflect and share best practices using different media channels

These steps were developed to explain the ways that teachers can develop an open schooling culture in their school. Many of these steps are directly connected to each other. For example, the creation of the school transformation group and sub-groups is directly connected with all activities at the school. As an example, the Professional Development Seminars working group, developed in step 1, will arrange and organize the respective seminars.

Since each step will affect one or more of the others positively or negatively, it is very important to establish a high level of cooperation among the school staff. For this reason, the school transformation group needs to demonstrate an effective leadership. If necessary, this group should be able to recruit relevant stakeholders to the group as consultants.

The following section describes each step in the focus of the SNAC project.

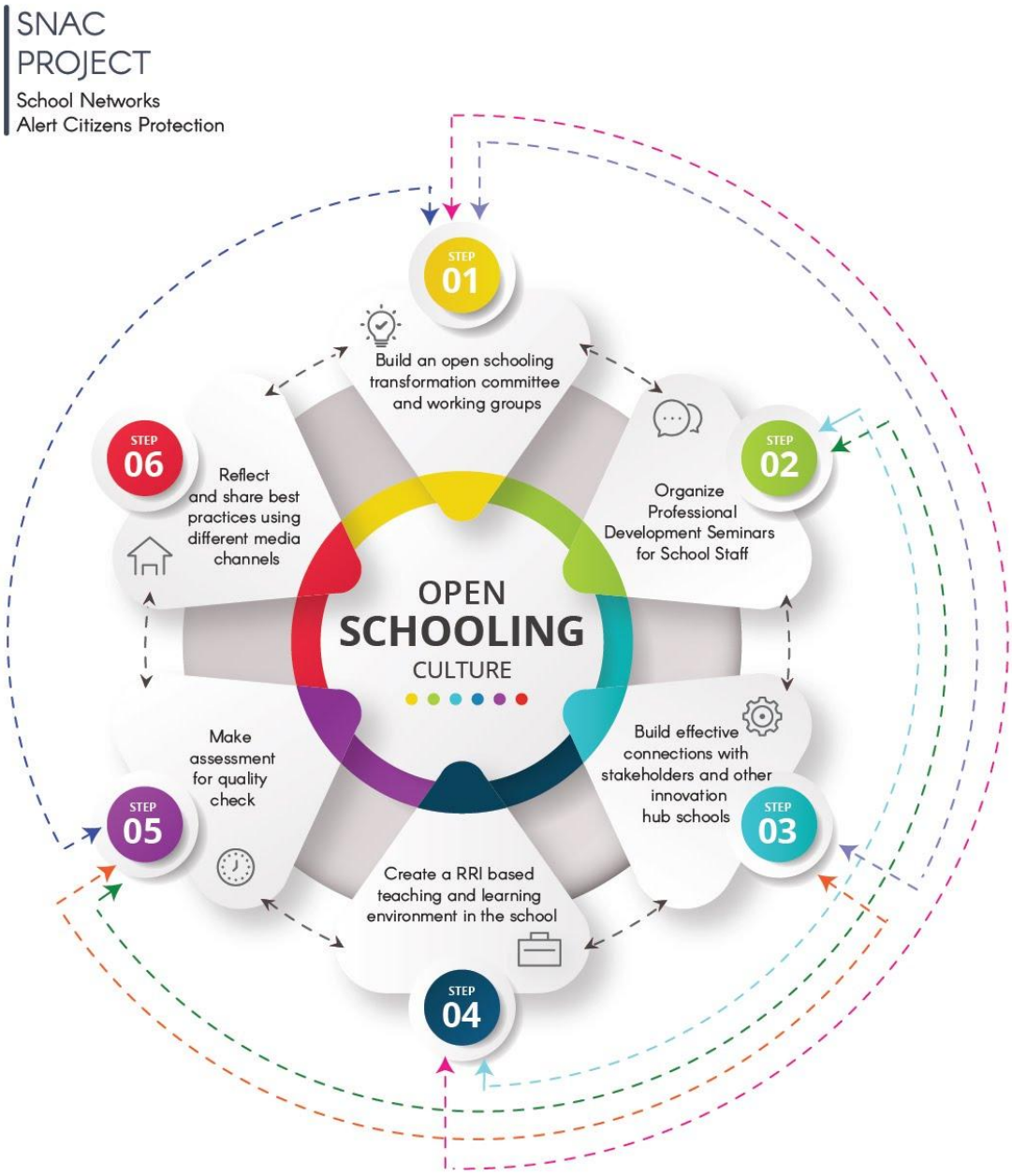

Figure 9. SNAC Project - Open Schooling Model (developed by Bulent Cavas).

Step 1: Build an open schooling transformation committee and working groups

One of the important challenges to bring an open schooling approach to the school environment is the need to set up an open schooling transformation committee at the school. This committee will be authorized to take decisions to implement the open schooling approach in the school.

In particular, the school principal or one of the deputy principals should chair this committee. At least three STEM teachers (recommended, not necessarily) should be

included in this committee, since SNAC is a STEM related project. The committee must meet at least twice a month to check the extent to which the open schooling approach is progressing at school. Alternative solution suggestions should be discussed and implemented for the problems during the implementation process.

Since it is a school development project, so, all school staff should understand the open schooling approach. For that reason, an introductory meeting for the school staff is needed to introduce them to this innovative process.

The introduction meeting should include:

- Open schooling approach
- Key elements of open schooling
- A new teaching and learning environment based on RRI
- Teachers professional development
- Collaboration with stakeholders
- School assessment

This intellectual output can be used as a guide for the items above. For example, the detailed information about the Open Schooling Approach is available in the first chapter. Information regarding RRI and RRI-based teaching and learning environments are provided in chapter 1 and step 4. OSOS Open School Development Plan can be used at the beginning of this process to create and present to the school staff a clear picture of the school's current status and future goals regarding the innovation process.

