Open schooling roadmap for Teachers

COSMOS (Creating Organizational Structures for Meaningful Science education through Open Schooling for all) / cosmosproject.eu

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Contents

Glossary

COSMOS	Creating Organisational Structures for Meaningful science education through Open Schooling for all
CORPOS	Core ORganisational Structure for Promoting Open Schooling
CoP	Community of Practice
HEI	Higher Education Institution
SDG	Sustainable Development Goals
SSI	Socio-Scientific Issue
SSIBL	Socio-Scientific Inquiry-Based Learning
STEM	Science Technology Engineering Mathematics
TPD	Teacher Professional Development

1. Introduction to the COSMOS Approach and Core Concepts

The COSMOS project aims to contribute to the discourse and practice of open schooling by offering several developments in the conceptual understanding and implementation of open schooling for science education in schools. Several core elements comprise the COSMOS approach to open schooling:

1. A comprehensive and multidimensional model of school openness (Ecological model of school openness—Sarid et al., 2024[1]);
2. A specific focus on the creation of organizational structures to support the implementation and sustainability of open schooling (CORPOS);
3. A pedagogy that supports the learning of science as, with and for the community (SSIBL-CoP).

In this section we articulate these three main elements of the COSMOS approach and clarify the relations among them. Other deliverables of the COSMOS project provide further resources for applying the COSMOS open schooling approach in schools supported by evidence-based insights and recommendations (i.e., theoretical framework, TPD handbook, roadmaps and policy briefs).

These three elements of the COSMOS approach to open schooling, and their integration in practice, offer a holistic vision of science education that facilitates student motivation to learn science, the skills and competences to engage in meaningful inquiry and address authentic social-scientific issues. Applying this vision entails a whole school approach that implicates not only school pedagogy but also school curriculum and organization. Thus, the aim of COSMOS is not only restricted to science education (when perceived from a limited disciplinary perspective) but focused on the development of engaged citizens, who apply scientific, inquiry-based, thinking as a mode of citizenship that is characterized by heightened awareness to the community and social issues, a dedication to the improvement of society and the necessary values, knowledge and competences to both realize themselves and contribute to the society.

The COSMOS (Creating Organizational Structures for Meaningful Science Education through Open Schooling for All) approach embodies transformative potential in science education by nurturing partnerships between schools and communities, promoting socio-scientific inquiry, and empowering schools to engage with real-world socio-scientific issues (SSI). It incorporates socio-scientific inquiry-based learning (SSIBL) within Communities of Practice (CoP) to structure science learning around socio-scientific issues thereby expanding educational practices to include community-based problem-solving.

[1] A. Sarid, J. Boeve-de Pauw, A. Christodoulou, M. Doms, N. Gericke, D. Goldman, P. Reis, A. Veldkamp, S. Walan & M. C. P. J. Knippels (2024). Reconceptualizing open schooling: towards a multidimensional model of school openness. *Journal of Curriculum Studies,* 1–19. https://doi.org/10.1080/00220272.2024.2392592

A key aspect of COSMOS is "**community integration and real-world relevance**". Through an open schooling model, science education intersects with community interests and challenges, creating a dynamic learning environment where students address local socio-scientific issues, such as environmental sustainability and health. Schools collaborate closely with local stakeholders—including government agencies, healthcare providers, and environmental organizations—to co-develop learning units, allowing students to see the direct impact and relevance of their studies.

COSMOS also focuses on "**empowering teachers as agents of change**". Teacher professional development (TPD) is central to this, equipping educators as curriculum developers to lead students through SSIBL frameworks within CoPs. Teachers become facilitators of inquiry-based learning, fostering skills in critical thinking, collaboration, and social responsibility. Through structured TPD, teachers improve their reflective practices and gain tools to nurture these community-oriented, inquiry-based models in their classrooms. For example, TPD models in different countries allow adaptation to diverse cultural and educational settings, highlighting COSMOS' adaptivity and potential for broad impact.

"**Sustainability and scalability through community ownership**" are integral to COSMOS. Designed for sustainability, it embeds educational practices within the local community fabric, creating a replicable model for other schools. The CORPOS (Core Organizational Structures for Promoting Open Schooling – Open schooling Team) within COSMOS helps institutionalize collaboration among schools, local organizations, and educational authorities. By involving stakeholders directly in the education process, COSMOS fosters shared responsibility and ownership of educational outcomes, essential for long-term sustainability.

"**Adaptability across diverse educational contexts**" is another strength of COSMOS. The approach accommodates specific community needs and priorities, tailoring implementations to urban and rural environments, primary and secondary schools, and varied socio-cultural contexts. This adaptability underscores the relevance of COSMOS across a wide range of schools and communities, showcasing its capacity for cross-contextual applications.

COSMOS additionally emphasizes "**addressing global and local socio-scientific issues**". It encourages student engagement with both local and global challenges, such as climate change, biodiversity loss, and public health, through SSIBL-based learning. Students are not only informed about these issues but also empowered to take action, instilling a sense of agency. This alignment with global challenges underscores COSMOS as an innovative model that contributes significantly to students' global competencies.

In summary, the COSMOS approach stands out as a powerful educational model that integrates science learning with community engagement, supports teacher empowerment, and addresses socio-scientific issues from local to global scales through adaptable, community-driven partnerships. This model presents a meaningful framework for fostering community-inclusive, inquiry-driven science education across diverse educational contexts.

NOTE: For more information on the COSMOS Framework, please access this link:
https://www.cosmosproject.eu/assets/front/files/repository/WP2-COSMOS-framework-EN.pdf

2. The Community of Practice (CoP)

2.1 Definition, purpose, and perceived/detected potentialities

The community of practice (CoP) represents a distinctive element of the COSMOS approach as it unites school and community stakeholders (e.g., students, teachers, families, scientists, companies, NGOs, science centres). CoP members share a common concern or a passion and learn how to improve their knowledge and behaviour as they interact collaboratively.

The aim of CoP in COSMOS is to address Socio-Scientific Issues using different types of inquiry, that are consequential to all stakeholders in the community, thus fostering networking, sharing of expertise and knowledge, and establishing best practices among CoP partners, including small and large enterprises that share and exchange knowledge through SSIBL. The CoPs can be developed locally, but also nationally or even internationally (connecting groups from different places with a common interest on a specific SSI). In COSMOS, the CoP is limited in time for the duration of the SSIBL design and implementation. However, if interest exists, the CoP can be prolonged in time, resulting in a sustainable process.

