Open schooling roadmap for Policymakers

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 COSMOS and Open Schooling Framework

1.1 The Purpose of the Roadmaps

The document "Open schooling roadmaps" provides practical guidelines/recommendations for schools interested in implementing an open schooling transformation process according to the COSMOS approach. It is organized in stages—accordingly to the main concepts of COSMOS (Core ORganisational Structure for Promoting Open Schooling or Open Schooling team, CORPOS; Community of Practice, CoP; Socio-Scientific Inquiry-Based Learning, SSIBL; and Teacher Professional Development, TPD)—offering different suggestions and examples (based on practice and real cases) on how each school (with a specific context and characteristics) can orientate in the implementation of such an open schooling process.

This document provides a structured framework for integrating the COSMOS approach across varied educational settings. It includes three critical supporting resources—**three roadmaps**—that extend the COSMOS framework's applicability, detailing its alignment with curriculum design, its implementation in classroom settings, and its broader impact on school-community collaboration. Each roadmap proposes a different way of exploring this document—a unique perspective—tailored to guide a different stakeholder—teachers, school leaders, or policymakers—in making informed decisions on adopting and sustaining open schooling practices within their institutions.

The different stages of each roadmap suggest to the readers an order of reading, not of implementing COSMOS in their own projects. For example, in all the roadmaps, the stages "Community of Practice" and "Socio-Scientific Inquiry-Based Learning" are frequently implemented in parallel.

Collectively, these roadmaps underscore the adaptability and long-term viability of the COSMOS approach, providing essential information to foster an educational environment that encourages active student participation in science education, meaningful community engagement, and a robust response to socio-scientific challenges.

1.2 What the COSMOS Approach Offers

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]);

[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

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.

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. CORPOS: Core Organizational Structure (Open schooling team)

2.1 Definition, purpose, and perceived/detected potentialities

The CORPOS is an organizational school structure that functions as an open schooling team or routine that convenes regularly to promote an open schooling culture and practices in school. The CORPOS is composed of stakeholders both internal (school staff) and external to the school organization, an Open Schooling Team. In the COSMOS project, the focus has been specifically on employing the open schooling approach in the context of science education, with the possibility that the open schooling process will extend beyond science to include other disciplines or subject matters.

Before elaborating on the formation of the CORPOS and its central attributes and responsibilities, it is crucial to stress the rationale or the importance of the CORPOS in the context of the present project and for embedding and promoting open schooling in any school context. In the literature on the failure of school reform (and improvement), various factors have been identified as those that inhibit successful school change. The CORPOS addresses three main factors: (1) that of a disconnect between new policies (even if these are evidence-based) and the understanding of school teams (especially teachers) that the new reform or policy is beneficial and connected to their own practice; (2) the disregard for *specific context* (needs and values), that is, regarding schools as homogenous entities and thus the reform as universally applicable; (3) an understanding that a diversity of voices in schools need to be heard so that the change or reform can be discussed by relevant stakeholders, especially teachers and students. The CORPOS addresses these three factors by creating a structure (and complementary routines) for school teams and promoters of the change process (external stakeholders) to discuss the change process so that open schooling is contextualized and adapted to the specific culture and needs of the specific school. Second, it provides a shared environment for diverse stakeholders – also those that are not formally part of the school organization – to share ideas, views, values and opinions regarding what open schooling means and how it impacts each one of them. When the CORPOS is truly diverse it functions as a holding environment or **open schooling professional learning community**, in which different voices are heard, and a holistic and more integrated understanding of open schooling can emerge in a given context. Finally, the CORPOS functions as a **motivation-enhancing mechanism** by making inner school connections between different stakeholders (particularly teachers from different disciplines), thereby allowing the formation of a systemic and organic view that contributes to the school as a whole.

CORPOS effectively **fosters sustained, community-centred education** by acting as a channel between schools and local communities. It aligns science education closely with pertinent socio-scientific issues, facilitating ongoing collaborations among schools, local organizations, and community members. The resulting community-focused science education connects students with pressing local concerns, making the learning experience not only relevant but also grounded in practical, societal applications of science.