In order to prepare the teachers to be active participants in the development of an open schooling approach Step 2 can provide to the school transformation committee effective ways to organize teachers' professional development seminars for the teachers, with the support of local stakeholders.

In the open schooling approach, maybe the most important thing is to engage different stakeholders' in the process. Step 3 presents how the school committee and related working groups could build effective relationships with stakeholders and how they can encourage their contribution to the school projects, created by students and teachers.

It is very important and necessary to check the progress of open schooling in the school. For that reason, a school assessment is necessary for each semester to see the real outcomes, impacts and gains of open schooling approach. Step 5 presents an approach on how the committee and the related working groups can assess their school.

The committee should start by building smaller working groups within the school committee with different assignments for each:

• ***Open schooling theoretical framework working group:***

This group is responsible for explaining to the whole school staff the theoretical framework of open schooling approach during the school meetings.

• ***Teaching and Learning transformation working group:***

This group is responsible for dissemination of existing RRI-based teaching and learning environments developed by other EU projects. In addition to teaching and learning environment, the working group should encourage students and teachers to create inquiry-based researches using stakeholders' contribution to solve real-life problems (for example: earthquakes and their influence on the buildings).

• ***Professional Development Seminars working group:***

This group is responsible for the necessary trainings that teachers need in order to implement open schooling approach in the school. For that reason, the group can organize the trainings using the effective links between school and stakeholders, thus utilizing the core part of the open schooling approach.

• ***Building Community working group:***

This group is responsible for creating effective links and bridges between schools and stakeholders.

• ***School Assessment working group:***

This group is responsible to assess the open schooling progress using suitable assessment tools.

Step 2: Organize Professional Development Seminars for School Staff

Teaching is a craft profession in which embodied experimental knowledge (Pratte & Rury, 1991, pp.61-63).