The Community of Practice (CoP), as implemented in the COSMOS project, demonstrates significant potential to foster educational reform and enhance science education by creating structured collaboration between schools and their surrounding communities. This approach offers several key perceived potentialities that make it a valuable framework for integrating socio-scientific inquiry and community-based learning:

- CoPs encourage teachers, students, and community stakeholders to collaboratively develop science-based learning units that address real-world socio-scientific issues (SSIs), fostering an enhanced sense of ownership and engagement among participants. Evidence from the COSMOS project shows that in both primary and secondary educational settings, students working alongside community members on issues directly impacting their local environment, such as waste management and biodiversity loss, experience a deepened commitment to these topics.
- The CoP model also supports the adaptation of scientific inquiry to local contexts, making science education more relevant and impactful. It not only deepens students' understanding of science but also fosters critical thinking and problem-solving skills around real societal issues, such as environmental sustainability and health-related topics. For instance, in Portugal, the CoP focused on preparing for natural disasters, while in Sweden, it explored genetically modified organisms, aligning with local priorities and expertise.
- The CoP builds partnerships that extend beyond school walls, drawing in various community members, including local government, environmental organizations, and healthcare institutions. This collaboration enriches the educational experience, providing students with a multifaceted understanding of socio-scientific issues and exposing them to diverse viewpoints and expertise. In Israel, partnerships with local activists and

environmental organizations enabled students to explore the tension between development and conservation, creating a comprehensive learning environment that emphasized real-world implications.

- Through the CoP model, the COSMOS project also lays the groundwork for a sustainable open schooling framework. The structured, iterative implementation of CoPs across various national and cultural contexts has led to valuable insights into best practices and challenges, ultimately creating a model adaptable to various educational settings. This adaptability ensures the long-term viability of CoPs as a vehicle for open schooling and community integration in science education.

2.2 Different examples of CoP

Communities of Practice (CoPs) play a crucial role in facilitating open schooling by bringing together diverse stakeholders to address real-world issues through education. CoPs provide a platform for teachers, students, community members, and experts to collaborate on various projects, enhancing the learning experience and fostering stronger connections between schools and their communities. Each CoP is unique, shaped by its context, goals, and the participants involved, allowing for a rich array of approaches to open schooling.

This guide presents a variety of examples from different countries, showcasing how CoPs can address a range of themes and issues. These examples illustrate the diverse possibilities for CoPs in different contexts, each fostering collaboration, inquiry, and community engagement:

- In Israel, the CoP for promoting healthy lifestyles and to address community well-being through education included a wide array of stakeholders: teachers, student teams, families and external community members like doctors and dieticians. This CoP's diverse membership exemplified how varied perspectives can enrich the learning experience and community impact.
- In the UK, a secondary school's CoP explored waste management and recycling within the community. This CoP included science and geography teachers, the school's careers advisor, and environmental scientists and researchers from a university, who collaborated to create a curriculum that encouraged students to investigate the life cycle and environmental impact of materials such as plastic, batteries and clothing, and to consider sustainable alternatives. The involvement of community professionals (e.g., local food and clothing bank community group) and school leadership to whom students presented their findings and possible solutions offered students a comprehensive perspective on environmental responsibility and facilitated meaningful connections between scientific concepts and their practical applications in everyday life.
- Portugal's CoPs covered two distinct topics in separate school clusters: earthquake preparedness and biodiversity loss. In one CoP, experts from civil protection agencies collaborated with teachers and students to discuss disaster readiness in seismically active areas, focusing on how communities can prepare for and mitigate the effects of natural disasters. In another CoP, entomologists, environmental educators, and municipal botanists engaged students in exploring the impact of biodiversity loss in urban

areas, allowing them to develop projects that promoted environmental conservation within their neighbourhoods. These CoPs highlight the versatility of the CoP model in addressing various socio-scientific issues and demonstrate how local expertise can enrich the learning experience.

- In Sweden, a CoP was developed around the socio-scientific issue of genetic modification, specifically exploring the question, "Are genetically modified organisms (GMOs) beneficial or harmful?" The CoP involved science teachers, a local university partner, and a contemporary art museum that has school programs focused on SSIs, that provided insights into biotechnology and ethics. Through this CoP, students were introduced to the scientific, ethical, and health-related aspects of GMOs, facilitating a balanced examination of the topic. By engaging in collaborative inquiry, students were encouraged to think critically about the applications and implications of biotechnology, equipping them with a broader perspective on science and public health. Several activities were developed combining art and science about the issue of Genetic Modified Organisms.
- In Belgium, a CoP involving STEM teachers, a school policy coordinator, educational advisors from the educational organization Djapo, trainers and researchers from Karel de Grote University, and law enforcement members focused on liveability and problems around the local neighbourhood (specifically the large park within which the school is located).
- In the Netherlands, a CoP focused on air quality and its implications for urban health, centring on the question of whether fossil fuel-powered vehicles like scooters (students' favourite transport vehicle) should be restricted in city areas. This CoP brought together science teachers, university researchers in the context of the international GLOBE project (https://globenederland.nl/). Students formulated their own research question and measured the levels of particulate matter on their way to school, comparing it to data provided by the National Institute for Public Health and Environment. The collaboration allowed students to understand scientific research methods while connecting with the broader community debate on urban environmental health. This CoP underscored the importance of data-driven inquiry and community involvement in addressing public health concerns.
- In Israel, a CoP was created around the environment-oriented socio-scientific issue of conservation versus urban development, focusing on the Jerusalem Gazelle Valley. This area faces pressures between conservation efforts and urban expansion, providing a real-world context for students to explore environmental science and ethics. The CoP involved science teachers, local activists, parents, and representatives from both governmental and non-governmental environmental organizations, enabling students to participate in discussions and activities related to biodiversity and sustainable development. The experience underscored the potential of CoPs to foster a deep understanding of environmental stewardship by linking school learning directly to community challenges.
- In Belgium, some CoPs centred around themes of health and sustainability. One school adopted "The Green Revolution" as a broad theme, branching into subthemes like

sustainable building, healthy sports activities, and the influence of interior design on well-being. Teachers, societal partners, and external experts, such as architects and health coaches, guided students through these topics, engaging them in defining research questions and exploring sustainable solutions. This CoP exemplifies how local professionals can bring practical insights into educational settings, making the learning process both hands-on and socially relevant.

2.3 Suggestions for Communities of Practice implementation in different contexts/realities

Implementing Communities of Practice (CoPs) within different educational contexts and realities can effectively bridge school learning with community needs and interests. Here are some suggestions for CoP implementation based on the COSMOS project experiences:

- **Urban Settings: Focus on Environmental Health and Urban Sustainability** – In densely populated urban areas, CoPs can address environmental health issues, such as air quality, waste management, or green urban spaces, which resonate with the lived experiences of students and community members. To implement CoPs in these settings:
  - Engage with Local Municipalities and Health Organizations: Urban CoPs benefit from partnerships with local health departments and environmental agencies. These stakeholders can provide valuable data and real-world insights into pollution levels, waste management practices, or urban green initiatives.
  - Emphasize Hands-On Data Collection and Analysis: Students can collect local environmental data, such as air quality readings or waste statistics, offering a practical link between their studies and community health.
  - Leverage Public Spaces: Activities like park clean-ups or urban tree-planting campaigns not only involve students in their community but also foster a sense of environmental stewardship, which can be enhanced by collaborating with local environmental groups or city councils.
- **Rural Settings: Agricultural Practices and Conservation Efforts** – In rural areas, CoPs can focus on agriculture, biodiversity, and conservation practices, allowing students to engage with issues relevant to their community's economic and environmental landscape.
  - Collaborate with Agricultural Experts and Conservationists: Local farmers, agricultural extension services, and conservation groups can provide practical knowledge on sustainable farming, biodiversity, and resource management.
  - Incorporate Socio-Scientific Inquiry on Local Ecosystems: Students can explore topics like soil health, water conservation, or wildlife habitats. Fieldwork in local farms or natural reserves can allow them to understand the balance between agriculture and ecosystem preservation.