Empowering teachers and students to serve as community actors is another cornerstone of CORPOS. This structure helps to integrate science education with real community needs. This role supports teacher development beyond traditional classrooms, enabling them to guide socio-scientific inquiry-based learning (SSIBL) initiatives. Through CORPOS action, the school gains agency to tackle local challenges, fostering a deeper connection with community stakeholders and providing authentic, hands-on learning experiences.

Sustainability and interdisciplinary network building are intrinsic to the CORPOS framework. It cultivates partnerships extending beyond conventional educational boundaries to include local government bodies, NGOs, environmental groups, healthcare organizations, and businesses. These boundary crossings enrich educational content, creating a sustainable support system for open schooling by fostering investment in common goals, including public health, environmental stewardship, and community development.

Another significant strength of CORPOS lies in its **emphasis on socio-scientific inquiry in education**. It equips students and teachers to address complex, real-world problems through an inquiry approach, encouraging a transition from theoretical learning to problem-solving rooted in scientific exploration and civic responsibility. This approach underpins a culture of critical thinking, ethical reasoning, and active citizenship, addressing the immediate socio-scientific issues that affect the community.

Finally, CORPOS **promotes a culture of reflection and continuous improvement within the teaching community**. Regular reflection on SSIBL implementation helps educators dynamically adjust their methods based on real-world feedback. This ongoing cycle of learning and adaptation enables schools to evolve their open schooling models in response to new insights and community needs, positioning CORPOS as a continuously responsive and resilient model for community-integrated science education.

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

2.2 Different examples of CORPOS

CORPOS structures can be diverse, including school leaders, teachers, external educational organizations, and higher education institutions. During the COSMOS project, several Open Schooling teams were created. Here are some examples:

- In Belgium, Novaplus School CORPOS included STEM teachers, a school policy coordinator, educational advisors from the educational organization Djapo trainers and researchers from Karel de Grote University, focusing on STEM education and integrating social issues relevant to the local community. This highlights how a school can leverage its STEM focus to engage with broader community issues, demonstrating the versatility of CORPOS in aligning educational priorities with societal needs.
- In Portugal, the CORPOS of Alfredo da Silva School Cluster was formed by primary and secondary school teachers along with members from IE-ULisboa and Ciência Viva, showcasing the value of inter-level educational collaboration within the CORPOS structure. This example underscores the potential for CORPOS to bridge different

educational stages, fostering a cohesive educational experience that spans a student's journey. It also shows that leadership support is critical, but involvement is not necessary for successful school engagement and implementation. Several members already knew each other from previous projects, which facilitated collaboration. Most meetings took place on-line according to the members' willingness.

- In Israel, Elzahara school's CORPOS comprised in-school members—the school principal, the school counsellor, social coordinator, and students from the school council —exemplifying a whole-school approach to health and wellbeing, and also out of school participants—5 different community representatives (a nurse from local health agency, a representative of local voluntary department, a representatives from a special education school and representative of an institution for inclusion of people with disabilities), emphasizing a broader community approach in order to capitalize on relevant community organizations for enhancing the change process. Leadership participation facilitated greater investment of time and resources by teachers and the school.
- In Sweden, a CORPOS was formed by secondary school science teachers, researchers from Karlstad University, and an educator from Alma Löv Museum, centred around Genetically Modified Organisms (GMO) and art. This example involved a unique approach by linking GMO discussions with art, illustrating how a CORPOS can lead to innovative educational projects that transcend traditional subject boundaries.
- In the Netherlands, one of the CORPOS comprised of science teachers from different subjects (biology, physics and chemistry) and two researchers from Utrecht University. The schoolboard was not involved to give the teachers trust, autonomy and ownership. All CORPOS meetings were in person at the school, optimizing the available time for the teachers and facilitating in-depth discussion and understanding of the SSIBL-CoP approach.
- In the United Kingdom, the CORPOS involved three Year 9 science teachers (one of them Assistant Head of Department), one societal partner from Winchester Science Centre and three partners from Southampton University. All CORPOS meetings were in-person, which in the participants' opinion facilitated engagement and supported more in-depth discussion and exploration of issues.