In many countries, teachers begin their professional life after 4 years of undergraduate education. It is not possible to provide all the knowledge, skills and experiences that will fulfill the professional needs of teachers within these four years of university education. Teachers learn the knowledge and skills through many specializations during their professional lives. In this process, professional development seminars, provided to teachers, play important roles in effective implementation of innovation processes such as "open schooling" in learning and teaching environments.

The Teaching and Learning International Survey (TALIS) adopts a broad definition of professional development among teachers: "Professional development is defined as

activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher." (OECD, 2009)

OECD (1998) reports the objectives for the professional development of teachers, which can be used when the professional development seminars are organized to:

• enhance individuals' knowledge of a subject in light of the recent advances in the area;

• update individuals' skills, attitudes and approaches in light of the development of new teaching techniques and objectives, new circumstances and new educational research;

• enable individuals to apply changes made to curricula or other aspects of teaching practice;

• enable schools to develop and apply new strategies concerning the curricula and other aspects of teaching practice;

• exchange information and expertise among teachers and others, e.g. academics, companies; and

• help weaker teachers become more effective.

In order to implement open schooling approach efficiently to the school environment, it is necessary to arrange and organize professional development seminars for teachers. The professional development seminars should include training, practice and feedback, and provide adequate time and follow-up support.

The professional development activities can be one of the actions written below:

- Courses/seminars, attended in person

- Online courses/seminars

- Education conferences where teachers and/or researchers present their research or discuss educational issues

- Formal qualification programme (e.g. a degree programme)

- Observation visits to other schools

- Observation visits to business premises, public or non-governmental organizations

- Peer and/or self-observation and coaching as part of a formal school arrangement

- Participation in a network of teachers formed specifically for the professional development of teachers

- Reading professional literature

It is a responsibility of the Professional Development (PD) Seminars working group in the school to arrange and organize the professional development activities indicated

above in order to handle teachers' trainings to implement effective open schooling approach. The group should work with other working groups to organize PD actions.

During the SNAC Project, each partner of the consortium upon completion of the relevant intellectual outputs, guides and handbooks, will organize national preparatory workshops for STEM teachers from the network of the identified schools. In these training events teachers will be introduced to and practice educational scenarios and activities developed by the project. They will also practice and acquire knowledge on using the proposed instruments/sensors and related software tools for data collection, processing and analysis.

Step 3: Build effective connections with stakeholders and other innovation hub schools

The success and sustainability of the innovation process in the school is closely related to the development of stakeholders' community that will allow school administration to change the way of teaching and learning. It is important to build stakeholders' community in the school and engage it to help and support school staff wherever it needs stakeholders' contribution to school activities. These contributions will not only increase the motivation and interest of the students towards courses but will also increase the academic success of the students positively. What is important is the creation of a significant number of communities. It was observed in many applications that a huge number of communities have not worked for various reasons. Nevertheless, increasing the number or volume of communities increases the chances things to move forward – for instance the assessment of a content and its suitability for learning purposes, can best be assessed if the collective opinion of teachers and students is taken (Pavlova, 2017).

Building Community working group is responsible to build effective links with stakeholders'. Involving stakeholders to the teaching and learning environments will allow school staff to take important decisions to improve the quality of the education system in the school. The effective cooperation between school staff and stakeholders can help and support students' learning outcomes and gains.

For the reasons mentioned above, it is recommended that the Building Community working group should implement the Five Stage Stakeholder Engagement Framework (Krick et al, 2005), presented in Figure 10:

Figure 10. Five Stage Stakeholder Engagement Framework by Kricks et al., 2005

This framework includes five stages and three key fields (responsiveness, materiality and completeness). The five stages are described below:

The first stage is called ***"Think Strategically".*** This stage is used to set priorities and strengthen resources to ensure that school staff and stakeholders are working toward the common targets. For that reason, there should be a discussion on which stakeholders will be contacted, which issues will be discussed, and which ways should be used to reach the target strategically. An example is presented to engage stakeholders below:

What stakeholders can you engage?