- Host Community Workshops: Rural CoPs can hold workshops where students and community members share findings and discuss sustainable agricultural practices or conservation efforts, fostering a collaborative learning environment.

- **Resource-Constrained Settings: Focus on Essential Needs and Health** – In communities with limited resources, CoPs should target pressing local needs such as health, sanitation, or safe access to resources like water and energy.
  - Engage Health and Social Service Professionals: Involving health workers, local clinics, or water and sanitation experts can help students learn about essential health practices and community health challenges.
  - Use Accessible, Low-Cost Learning Materials: CoPs in resource-constrained settings should focus on inquiry-based learning methods that don't require extensive materials. For example, using community surveys, local case studies, and observations are low-cost ways for students to engage in meaningful learning.
  - Prioritize Real-Life Problem Solving: Community-driven research projects can address local health issues (e.g., access to clean water or nutrition), providing students with insights into the immediate impacts of science on daily life. By focusing on practical, community-beneficial outcomes, CoPs can create relevant and actionable learning experiences.
- **Culturally Diverse Settings: Inclusive and Contextualized Learning** – In culturally diverse communities, CoPs should recognize and integrate the unique cultural practices, values, and needs of each subgroup within the community.
  - Involve Community Leaders and Cultural Representatives: CoPs benefit from working with community leaders or representatives from various cultural backgrounds to ensure that activities and themes are respectful and relevant to all groups involved.
  - Select Inclusive Socio-Scientific Issues (SSIs): Topics like public health, environmental justice, or sustainable living resonate across cultures and can be approached from multiple perspectives, making them suitable for diverse groups.
  - Implement Culturally Sensitive Pedagogies: Encourage students to bring their own experiences and cultural knowledge into discussions. CoPs can use case studies or examples from various cultural contexts, allowing students to see how scientific inquiry applies in different ways worldwide.
- **Technology-Enhanced Settings: Digital Learning and Virtual Collaboration** – In settings with strong technological infrastructure, CoPs can leverage digital tools to enhance learning and connect participants beyond physical boundaries.
  - Use Digital Data Collection Tools: Sensors, apps, and other digital tools enable students to collect and analyse data on local issues like air quality or water usage in real-time.

- Facilitate Virtual CoPs with Broader Communities: Digital platforms allow students to collaborate with experts, other schools, or even international communities, expanding their learning network and offering a broader perspective on their local issues.
- Encourage Project-Based Learning through Virtual Collaboration: Digital CoPs can facilitate projects that involve online research, virtual field trips, or remote expert consultations, enabling students to engage with broader scientific and socio-political contexts.

2.4 Suggestions for CoP Composition and Topics

Designing an effective Community of Practice (CoP) composition and selecting relevant topics are key factors in creating meaningful and sustainable learning experiences. Insights from the COSMOS project illustrate how a well-structured CoP can bring together diverse expertise and address locally relevant socio-scientific issues. Here are suggestions for CoP composition and topic selection based on these insights:

- **Suggested CoP Composition** – The effectiveness of a CoP relies on a carefully selected mix of stakeholders who bring various perspectives, resources, and expertise to the group. A diverse CoP composition encourages a collaborative environment, where each member contributes to addressing socio-scientific issues from unique angles. Recommended CoP members include:
  - School Teachers and Coordinators: Teachers are central to CoPs, as they guide students' learning processes. Including teachers from different subject areas, such as science, social studies, or language arts, enriches the CoP by allowing for interdisciplinary approaches to topics.
  - Higher Education Institution (HEI) Partners: Professors, researchers, and education specialists from universities can provide research-based insights, resources, and methodological support. In COSMOS, HEI partners helped introduce socio-scientific inquiry methods and facilitated professional development for teachers.
  - Community Representatives and Local Authorities: Local government officials, public health experts, or environmental agency representatives bring practical, community-specific knowledge, helping ground CoP topics in the real-life issues affecting the community. Their presence also provides students with valuable perspectives on policy and community impact.
  - Subject Matter Experts (SMEs): Depending on the CoP's focus, experts in fields like public health, environmental science, or engineering can enrich discussions with specialized knowledge and real-world applications. These experts help make the learning process tangible by sharing the latest research, data, or case studies related to the CoP topic.
  - Students and Student Representatives: Including student representatives in the CoP planning phase can provide insight into their interests, motivations, and concerns. This approach helps ensure that topics are relevant to students' lives and promotes student-led initiatives within the CoP.

- Parents and Local Community Members: Involving parents and community members fosters broader engagement and creates a support system for CoP activities. Community members can offer perspectives on local cultural or environmental issues, and their participation helps bridge the gap between school and community life.

- **Recommended CoP Topics** – Selecting topics that resonate with both students and the broader community is essential to fostering engagement and relevance. The COSMOS project highlights several themes well-suited to CoPs, each focusing on locally relevant socio-scientific issues (SSIs) and promoting interdisciplinary, inquiry-based learning. Suggested topics include:

  - Environmental Sustainability and Conservation – Biodiversity loss, water conservation, sustainable agriculture, climate change adaptation, and urban green spaces. Environmental issues resonate across urban and rural contexts, making them universally relevant. Topics like urban pollution or conservation can involve students in real-life science activities, such as data collection on local biodiversity or air quality monitoring. These topics encourage students to explore and implement solutions for sustainable practices in their own communities.

  - Health and Well-Being – Public health, nutrition, physical fitness, and mental health awareness. Health-focused topics are particularly relevant in schools, where students can directly relate to themes of wellness and lifestyle. CoPs centred on public health issues can partner with local health experts or community organizations to explore how lifestyle choices impact health. This focus also allows for discussions on global health issues, such as pandemics, and can promote health literacy among students.

  - Science, Technology, and Society (STS) – Genetic modification, artificial intelligence, data privacy, and renewable energy. STS topics allow students to investigate the ethical, social, and economic impacts of scientific advancements. These discussions encourage critical thinking as students consider both the benefits and potential consequences of technologies like AI or genetic engineering. In the COSMOS project, genetic modification was an SSI used in the Swedish context, supporting students in understanding scientific innovation's role in society and its ethical implications.

  - Community and Social Responsibility – Waste management, recycling, urban planning, and social justice issues such as equity and inclusion in relation to SSIs. Topics of community and social responsibility foster a sense of civic duty and encourage students to think about their role in society. CoPs that focus on waste reduction or recycling can partner with local environmental groups or city councils, engaging students in projects that have immediate community impact. Social justice topics can also be explored, connecting students to issues like gender equality, cultural diversity, and human rights.