2.3 Suggestions for CORPOS implementation in different contexts/realities

The implementation of CORPOS (Open Schooling team) across different educational contexts and realities requires thoughtful adaptation to match each school's unique environment, priorities, and community. While the core objectives of CORPOS focus on fostering collaboration, openness, and sustainability in science education, how these objectives are achieved will vary according to the needs and opportunities of each setting.

This guide provides actionable suggestions for the effective establishment and functioning of CORPOS, emphasizing strategies that promote meaningful collaboration, sustained momentum, and continuous improvement. The goal is to enable schools to evolve into open learning

environments that empower all stakeholders to actively participate in a collaborative educational journey. Here are some actionable suggestions:

- **Matching school's strategic priorities** – Ensure a diverse composition that reflects the school's strategic priorities and context. Implement a flexible approach, allowing the CORPOS to adapt to changing school priorities and contexts.
- **Adapting to Local Socio-Scientific Priorities** – In **urban areas**, focus on issues such as air quality, waste management, or sustainable urban development. For example, partnerships with local environmental agencies or public health officials can facilitate projects on particulate matter or recycling initiatives. These partnerships allow students to gather data, collaborate on solution-oriented discussions, and share findings with the broader community. In **rural areas**, emphasize projects relevant to local activities and environmental concerns, such as agriculture, water quality, or biodiversity conservation. Engage local farmers, agricultural scientists, or environmental groups to address specific rural challenges, like soil health or sustainable farming practices, thus making learning relevant to students' immediate surroundings.
- **Focused and Shared Goals** – Define clear, achievable goals for the CORPOS to work towards. Shared goals among CORPOS members help maintain focus and momentum. Develop a mutual understanding and commitment towards common goals for the CORPOS initiative. Establish milestones and long-term outcomes to provide direction and motivation. Developing a multi-year vision for the CORPOS can help maintain focus and momentum, providing a roadmap for sustained collaboration and impact. Remain adaptable to changes within the school and community environment. Integrate sustainability into the curriculum and projects to embed the importance of continued efforts.
- **Diverse Membership and Stakeholder Inclusion** – Actively seek partnerships with local organizations and stakeholders. Ensure a wide representation of the community, including local companies, environmental groups, and cultural institutions. Include members from various backgrounds, including teachers, researchers, community members, and policymakers. Incorporating members from beyond the immediate school community, such as local businesses or cultural institutions, can bring fresh perspectives and resources into the CORPOS, enriching the open schooling process. Strengthen ties with the community by involving local stakeholders in planning and decision-making processes. The collaborations can be initiated within already existing networks or networks can be developed through recruitment.
- **School Leadership's Involvement** – The engagement of the School Leaders in the CORPOS is a significant success factor. Working with the School Leaders—and not only with the teaching staff—on the openness dimensions—and perhaps particularly on 'shared governance'—may prove to be important for enhancing the various openness dimensions of COSMOS.