Researchers – *How do we design a research? / What should our focus be? / How can we collect data? Etc.*

Get researchers involved in students' projects; They can help them get started and feel confident in their ideas and provide feedback and general guidance during all the research stages.

Seismologists – *How do we record seismic data? / How can we locate the epicenter of an earthquake? Etc.*

SNAC is a citizen seismology project and thus, involving seismologists (or scientists in related fields) is important. They can really motivate students and help teachers to navigate through the process of collecting data, analyzing it and actively engage students in these processes.

Civil protection organizations and/or NGO's – *How can we protect ourselves from an earthquake? / how can we inform others? Etc.*

You cannot only approach the concept of earthquakes through the "science lenses" but also through the civil protection perspective. Students can inform their peers, school, community and organizations in their country in various ways (public events, social networks etc.) and can help them tackle this issue effectively.

Other schools – *What seismic data did other schools record? / Can we collaborate to identify the epicenter of an earthquake? / Did other schools of the network record the earthquake? Etc.*

Your school is part of a large school seismic network with a lot of collaboration opportunities, so you do not hesitate to take advantage of them. Share data, good practices, ideas and most importantly - share experiences.

Through the open schooling approach students find meaning and motivation to participate and learn since they embark on tackling real problems that their community encounters outside of school with the vital contribution of local stakeholders.

The second stage is ***"Analyzing and planning".*** This stage includes processes to be followed such as how to analyse and plan how you can reach stakeholders, how school students can get contribution from each other and from stakeholders, and how to organize the time process for effective cooperation in the school environment. The questions below can be used for this stage:

Which stakeholders are affected or affect the problem/issue identified by the students, the processes of the project and/or the outcome? Which stakeholders or citizens of the community (e.g. parents) are interested in the project and wish to be involved?

The third stage is ***"Strengthen Engagement capacities".*** This stage is the most important stage. In particular, it is necessary to find alternative ways to make stakeholders encouraged to contribute effectively. In order to receive their response to an issue, school staff should develop internal skills. These skills should be clarified

in order to set effective communication with stakeholders. For that reason, it is needed to identify in advance the activity/role each stakeholder can partake and explore possible ways on how to convince them about the benefits of their participation for their community.

The fourth stage is ***"Designing the process & Engaging".*** At this stage, one of the most effective ways of engagement should be determined. As school staff, you can design the process to be implemented. Encouraged stakeholders would be ready to offer the necessary contributions in the open schooling environment. This stage requires communication with the identified stakeholders to inform them about the project and the role they can have in it. Find common ground between their expectations and your goals. As you start working on your project, consider the dynamic aspect of your collaboration; as your project starts to take shape, the way you collaborate with stakeholders might change, too. Be ready to make adjustments and explore possible fruitful communication channels that will enhance their engagement. You can collaborate with someone during a certain task or during the entire project. Be open to suggestions and constructive feedback. There are many ways to keep the communication with your partners: field study-visits, skype meetings, phone calls, emails etc.

Final Stage: ***"Act, Review and Report".*** This is the stage where the engagement process is evaluated. At this stage, follow-up planning should be discussed and scheduled with the schools transformation committee. In addition, it is necessary to put forward some results, such as how the relationships among students, teachers and stakeholders were, what the problems were, and which ways of engagement worked best. The experiences, gained by school staff, will contribute to the development of the next cycle more effectively. Make sure that you involve them in some way in the outcomes of your project (e.g. in a conference or by mentioning their organization on your poster) so that they feel like their work and guidance was recognized and appreciated.

The Five Stage Stakeholder Engagement Framework, described above, can help and support school staff to build effective links and communications with stakeholders. For that reason, the related subgroup should plan and arrange necessary tasks to follow the steps defined above.