  - Emergency Preparedness and Resilience – Disaster preparedness (e.g., for earthquakes, floods, or wildfires), crisis management, and sustainable infrastructure.

In regions susceptible to natural disasters, CoPs on emergency preparedness are particularly relevant. These topics not only educate students on practical life skills but also foster community collaboration and resilience. By working with local emergency services or civil protection agencies, CoPs can help students understand disaster risks and contribute to local preparedness initiatives, as seen in Portugal's earthquake preparedness project in COSMOS.

- **Additional Topic Selection Tips**:
  - Align with Local Issues and Priorities: Topics that are directly relevant to the local community's challenges or goals create a stronger sense of purpose for CoPs. For instance, urban schools may focus on pollution and transportation, while rural schools could explore sustainable agriculture or water resource management.
  - Use Inquiry-Based Themes: Topics should lend themselves to Socio-Scientific Inquiry-Based Learning (SSIBL), where students can ask questions, conduct research, and implement solutions. SSIBL themes support active learning and help students develop problem-solving skills relevant to real-world issues.
  - Incorporate Cross-Disciplinary Elements: CoP topics can blend multiple disciplines, encouraging students to see the interconnectedness of science, social studies, ethics, and language arts. This interdisciplinary approach broadens students' understanding and allows for a more comprehensive exploration of each issue.

2.5 How to overcome the obstacles and difficulties in CoP functioning

Implementing Communities of Practice (CoPs) within educational settings comes with challenges that can hinder their effectiveness. Based on the insights from the COSMOS project, here are the primary obstacles and difficulties encountered in CoP implementations, along with strategies to address them:

- **Limited Time and Resources** – One of the most cited difficulties is the limited time available for teachers and students to engage fully in CoPs. Teachers often have heavy workloads, and CoP activities require additional planning, coordination, and reflection time. Furthermore, schools with constrained budgets may lack the resources to facilitate CoP activities effectively, such as materials, transportation, or digital tools. To overcome time and resource constraints, CoP projects can start with smaller, focused initiatives that fit within existing curricula and require minimal extra resources. Schools might also consider creating rotating schedules where teachers are given dedicated time for CoP planning. Collaborating with local organizations or utilizing digital tools, such as virtual meetings or online resources, can reduce logistical demands and costs.
- **Engagement from Stakeholders** – Gaining full involvement from all stakeholders, including school administrators, community members, and even students, can be challenging. Some may view CoPs as extra work or struggle to see the immediate value of participation. Without buy-in, the CoP can suffer from lack of motivation and lower participation. To secure stakeholder engagement, CoPs should start with clear,

achievable goals that demonstrate quick, positive impacts. Schools can host informational sessions to explain the CoP's benefits and invite testimonials from participants who have found value in similar initiatives. Additionally, showcasing early wins, such as completed projects or positive feedback from students, can help garner further support and involvement.

- **Inconsistent Participation and Commitment** – Consistent participation is crucial for CoPs, yet schools often face challenges maintaining commitment, especially if participants face competing priorities. Changes in staff or fluctuating student interest can also disrupt continuity. Developing a structured CoP schedule with regular, manageable sessions can foster routine participation. Schools should consider assigning specific roles to CoP members (such as project coordinators or team leaders) to create a sense of responsibility and continuity. Including CoP activities in the curriculum or school calendar as formal requirements, rather than optional extracurriculars, can help sustain involvement.
- **Lack of Training and Professional Development for Teachers** – Teachers may lack experience with CoP models or inquiry-based learning approaches, which can hinder effective facilitation. This lack of training can lead to uncertainties in implementing CoP activities or integrating them within existing curricula. Offering targeted Teacher Professional Development (TPD) on CoP facilitation and socio-scientific inquiry methodologies, as demonstrated in the COSMOS project, can build teachers' confidence and competencies. Workshops, mentorship programs, and resources tailored to CoP facilitation can help teachers effectively lead and engage students. Encouraging collaborative planning sessions among teachers can also foster a supportive learning community where teachers can share experiences and strategies.
- **Difficulty in Maintaining Community and External Partnerships** – Maintaining ongoing relationships with community partners can be difficult due to differing schedules, priorities, or goals. External partners, such as local organizations, may not be readily available to participate, or may only commit for short-term engagements, affecting the CoP's consistency. Building long-term partnerships starts with selecting partners who have a vested interest in the CoP's theme and outcomes. To solidify commitment, schools can draft partnership agreements outlining roles, responsibilities, and expectations. Additionally, organizing an annual CoP event, like a community showcase or project fair, can keep external stakeholders invested and allow for periodic reconnection and reflection on joint progress.
- **Challenges in Contextualizing Content to Local Needs and Realities** – CoPs aim to address locally relevant socio-scientific issues, but contextualizing these topics to suit diverse educational settings and student needs can be complex. Teachers and students may struggle to see the relevance of certain issues or to engage with topics that seem too broad or distant from their immediate environment. CoPs should prioritize locally relevant themes that resonate with the community, such as public health, local environmental concerns, or cultural heritage. Schools can conduct preliminary surveys to identify issues that are meaningful to students and community members. Flexibility in the CoP structure,

allowing each school or classroom to adapt themes to their specific interests, can also enhance relevance and engagement.

- E**valuating and Demonstrating CoP Impact** – Assessing the outcomes and impacts of CoPs can be challenging, especially when measuring qualitative changes like community engagement or shifts in student attitudes toward science. Without clear assessment methods, it can be difficult to demonstrate the value of CoPs to stakeholders. Schools can implement both qualitative and quantitative evaluation methods, such as surveys, interviews, and reflective journals, to capture a comprehensive view of the CoP's impact. Tracking student participation, projects completed, and feedback from community partners can provide concrete indicators of success. Additionally, schools can showcase student projects and learning outcomes in public forums, such as community events or school exhibitions, to demonstrate and celebrate the CoP's tangible benefits.
- **Navigating Cultural and Social Diversity** – CoPs that operate in culturally or socially diverse communities may face challenges ensuring inclusivity and addressing differing perspectives within a shared learning environment. These differences, if unacknowledged, can lead to miscommunication or a lack of cohesion within the CoP. To foster inclusivity, CoPs should establish guidelines for respectful communication and actively include diverse voices during planning and implementation. Involving community leaders or representatives from different cultural groups can ensure that the CoP respects and integrates various perspectives. Additionally, facilitating culturally relevant topics and materials can help bridge differences, creating an inclusive environment where all participants feel valued and engaged.

2.6 How to promote social justice within the CoP

Developing Communities of Practice (CoPs) within educational settings offers a significant opportunity to promote social justice by creating inclusive, equitable, and participatory learning environments. A CoP should include diverse stakeholders representing the community's cultural, social, and economic composition. This ensures that a variety of perspectives are considered and that all voices are heard. Schools should actively involve teachers, students, community leaders, parents, companies, and representatives from organizations advocating for equity and inclusion. By diversifying participation, CoPs can avoid over-reliance on powerful external entities whose agendas might overshadow the group's objectives. For example, limiting partnerships with multinational corporations to advisory roles, rather than decision-making positions, can help maintain balance and preserve the CoP's focus on community needs.