- **Dynamic Membership** – Allowing for changes in CORPOS membership can keep the group responsive to evolving needs and opportunities, ensuring sustained relevance and engagement.
- **Community Mapping** – Engage in community mapping exercises to identify potential local resources, challenges, and partners that could enrich the CORPOS's initiatives. Look for opportunities to expand the CORPOS by including new members and partners.
- **Clear Role Definition and Distribution** – Clearly outline the expectations and contributions of each member to avoid overlap and maximize efficiency. Establishing clear roles within the CORPOS can mitigate potential overlaps in responsibilities, ensuring that each member can contribute effectively without redundancy.
- **Regular Meetings and Clear Communication Channels** – Schedule regular meetings for planning, updates, and to maintain momentum. Establish clear communication channels and regular meetings to foster a shared vision among CORPOS members.
- **Flexible Meeting Formats** – Adopt a mix of in-person and virtual meetings to accommodate busy schedules and facilitate broader participation.
- **Professional Development Support** – Offer training sessions for teachers and other CORPOS members focused on open schooling concepts and principles, inquiry-based learning, and community engagement strategies to build a common understanding of goals and methodologies. Host interactive workshops where CORPOS members can brainstorm and prototype project ideas, leveraging diverse expertise and fostering a collaborative spirit.
- **Student Engagement** – Actively involve students in the CORPOS process, allowing them to voice their ideas and interests, to directly contribute to decision-making processes and learn from real-world practitioners. Encourage students' participation in CORPOS activities to bridge the gap between classroom learning and real-world applications. Empower students to take on leadership roles within CORPOS projects to foster a sense of ownership and engagement (e.g., School Student Council). Develop an alumni network for past participants to share experiences, mentor current members, and sustain long-term engagement.
- **Evaluation and Reflection** – Reflection is crucial to CORPOS' long-term success, so schools should establish regular check-ins with all partners to assess for effectiveness, share learning experiences, and make iterative improvements. This continuous feedback loop helps build a sustainable CORPOS that evolves with changing community needs.
- **Aligning with Local Educational Policies** – Schools should look for ways to align CORPOS initiatives with broader educational policies or regional goals. When CORPOS projects align with curricular objectives or government educational priorities, they become more sustainable and easier to scale, as they have institutional backing and relevance within the educational framework.
- **Peer-to-Peer Learning** – Establishing exchanges or shadowing opportunities with other schools engaged in open schooling can provide fresh insights and motivation.

- **Recognition and Awards** – Recognize and celebrate achievements to motivate continued involvement. Establish a system of recognition and awards for active participation and outstanding contributions to the CORPOS's goals, fostering motivation and appreciation. Holding regular sessions where CORPOS members reflect on successes, challenges, and lessons learned can foster continuous improvement and adaptability. Integrate sustainability into the curriculum and projects to embed the importance of continued efforts.

2.4 Suggestions for CORPOS Composition and Topics

The composition and focus areas of CORPOS (Open Schooling team) play a crucial role in determining how open schooling is realized in diverse educational settings. By aligning CORPOS topics with local issues, resources, and stakeholders, schools can create meaningful learning opportunities that not only enhance academic outcomes but also contribute to community well-being and development.

A well-composed CORPOS brings together educators, students, community members, and experts, facilitating a collaborative environment where all members contribute to a science curriculum that is responsive to local issues:

- **Core Members**:
  - **Teachers and School Administrators** – Include teachers from multiple disciplines (science, geography, social studies) who can provide a well-rounded approach to socio-scientific issues. Having administrators on board ensures the initiative aligns with school goals and policies.
  - **Higher Education Institutions (HEI)** – Involving local universities or colleges brings in academic expertise, providing access to research, mentors, and occasionally even facilities like labs. HEI partners can help guide the SSIBL (Socio-Scientific Inquiry-Based Learning) process and support teachers in scientific inquiry.
  - **Local Government and Public Services** – Representatives from municipal departments (e.g., public health, environmental protection) can supply real-world data and resources, facilitating projects on community-relevant topics and ensuring students' work is valuable to local authorities.
  - **Non-Governmental Organizations (NGOs)** – NGOs focused on environmental, social, or health issues can serve as partners who contribute their unique insights, networks, and resources. Their involvement brings students closer to active community issues, enhancing the real-world impact of their projects.
  - **Community Stakeholders** – Engaging community members, such as parents, local business owners, and civic leaders, not only fosters a sense of ownership but also allows for a more diverse perspective on socio-scientific issues. They bring insights into local needs and concerns, providing direction on which topics may resonate most with the community.
- **Specialist Contributors**:

- **Subject Matter Experts** – Specialists in fields relevant to the chosen socio-scientific issue (e.g., climatologists, urban planners, nutritionists) add depth to the learning experience, offering expert insights that are not always available in school settings. Experts can host workshops, provide research data, or mentor students on complex topics.
- **Technologists and Makerspace Representatives** – Bringing in professionals from makerspaces or technology centres allows students to explore hands-on, innovative solutions. These contributors can guide students in using new tools and technologies, especially for projects focused on engineering or environmental solutions.