The most important part of the open schooling approach is the stakeholders' engagement. For that reason, we strongly recommend to the Building Community working group to create a small size stakeholders' community to discuss and share teaching and learning activities including scientific project creation, data collection, observation, lab works etc. in order to better implement the open schooling approach.

In the SNAC project, the participating schools will become open hubs of innovation, education, training and information about civil protection and seismic activity for their local community. A seismic school network has been already established during the

Schools Study Earthquakes (SSE) project which is growing ever since. Thus, the SNAC schools will be part of an already established network and through the new platform developed by the consortium, the communication between schools will be enhanced.

The focus on citizen seismology will facilitate the development of ongoing collaboration with local stakeholders. Schools can also develop networks of collaboration with local citizens and authorities, research and science centers, civilian protection agencies, local businesses and other local stakeholders.

Step 4: Create an RRI-based Teaching and Learning Environment in the school

The importance of including RRI concept in STEM education is lying in the fact that students will gain scientific literacy and skills necessary for a future STEM career. Moreover, students can understand the relation between science, innovation and society, which is essential for making decisions that affect the societies. To better achieve the introduction of RRI principles in STEM education, the design and implementation of learning activities sequences, integrating the inquiry and project-based learning approaches, are needed. A core practice in both learning methodologies, inquiry and project-based, is the discussion dimension. Thus, teachers who wish to include RRI into STEM lessons, must emphasize that in the discussion phase, where students present their results/solutions and can participate in debates with other societal actors, such as researchers, citizens, teachers etc. The focus of the discussion phase might include socio-scientific issues, ethical issues and/or sustainability. Of course, in order to communicate well, students must also reflect on the processes, followed during their work, in relation to the value, relevance, consequences and ethics of their research.

All students are actively engaged in STEM activities in an inclusive learning environment with reflection and communication being integral parts of their projects. Here are some guidelines in relation to RRI on how to identify a problem/ question that will be the "driving force" for your students:

- **Can we deliver what we promised?**

Do we have the right tools to investigate this problem further? Do the students have the skills and competences to understand the problem and related concepts? Can we devote the necessary time into investigating the problem?

- **Ethics:**

Will the project have any consequences and on what/whom? How can they be minimized/maximized? Are all ethical issues addressed (e.g. anonymity of participants in interviews, respect of the environment)?

- **Is there any societal value?**

Is this a real-life problem? Does it concern the school/community/students? Is the expected result/learning outcome going to be useful in helping to resolve the problem?

*Remember the words of Einstein: "**Not everything that can be counted counts. Not everything that counts can be counted".***

- Engagement:

Is this problem something that the students will be interested in? Is it significant for them? The best way to answer these questions is to let your students identify problem(s) and determine how they can tackle them (with your guidance) to ensure maximum involvement and motivation.

In the open schooling environment, teaching and learning should be supported by the project-inquiry based learning. During the last ten years, many European Union projects produced teaching and learning materials for school staff. Below, you can find some project details where your school staff can reach free project-inquiry based teaching and learning materials:

Examples of the EU Supported Projects:

Many framework programs and Erasmus+ projects were supported by European Union to realize the goals defined by the European Commission. The projects (related to science education) explained below are just few examples, funded by European Union. More projects can be found at Horizon 2020 and Erasmus+ web pages.

The name of the project **:** Professional Reflection-Oriented Focus on Inquiry based Learning and Education through Science (PROFILES)

Web address **:** http://www.profiles-project.eu/

The aim **:** The main aim of the PROFILES project is to create innovative learning environments and programmes for the enhancement of teachers' continuous professional development in order to disseminate Inquiry-Based Science Education (IBSE) in more effective ways in science teaching and learning supported by stakeholders from different areas of society.