To respect social justice, CoP themes must resonate with the lived experiences and challenges of the community. Topics such as health equity, environmental justice, or access to education should be tailored to the specific needs of underprivileged or vulnerable groups. For example, in areas facing environmental disparities, CoPs could focus on access to clean water or reducing local pollution. Care must be taken to ensure that collaborations with corporations do not promote narrow corporate-driven solutions that align more with marketing goals than genuine community benefit. Independent local experts and grassroots organizations should play central roles in guiding these themes.

Active measures must be taken to ensure all participants feel empowered to contribute. Teachers should use inclusive practices that accommodate diverse learning needs and linguistic differences. Safe spaces for discussion should be created, where all members feel respected and valued. Avoiding hierarchical structures in CoPs fosters collaboration rather than dominance by any group or individual. Regular feedback mechanisms should be implemented to check whether all participants feel included and whether the CoP remains focused on its equitable and community-driven goals.

Social justice principles should also be explicitly integrated into CoP activities. This involves educating participants about systemic inequalities and their impact on the community, using inquiry-based learning to examine local and global inequities, and encouraging critical reflection on power dynamics, both within the CoP and in the broader societal context.

CoPs must proactively identify and mitigate barriers that may prevent full participation. This could involve providing transportation, childcare, or flexible schedules for participants with logistical challenges, offering materials and sessions in multiple languages or providing translation services to ensure linguistic inclusivity, and leveraging digital tools to allow virtual participation for those unable to attend in person, while ensuring equitable access to technology. Similarly, CoPs should diversify their funding sources to avoid dependence on a single sponsor, which could create implicit pressure to align with their interests.

Collaboration within CoPs should focus on empowering all participants to co-create knowledge and solutions. This requires recognizing and valuing the unique expertise and experiences of all members, encouraging shared decision-making, and prioritizing actions that address systemic inequities.

Finally, effective CoPs often extend their impact beyond immediate educational settings by advocating for systemic changes. This might include working with policymakers to address broader social and environmental injustices, developing proposals or public campaigns that highlight community needs and push for equity-focused reforms, and creating long-term partnerships with local organizations to sustain social justice initiatives. These advocacy efforts should focus on grassroots solutions and policies that reflect the genuine needs of the community.

NOTE: For more information on Communities of Practice (CoP), please access this link:
https://www.cosmosproject.eu/assets/front/files/repository/WP2-COSMOS-framework-EN.pdf

3. Socio-Scientific Inquiry-Based Learning (SSIBL)

3.1 Definition, purpose, and perceived/detected potentialities

Socio-Scientific Inquiry-Based Learning (SSIBL) serves as a *pedagogy* that fosters open schooling in science education. SSIBL was developed and tested in pre- and in-service TPD programmes for primary-, lower- and upper-secondary science education, in the FP7 PARRISE project. Through SSIBL, students can see and experience the links between science *in*, *for* and *with* society. This is achieved through the interrelation of three key pillars of the SSIBL framework: socio-scientific issues (**SSI**), inquiry-based learning (**IBL**), and citizenship education (**CE**), under the umbrella of RRI (Responsible Research and Innovation). Socio-Scientific Inquiry-Based Learning operationalises **RRI** in the context of science education. It is learning through asking authentic questions about controversial issues arising from the impacts of science and technology in society. These questions are open-ended, involve participation by concerned parties, and are aimed at solutions which help to enact change. An important end point of SSIBL is to promote action. SSIBL inquiries can be short term or long term. Short term inquiries can complete the outcomes in one or two lessons. SSIBL includes three stages:

- Students and science teachers will *raise specific investigative questions connected to real-life*, which require the involvement of multiple stakeholders identified (ASK),
- all stakeholders involved will collaboratively support students in *conducting personally relevant inquiries* (FIND OUT),
- students, and stakeholders (e.g. families, scientists, companies, science centres), will substantiate their science knowledge and learn how it can be applied within their communities. As a result, they develop *decision-making skills and formulate modes of action* (e.g. campaigning for climate action, writing to their local authorities) that empower them to contribute responsibly to their communities (ACT).

The activities developed within the COSMOS project demonstrated several potentialities of the SSIBL approach:

- **Enhanced Student Engagement and Agency** – The SSIBL framework empowers students to become active participants in scientific inquiry by investigating SSIs that affect their immediate environment and are personally relevant to them. By emphasizing real-world issues, SSIBL increases relevance, making science education more engaging. This relevance encourages students to develop critical thinking and problem-solving skills and nurtures a sense of agency, as students perceive themselves as contributors to their community's well-being.
- **Development of Global Competencies and Responsible Citizenship** – SSIBL promotes scientific literacy and global citizenship by addressing themes like climate change, public health, and sustainable development. Students learn to critically analyse information, formulate questions, and conduct investigations within their local communities, aligning with global competencies such as collaboration, ethical reasoning, and social

responsibility. This approach also allows students to confront complex ethical and societal questions, enhancing their readiness to participate in informed civic life.

- **Building Collaborative Learning Communities** – The SSIBL model leverages CoPs, where teachers, students, parents, and local experts collaboratively design and implement learning units. These partnerships provide rich, diverse perspectives on SSIs and support an interdisciplinary approach that extends beyond traditional science classrooms. CoPs also foster professional development among teachers, supporting them as facilitators and reflective practitioners within the framework of open schooling.
- **Teacher Empowerment and Professional Development** – The TPD framework is based on a structure process for understanding the SSIBL pedagogy, equipping teachers with the skills needed to implement inquiry-based learning and open schooling effectively. Teachers gain hands-on experience in creating SSIBL units, reflecting on their practices, and adapting their instruction to meet diverse educational contexts. This empowerment of educators as "agents of change" is vital for sustainable pedagogical innovation.
- **Adaptability Across Diverse Educational Contexts** – One of the strengths of SSIBL is its flexibility, allowing for contextual adaptation across different schools and cultures. Implementation reports reveal that SSIBL has been adapted to various community issues, educational priorities, and resources, with different countries focusing on region-specific SSIs. This adaptability not only underscores the robustness of SSIBL but also affirms its potential to be an inclusive approach that resonates with varied cultural and institutional contexts.

NOTE: For more information on SSIBL approach, please access this link:
https://www.cosmosproject.eu/assets/front/files/repository/WP2-COSMOS-framework-EN.pdf

3.2 Different examples of SSIBL questions and environments (ASK)

Socio-Scientific Inquiry-Based Learning (SSIBL) fosters critical thinking and problem-solving by encouraging students to explore real-world questions that integrate science, social issues, and civic engagement. SSIBL environments are designed to provide authentic contexts where students can investigate complex, controversial issues, and engage in informed discussions, reflecting on both scientific understanding and social implications.