Contribution to the science education **:** PROFILES type teaching and learning modules for teachers and students, Continuous Professional Development Models for Teachers, Stakeholders Contribution to Science Education

The name of the project **:** Ark of Inquiry

Web address **:** http://www.arkofinquiry.eu/

The aim **:** The Ark of Inquiry project centres around two closely related concepts: Responsible Research and Innovation (RRI) and Inquiry-Based Science Education (IBSE). Ark of Inquiry aims at raising youth awareness to Responsible Research and Innovation (RRI), as well as building a scientifically literate and responsible society through Inquiry-Based Science Education (IBSE).

Contribution to the science education **:** Pedagogical framework for identifying inquiry-based activities that promote pupils' awareness of Responsible Research and Innovation (RRI); RRI-related inquiry-based activities; Making the inquiry-based activities available across Europe through the Ark of Inquiry platform

The name of the project **:** brEaking New Ground In the sciencE Education Realm (ENGINEER)

Web address **:** http://www.engineer-project.eu/

The aim **:** The main aim of the project is to introduce engineering into primary school and museum programmes throughout Europe and inspire the next generation of innovators and problem-solvers.

Contribution to the science education **:** Engineering modules for schools and museums.

The name of the project **:** Open Schools for Open Societies

Web address **:** https://www.openschools.eu/

The aim **:** The Open Schools for Open Societies project (OSOS) provide innovative ways to explore the world: not simply to automate processes but to inspire, to engage, and to connect. It supports the development of innovative and creative projects and other educational activities.

Contribution to the science education **:** Open schooling values and principles for action around curriculum, pedagogy and assessment, Offering guidelines and advice on issues such as staff development, redesigning time and partnerships with relevant organisations (local industries, research organizations, parents associations and policy makers), suggesting a range of possible implementation models from small-scale prototypes through to setting up an “open school within a school” or even designing a new school.

The name of the project **:** Schools Study Earthquakes

Web address **:** http://sse-project.eu

The aim : The main aim of the project is to build a network of schools that study real data, do analysis of real situations and monitor earthquake phenomena in real time using Inquiry Based Science Education in teaching and learning environments

Contribution to the science education: Real time earthquakes data collected from Eastern Mediterranean countries, Inquiry Based Teaching and Learning Activities for earthquakes, Seismology Handbook for teachers.

Project Suggestions in the Context of SNAC

In the SNAC project, we aim to involve 100 School Nodes where innovative students' projects and activities will be implemented, such as:

a) Development of early warning apps and devices that could be used to reduce the consequences of an earthquake. As the time is limited between the arrival of the first seismic wave and the main seismic event students will explore ideas and solutions to prevent major damages by e.g. cutting the power or the gas supply to the school building, houses, train stations, metro stations etc.

b) Sonification of Seismic waves: it will combine efforts of students, science teachers, music teachers, scientists and musicians. It will help students (of all ages) better understand the natural phenomena and learn sonification and audiofication. The collaboration between science and music shows how creative technique of listening to live scientific data has a social impact (on all the stakeholders) through a public, ecologically driven, audio broadcast.

c) Annual School competition "Make your own Seismometer": Student groups are invited in collaboration with their teachers to build an improvised seismograph and record the whole process in a presentation accompanied by photographic or other audiovisual material. School groups must submit their work for evaluation by a team of scientists and teachers with emphasis on:

- Skills development (exploratory learning, problem solving, creativity, cooperativity group work)
- Inclusion of individuals from vulnerable social groups and people with disabilities and/or skills.
- Students' understanding of the civil protection parameters related to the treatment and prevention of earthquake impacts in the country.

Furthermore, the project will deploy alternative approaches in order to engage students with learning difficulties, low interest or disabilities such as the already mentioned sonification of seismic waves etc. Students (and teachers) will have the

chance to develop their own approaches and studies and to present their work according to their interests and skills.

Step 5: Make Assessment for Quality Check

To evaluate the SNAC project and to ensure its sustainability, the outcomes and the overall impact will be measured based on quantitative and qualitative indicators at three levels: students, teachers, and schools. Various evaluation tools and methods (e.g. questionnaires, interviews, evaluation of students' learning products) will be employed to adequately evaluate the project. All the evaluation tools and related guidelines are available in Output 4: Evaluation Methodology, Analysis of Results. Since inquiry and project-based learning methodologies are expected to be employed by the school staff within the open-schooling framework, the evaluation tools regarding students' skills and attitudes can be really useful for you in identifying the progress being made during the implementation of the 4th step.

The SNAC project is expected to reach 200 teachers and school heads during teachers' trainings and approximately 4000 students (=200 teachers x 20 students per teacher) aged 12-18 during the implementation phase. The aim of the project is to reach as many schools as possible, but it is expected to have 100 schools participating in the project (20 schools per country). The **quantitative indicators** concern the recording of these numbers, as well as the gathering of information regarding the schools/teachers drop-out rate, gender-balance and the number of collaborations within the school and with other schools.

The **quantitative indicators** based on the three levels of participants (students, teachers, schools) are presented below:

Students:

- strong shift or enhancement of positive attitude towards STEM disciplines

- strong shift or enhancement of students' inquiry skills, problem solving competences, interdisciplinary thinking and digital literacy

Teachers:

-the grand majority of the teachers find the offered training seminars and workshops highly beneficial for the development and enrichment of their attitudes, skills and competences

- the grand majority of the participant teachers feel confident to develop innovative, interdisciplinary educational or/and technology-enhanced activities for their classroom practice

Schools:

- the majority of schools consider their participation in the project as highly beneficial and enlightening and that it further facilitates their participation in other projects and initiatives

- the majority of schools through or within the project created or established opportunities for educational collaborations or plan to collaborate in the future with other schools in the area/region/country or other countries.

One of the most important steps in the success of the open schooling philosophy is the on-going evaluation of the innovation process so that it becomes apparent whether or not the school is effectively applying this approach. There are many assessment methods you can employ, but we suggest to use the Self Reflection Tool developed in the context of the OSOS project. This tool will help you to identify the status of your school, and to give you the necessary information in order to choose a relevant strategy to follow during your forthcoming implementation activities.

You also have access to the OSOS Self Reflection Tool in the OSOS portal (https://portal.opendiscoveryspace.eu/en/osos). After the completion of each section of the tool, you will get a report which presents your answers in a table and informs you about the school status in relation to its openness (Enabled, Consistent, Integrated or Advanced).

To facilitate the periodic assessment in the school level always take into account the Open School Development Plan that you have filled in at the beginning of your implementations within the open-schooling framework (see Step 1).

Step 6: Reflect and share best practices using different media channels

After completing the steps described above, open schooling culture is expected to occur in the school teaching and learning environments. It is assumed that the school comes to this stage with the help and support of the established working groups that cooperated and worked effectively with the stakeholders to create an open schooling culture.

As a result of this cooperation, it is expected to see that teachers change their teaching methods and use student-centered approach. Students carry out joint projects with the stakeholders for the problems that occur in the society. They discuss the data they obtained and present it to larger audience in the appropriate environments.

The school reports the studies and develops best practices. This data should be converted into reports and shared effectively with the society through the various media channels listed below. It is particularly important to identify adequate mechanisms and metrics for assessing digital content, especially in the context of enhancing the quality of the education process (Pavlova, 2017).

These media channels are;

- Meetings, Teleconferences, Video Conferences: Project outputs can be shared in teacher education conferences.
- Events: Schools can open stands in different social events. It is important to present results in open public and networking events.
- Social Media & Digital Communities: Social media applications are digital tools with important social role for communicating, sharing and producing content. They accelerate the interaction of different users in the same working field. Examples of such tools are school web page, Facebook, Instagram, Twitter etc.
- Documentation: School reports/booklets can be prepared and shared with the National Ministry of Education as innovation development project. These reports/booklets can also be shared with the schools that wants to bring school innovation to their teaching and learning environments.
- Publications: The best practices from open schooling activities can be published in books, research papers in journals, blogs, newspapers and magazines.
- Visual Broadcasting: Project results can be shared in audio and video broadcasting media such as radio, podcasts, film, television and streaming video.
- Messages: Point-to-point information exchanges between people and groups such as email through a school association.
- Graphics: Posters and billboards can be prepared about project processes.