This guide presents a variety of SSIBL examples used in COSMOS, from different contexts and countries, highlighting how diverse questions and learning environments foster student-centred investigations and actions. Here are some examples:

- **Is GMO good or bad?** (Sweden): Students explored this question through art and science activities at a museum and school, showing the interdisciplinary nature of SSIBL.
- **How can we live sustainably on a planet that shakes?** (Portugal): Addressing earthquake readiness and its social implications through inquiry and activism.
- **How can we promote healthy lifestyles in our community?** (Israel): Focused on diet, exercise, and well-being and incorporating science education and community well-being.

- **What are the effects of e-bikes racing through parks?** (Belgium): Investigating the social and environmental impact.
- **How can we reduce homelessness in our community?** (Belgium): Students developed solutions through research and community engagement, integrating social and scientific inquiry.
- **What should we do about waste management at our school?** (United Kingdom): Students identified solutions for their school's waste management practices.
- **Should fossil-fuel-powered vehicles like scooters be restricted in our city?** (Netherlands): Students explored air quality by measuring particulate matter levels using sensors using sensors on their bike when travelling from home to school. This inquiry was supported by environmental experts who helped students analyse data. The project promoted awareness of air pollution's health impacts and led to student-generated proposals for reducing city traffic emissions.
- **Is artificial intelligence beneficial or harmful to society?** (Sweden): Students examined AI by exploring technologies such as virtual assistants, self-driving cars, and recommendation algorithms. They discussed the ethical implications of AI in society and reflected on its influence on daily life through debates, fostering critical engagement with technology.
- **How will the construction of a new roadway impact local wildlife and human communities?** (Israel): Students conducted ecological and environmental investigations on a proposed roadway's impacts. They conducted field trips to nearby forests, studied local species, and interviewed environmental professionals. These activities provided insight into ecosystem disruptions and pollution impacts, promoting critical thinking on sustainable urban planning.
- **What do buildings of a sustainable future look like?** (Portugal): Students investigated sustainable architecture through several activities. Older students researched energy-efficient materials and water conservation methods, and they shared their findings with younger students, fostering cross-age learning. The project concluded with students constructing model buildings featuring green roofs and solar panels.

3.3 Different examples of integrating social, personal and scientific inquiry in the exploration of open-ended questions (FIND OUT)

Integrating social, personal and scientific inquiry into the exploration of open-ended questions enables students to address complex, real-world issues that intersect science, society, and environment. By engaging with these multifaceted topics, students learn consider their own position and values in relation to the issues investigated, learn to gather and analyse data, develop solutions to societal challenges, and advocate for positive change. This approach not only enhances their scientific literacy but also fosters civic engagement and critical thinking.

This guide provides a variety of examples that demonstrate how integrating social, personal and scientific inquiry can deepen understanding and inspire action:

- **Impact of Urban Development on Biodiversity and Community Well-being**
  - **Question**: "How will the construction of a new roadway impact the local ecosystem and community life?"
  - **Social Inquiry**: Students conducted surveys and interviews with residents to understand public concerns, including noise pollution and traffic. They collaborated with environmental professionals and local municipality representatives, which enriched their inquiry by incorporating diverse perspectives and authentic social data.
  - **Scientific Inquiry**: Field trips to the forest where construction would occur allowed students to gather data on the local microclimate and species diversity. Using sensors and data analysis, they measured micro-climate variables and pollution levels, documented species diversity and observed the ecological impacts, fostering a scientific understanding of environmental changes.
  - **Personal Inquiry**: Consider personal opinions and values in this issue, write them down. Engage in dialogue with peers to inquire their values and beliefs.
- **Exploring Urban Pigeon Populations and Human-Wildlife Interaction**
  - **Question**: "What role do pigeons play in urban environments, and how do different stakeholders perceive their presence?"
  - **Social Inquiry**: Students interviewed local residents, tourists, and business owners to gather diverse opinions on presence of urban pigeons. This interaction helped students understand varying viewpoints on urban animals, helped to develop a nuanced opinion of their own and contributing to a holistic understanding of human-wildlife relations.
  - **Personal inquiry**: Consider personal opinions and values in this issue, write them down. Engage in dialogue with peers to inquire their values and beliefs.
  - **Scientific Inquiry**: Students conducted a citizen science project in partnership with a university, gathering data on pigeon population distributions in urban areas. This scientific inquiry supported the exploration of ecological impacts, allowing students to relate quantitative data with qualitative insights from the community.
- **Health Implications of Urban Air Pollution**
  - **Question**: "How does air quality affect public health in our city, and should policies limit fossil-fuel-based transportation?"
  - **Social Inquiry**: Students discussed health concerns with local healthcare professionals, gaining insights into the social and economic implications of air pollution on community health. By engaging with diverse perspectives, students learned about the social responsibility of environmental health interventions.

- **Personal inquiry**: Consider personal opinions and values in this issue, write them down. Engage in dialogue with peers to inquire their values and beliefs.
- **Scientific Inquiry**: Using air quality sensors, students measured particulate matter across different city locations. Data collection and analysis provided a scientific foundation to inform public health advocacy, bridging empirical evidence with community perspectives on air quality policies.

- **Ethical Considerations and Social Impact of Artificial Intelligence (AI)**
  - **Question**: "Is AI beneficial or harmful to society, and what ethical considerations should guide its development?"
  - **Social Inquiry**: Students explored societal views on AI by interviewing stakeholders, including educators, local technology experts, and community members. This social perspective introduced students to ethical concerns about privacy, employment, and the future of AI.
  - **Personal inquiry**: Consider personal opinions and values in this issue, write them down. Engage in dialogue with peers to inquire their values and beliefs.
  - **Scientific Inquiry**: Through a series of activities, students investigated the technical foundations of AI, including machine learning algorithms and data usage, providing them with a balanced view of both scientific innovations and societal impacts.
- **Sustainable Waste Management in Schools and Communities**
  - **Question**: "How can schools contribute to sustainable waste management practices?"
  - **Social Inquiry**: Students collaborated with waste management experts and surveyed school staff and families to assess attitudes toward recycling and sustainability. This interaction highlighted social motivations and barriers to waste management practices within their community.
  - **Personal inquiry**: Consider personal opinions and values in this issue, write them down. Engage in dialogue with peers to inquire their values and beliefs.
  - **Scientific Inquiry**: Students analysed school waste production by categorizing waste types and studying recycling options. This inquiry was both hands-on and data-driven, promoting environmental awareness through direct community action.