3. CONCLUSIONS, RECOMMENDATIONS AND FUTURE STEPS

3.1. Conclusions and recommendations

From what has been said in the previous chapters, the practice of Open Schooling is regarded as a powerful tool for reshaping the school activity and for the growth of scientific citizenship in the extracurricular population.

The curricular disciplines whose teaching could benefit from projects focused on open schooling, are numerous. This is evidenced, for example, by the great variety of topics that characterize the experiences being implemented in the OSOS project, to which SNAC could be considered as a supplement, focused on a more specific disciplinary area.

However there are several properties that contribute to strengthening the educational and social potential of SNAC:

• the countries of all the project partner organizations are characterized by a high seismic risk, therefore the earthquake issue is quite important by the general population and by students and teachers in particular;

• within the project a seismic network will be built whose seismometers will be installed directly at the premises of schools, chosen in the countries of the partner organizations. The seismic network will be an extended version of the existing one, realized within the Erasmus+ Schools Study Earthquakes project, held in the 2015-2017 biennium;

• the seismometers installed in schools will be provided by the project consortium and their management will be entrusted directly to the students under the guidance of teachers who will be trained in the context of specially organized workshops.

The action plan to be undertaken within the framework of SNAC has been structured based on the experience already gained in the Horizon 2020 OSOS project, under a programmatic-organizational point of view, and of SSE project on a more strictly disciplinary level.

Open Schooling therefore represents the peculiar trait of SNAC and the referring aspect for the teachers who want to participate with their classes.

Therefore, the roadmap described in this outcome for the participating schools will not only be the simple educational outcome, but above all - the interaction with societal actors external to the school environment and openness to citizenship in general.

To examine these aspects in more depth, readers are referred to chapter 1 of this roadmap (The Open School Environment: Theoretical Framework).

The main features of Responsible Research and Innovation as listed in section 1.8 (e.g.: public engagement; science education; open access; etc.) are widely considered within SNAC

3.2. Future steps

This Open Schooling Roadmap will be followed by a complete training programme addressing teachers and school heads. It will be available by the middle of 2019 and will provide participant teachers and school heads with practical knowledge, background information and guidance. It will explain how to implement the necessary changes and with the intervention skills to best plan and then diffuse innovation in their schools, helping them to evolve to an Open Schooling Environment, establishing Responsible Research and Innovation (RRI) principles.

As said above, SNAC will use and expand the existing network of the SSE project installed seismometers. All the data provided by the seismometers (existing and the new, installed within SNAC) will be made available to the project's beneficiaries by an integrated platform that will utilize the scientific data and transform it to an educational tool through an intuitive interface with the latest advancements on data visualization. Also, this fundamental tool is foreseen to be ready by the middle of 2019.

During the summer of 2019, a SNAC Summer School will take place in Marathon, Greece. This summer school aims to offer a high-impact and transformative experience in personal and organizational level through a series of workshops, best practices and challenges focusing on open schooling and the study of earthquakes. The summer school could be attended by the interested European teachers who could exploit the Erasmus+ grant using the relevant application forms available on the websites of their national agencies in each country.

All the experiences gathered within the local projects, implemented by the schools, with a particular focus on the most significant ones, will be collected and reported in the Recommendations for Future Use, an intellectual output that will be available by summer of 2020. Apart from summarizing the work done by the teachers and schools in the participating countries and identifying showcases of best practices, it will include valuable information that will facilitate the partners' communication with local authorities and other stakeholders about the possible exploitation of the project's outcomes in different or wider settings.

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