3.4 Different examples of solutions formulated to enact change (ACT)

Enacting change through practical solutions allows students and communities to transform ideas into tangible actions that make a positive impact. These examples illustrate how open-ended inquiries and socio-scientific questions can lead to the development of projects and initiatives that promote sustainability, health, social awareness, and technological literacy. By applying interdisciplinary approaches, these solutions encourage hands-on learning, foster community

involvement, and provide opportunities for students to develop problem-solving skills that address real-world challenges:

- **School Biodiversity Enhancement in the UK** – In a project focusing on local biodiversity, students worked with parents, teachers, and local wildlife organizations to create action plans for enhancing their school grounds. Activities included planting pollinator-friendly plants and constructing hedgehog habitats. To sustain their efforts, students wrote letters to the city council, advocating for broader community support for biodiversity initiatives in local schools.
- **Sustainable School Design in Portugal** – The project involved both primary and secondary school students collaborating to envision "The School of the Future." Secondary students created digital models with sustainable features like photovoltaic panels for energy, green roofs, and improved temperature regulation and water management systems, while primary school students constructed physical models. The solutions were presented to local authorities and the school's administrative board, resulting in actions such as tree planting around school grounds, installing plant beds to improve green spaces and enhanced water drainage system.
- **Dietary Changes and Sustainable Nutrition in Israel** – In an effort to promote sustainable dietary habits, students explored food waste reduction and healthy eating practices. They developed educational games and created holiday gift packages from reusable materials, which they distributed within the school community. This project extended to students' families, where students led initiatives to incorporate sustainable dietary changes at home, thereby broadening the impact beyond the classroom.
- **Architecture and Environmental Awareness in the Netherlands**: Students studied sustainable construction materials, energy conservation, and architectural design by interviewing experts. Based on their inquiries they presented their recommendations for a more sustainable school building to the school leader. This project emphasised practical sustainable applications in the current school building and stressed the importance of environmentally responsible construction for their new school building.
- **Food Waste Management and Community Awareness in Belgium** – To address food waste, students partnered with local organizations and community leaders to create a food recycling initiative. They raised awareness in the school community, which included setting up designated bins for food separation and promoting responsible consumption through posters and workshops. This community-based solution encouraged long-term waste reduction habits among students and staff.
- **Clothing Waste Reduction through School Uniform Recycling in the UK** – To address clothing waste, students suggested creating a second-hand uniform shop, modelled after platforms like Vinted, where parents and students could trade gently used uniforms. This solution would not only reduce waste but also promote inclusivity by providing affordable options for students from all economic backgrounds. The proposal fostered open dialogue within the school, addressing concerns around stigma and encouraging community-driven solutions.

- **School Biodiversity and Green Spaces in Portugal** – Students identified issues related to green spaces and environmental sustainability within their school. They proposed the planting of trees, installation of photovoltaic panels, and improvements to water drainage systems to foster a more sustainable environment. These solutions were formalized in detailed cost and action plans, presented to the School's Directive Board and local government. With support from the City Hall, several trees and plants were installed around the school, and organic composters were provided to both the school and local community.
- **Public Demonstration and Petition Against Urban Development in Israel** – Faced with a planned roadway construction impacting local ecosystems, students and their families conducted social and scientific inquiries into the project's potential environmental consequences. To advocate for change, they organized a public demonstration, circulated a petition, and met with local officials to discuss alternatives. This project exemplified active civic engagement, with students taking ownership of local environmental advocacy.

3.5 How to overcome possible difficulties during SSIBL implementation

Implementing Socio-Scientific Inquiry-Based Learning (SSIBL) can present challenges, from resource limitations to issues of time, engagement, and curriculum alignment. However, with thoughtful strategies and a proactive approach, these difficulties can be effectively managed to foster meaningful learning experiences. This guide offers practical solutions to overcome potential obstacles during SSIBL implementation, ensuring that projects remain engaging, relevant, and impactful.

- **Teachers' Time Constraints and Workload** – Teachers often struggle to find sufficient time to implement the SSIBL stages, especially the ACT phase, due to tight schedules and heavy workloads. Starting SSIBL activities earlier in the school year can allow for gradual progression through each phase. Additionally, embedding SSIBL within the existing curriculum—as opposed to treating it as an add-on—helps teachers integrate it seamlessly into their lesson plans, reducing the need for extra preparation time.
- **Students' Time Constraints** – Adopt flexible scheduling practices to allow students dedicated time for project work without compromising traditional academic responsibilities. Advise on simplifying the scope of projects to ensure they are manageable and achievable within set timeframes. Tackle scheduling conflicts by integrating SSIBL projects into the regular curriculum where possible. Manage large project scopes by breaking them down into manageable phases. Monitor the workload and stress levels associated with SSIBL projects, ensuring they contribute positively to student well-being.
- **Lack of Teacher Training and Confidence in SSIBL** – Many teachers feel unprepared to facilitate socio-scientific inquiries and community-oriented actions due to limited professional development focused on SSIBL methods. Providing ongoing teacher professional development (TPD) specific to SSIBL equips teachers with necessary skills

and confidence. For example, training sessions can cover how to co-design SSIBL projects with students and external stakeholders, boosting teachers' readiness for implementing inquiry-based projects and community collaborations (D5.2 – Teacher Professional Development Handbook).

- **Establishing and Sustaining Community Partnerships** – Building and maintaining partnerships with community organizations for SSIBL projects is challenging, often due to limited mutual interest or logistical constraints. Early networking and clearly communicating the potential benefits of collaboration (such as shared goals in addressing local socio-scientific issues) can help establish lasting partnerships. Identifying and focusing on stakeholders whose missions align with the project theme, such as local environmental groups for a biodiversity project, can foster more engaged partnerships. Encourage parental involvement in projects through workshops or as project contributors to strengthen community ties. Organize panels with community experts in various fields to offer insights and advice on student projects. Use public showcases and local media to highlight SSIBL projects and achievements, increasing community interest and potential support.
- **Lack of School Support** – Inconsistent involvement from school leadership can limit the reach and sustainability of SSIBL implementations. Schools with strong leadership support for SSIBL often see greater integration and lasting impact. Engaging school leaders early in the SSIBL planning process, perhaps by involving them in the selection of socio-scientific issues, can build support. Encouraging leaders to attend SSIBL events and showcase student achievements reinforces their investment in the program.
- **Schools' Rigid Curriculum Structure or Organizational Culture** – Some schools may have a rigid curriculum structure or organizational culture that resists change, making it difficult to implement the more flexible, inquiry-based SSIBL approach. Demonstrating how SSIBL aligns with existing educational goals, such as developing critical thinking or social responsibility, can help secure buy-in. Where resistance is high, small-scale pilots can introduce SSIBL elements, showing teachers and administrators the approach's benefits without overwhelming existing structures. Work within and across curricular boundaries to find spaces for SSIBL projects. Use thematic units that integrate SSIBL with core curriculum areas – ensuring it aligns with educational objectives and leverages students' interests – to enhance relevance and application. Work towards integrating SSIBL projects flexibly within the curriculum, allowing for deep exploration without compromising core content coverage. Work with CoP members to develop curricular units that incorporate SSIBL stages and align with community needs. Embedding SSIBL within the curriculum reduces the perception of it as an "add-on" and supports seamless integration.
- **Students' Engagement Challenges** – Use real-world issues that are relevant to students' lives and local context to spark interest and commitment. Mitigate engagement challenges by connecting projects to students' interests and future aspirations. Tailor projects to match community needs. Placing students at the centre of the SSIBL process, allowing them to drive the inquiry and action phases, can enhance engagement.

Recognize and celebrate the learning journeys and personal growth of students through SSIBL projects, beyond just project outcomes.

- **Lack of Students' Autonomy** – While SSIBL emphasizes student autonomy and inquiry, some students may struggle with the open-ended nature of socio-scientific issues, which can hinder engagement. Providing structured guidance within each phase of SSIBL, such as using controversy maps or visual guides for the ASK phase, helps students navigate complex issues. Moreover, integrating hands-on activities or real-world problem-solving within the FIND OUT and ACT stages can make the inquiries more relatable and engaging.
- **Resource Constraints** – Leverage community resources and digital tools to extend learning beyond the classroom. Develop a network of resources including local experts, community organizations, and online platforms to support diverse SSIBL projects. Conduct community mapping exercises to identify potential project topics, partners, and resources.

4. How to Integrate SSIBL and CoP through the Three Stages (ASK, FIND OUT, ACT)

Integrating SSIBL and CoP requires a dynamic, collaborative approach that leverages the strengths of the school, its students, and the broader community. In all stages, the integration of SSIBL and CoP can transform learning into a dynamic, community-engaged process that not only enhances educational outcomes but also fosters a sense of agency and responsibility among students. By drawing on the strengths and resources of the CoP, schools can provide enriched, real-world learning experiences that prepare students for the complexities of modern societal challenges. Here are some examples of integration SSIBL and CoP:

- **ASK Stage: Formulating the Socio-Scientific Issue (SSI) and Engaging CoP Members** – The ASK stage involves identifying a relevant SSI and formulating questions that engage CoP members, including and perhaps most importantly, the students. This stage is essential for setting the inquiry's direction and grounding it in real-world relevance. Integrating CoP and SSIBL at this stage concerns deepening the engagement of CoP members, including relevant external stakeholders, in the formulation of inquiry topics and research questions and this involves also mapping controversies and different standpoints and experiences regarding a given issue. Moreover, by accounting for perspectives from both internal and external members, the CoP can contribute to the ASK stage by selecting topics that resonate with both local community concerns and curriculum goals. In one implementation, teachers and CoP members, including local scientists and parents, collaboratively identified the theme of biodiversity loss linked to a school pond. This SSI was introduced through a letter from the headteacher to students, fostering engagement by presenting the SSI as a community concern.

  Facilitators should ensure that CoP members have opportunities to contribute early in, this stage. Providing platforms for brainstorming sessions or community consultations can enhance the relevance and support for SSIBL projects.

- **FIND OUT Stage: Collaborative Inquiry and Research with CoP Support** – In the FIND OUT phase, students investigate the formulated questions through research and data collection, with CoP members often playing critical roles in guiding the research, participating in the inquiry process or providing resources. During this stage, CoP members can offer expertise, personal knowledge or resources that expand students' research capabilities. Collaborative inquiry allows various stakeholders to share knowledge, construct knowledge and share personal experiences that are relevant to a comprehensive understanding of a given issue. This is especially the case in addressing social-community aspects of the issue. For example, students examining air quality in Belgium collaborated with environmental experts from the CoP, who provided them with air monitoring equipment and helped analyse pollution data. Such partnerships enrich the inquiry by offering technical support and insights beyond classroom knowledge. To maximize CoP involvement, schools should identify specific skills or resources each CoP

member can contribute, such as data analysis tools or environmental expertise. Regular updates and communication with CoP members ensure they stay informed and ready to assist as students' progress through the inquiry.

- **ACT Stage: Implementing Solutions with CoP Collaboration** – The ACT phase occurs when students, preferably together or with the support of other CoP members, apply their findings to take socially responsible action. This stage benefits greatly from CoP involvement, as members can facilitate real-world applications of students' solutions. CoP members can help bring student-led initiatives to life by either actively participating in these actions (such as family members), or by providing relevant resources and support for action. In Portugal, students proposed sustainable school features, such as green roofs and shaded areas, which were implemented with support from local government and CoP partners. Involving CoP members in this final stage provides students with a platform to enact meaningful change, reinforcing the relevance of their inquiry. Schools should formalize commitments from CoP members during the planning phase to support the ACT stage, ensuring resources, guidance, and access to community platforms are available when students are ready to act. This can be facilitated through community presentations, where students share their findings and proposed actions, promoting accountability and visibility within the CoP (D 2.1 – COSMOS Framework).

NOTE: For more information on how to integrate SSIBL and CoP through the three stages of ASK, FIND OUT, ACT, please access this link:
https://www.cosmosproject.eu/assets/front/files/repository/WP2-COSMOS-framework-EN.pdf

5. Promoting the Sustainability of the COSMOS Approach in Schools

Promoting the sustainability of the COSMOS approach in schools involves fostering an environment where open schooling and Socio-Scientific Inquiry-Based Learning (SSIBL) are embedded into school culture, curriculum, and community partnerships. The sustainability of a project refers to its ability to maintain its outcomes, benefits, and operations over the long term, without requiring continuous external resources or support beyond its initial funding or setup. A sustainable project is designed to continue delivering value and meeting its objectives after the project lifecycle, ensuring lasting positive impacts. This section provides insights and actionable steps for teachers, school leaders, and policymakers to ensure the COSMOS approach remains effective and impactful.

5.1 Building a Culture of Open Schooling

To embed the COSMOS approach into everyday teaching practices, teachers should focus on connecting classroom science lessons with real-world issues that matter to students and their communities. Selecting Socio-Scientific Issues (SSIs) relevant to students' lives encourages active participation and helps students see the value of their learning beyond the classroom. Teachers can develop lesson plans that incorporate SSIBL activities, making inquiry-based learning an integral part of science education.

5.2 Strengthening Community and Stakeholder Engagement

Teachers can promote sustainability by forming and nurturing relationships with local experts, such as environmental scientists, healthcare professionals, or industry leaders, who can contribute real-world perspectives to the SSIBL curriculum. Inviting stakeholders to participate in classroom activities, or organizing visits to local organizations, reinforces the relevance of open schooling and deepens students' engagement.

5.3 Ensuring Continuous Teacher Professional Development (TPD)

Ongoing professional development is essential for teachers to keep abreast of best practices in open schooling and SSIBL. Teachers can engage in peer-mentoring programs, workshops, and online courses that help them refine their skills and expand their knowledge. Reflective practice, such as reviewing and discussing SSIBL activities with colleagues, ensures continuous improvement in implementing the COSMOS approach.

5.4 Integrating COSMOS into School Curricula and Policies

Teachers can work within the existing curriculum to identify areas where SSIBL aligns naturally with national or regional standards. Developing lesson plans that integrate SSIBL into standard curriculum objectives, such as environmental science or civic education, ensures that COSMOS is seamlessly embedded into regular coursework. Teachers can advocate for SSIBL inclusion by showing the positive impact of these activities on student engagement and learning outcomes.

5.5 Monitoring and Evaluating Impact

Teachers can use self-assessment tools, student feedback, and classroom observations to monitor the effectiveness of SSIBL activities. Reflecting on students' responses to COSMOS-based projects helps teachers adapt their approaches and provides data for future improvement. Sharing findings and experiences with colleagues fosters collective growth and refinement of the COSMOS approach within the school.

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