This guide outlines various thematic suggestions for CORPOS composition, ranging from environmental stewardship to tech-driven initiatives, all aimed at enriching the school curriculum through real-world applications and community partnerships.

- **Environmental Focus** – Schools located in areas with environmental concerns, such as pollution or biodiversity loss, can partner with local environmental NGOs and environmental agencies to integrate these issues into the curriculum, fostering environmental stewardship among students and supporting sustainability and climate change education. Collaborate with local craftspeople and artisans in the development of sustainability projects.
- **Sustainable Energy Projects** – Schools in regions with renewable energy initiatives can include local energy companies or startups to explore sustainable energy solutions, enhancing STEM education with a focus on sustainability.
- **Citizen Science Projects** – Collaborate on citizen science projects where students collect data and contribute to real scientific research conducted by the museum.
- **Collaborations with Science and Technology Museums and informal learning centres** – Joint projects with Science and Technology Museums and informal learning centres offers numerous benefits for schools aiming to implement the COSMOS approach. Such partnerships can significantly enhance the scientific inquiry and technology application aspects of education. By leveraging the resources and expertise of Science and Technology Museums, schools can greatly enhance their educational offerings, providing students with unique opportunities to engage in scientific inquiry and explore technological applications in meaningful ways. Organize science fairs and competitions in collaboration with the museum, fostering a spirit of inquiry and innovation among students. Develop exhibits around current scientific issues or breakthroughs, such as climate change, renewable energy, or space exploration.
- **Sustainable Farming and Food Security Projects** – Collaborating with agricultural cooperatives can greatly enhance educational initiatives related to sustainable farming and food security. The focus on promoting healthy lifestyles and community well-being can include projects on sustainable agriculture and food security, leveraging local agricultural cooperatives' expertise. Engage students in research projects that involve data collection and analysis on crop yields, soil health, and sustainable practices, in collaboration with cooperatives. Establish community gardens or urban farming projects

in partnership with agricultural cooperatives, integrating these into the school's curriculum.

- **Tech-Driven Initiatives** – Incorporating technology companies as part of the CORPOS can introduce innovative learning tools and digital literacy projects, bridging the gap between education and the tech industry. Arrange demonstrations of new technologies and their applications, providing students with a hands-on understanding of technological advancements.
- **Civic Engagement and Democracy** – Partnering with local government bodies or NGOs focused on civic education to develop projects that engage students in understanding and participating in democratic processes, promoting civic engagement, community development projects, social justice, human rights, and environmental activism projects.
- **Cultural Projects** – In regions with rich cultural heritages, CORPOS can include local artists, historians, and cultural institutions to integrate local history and culture into the learning process, enhancing student identity and engagement.
- **Public Health Campaigns and Wellness Initiatives** – Collaborating with local health organizations, sports clubs and recreational centres to address public health issues through school projects can sustain interest and impact and promote physical education and team building. Collaborate with health departments to address public health issues, integrating health science into the curriculum while contributing to community well-being.
- **Art and Science Fusion** – Projects that fuse art and science, collaborating with local artists and scientists to explore scientific concepts through creative expressions, making science more accessible, multifaceted and engaging and integrating arts into STEM (STEAM) projects.

2.5 How to overcome the obstacles and difficulties in CORPOS functioning

Implementing CORPOS (Open Schooling Team) effectively requires addressing the various obstacles and difficulties that can hinder its functioning. While the goals of fostering open schooling are ambitious and valuable, the challenges encountered in practice can range from a lack of resources and organization to issues with communication, sustained participation, and community engagement. This guide provides practical strategies to overcome these challenges and build a robust, dynamic CORPOS that can thrive despite common obstacles:

- **Lack of Resources** – Ensure sufficient resources and time are dedicated to CORPOS activities. Identifying and securing resources early on can address potential material and logistical challenges, ensuring that the CORPOS has the necessary support to sustain its activities. Address time constraints and workload by clearly defining roles and expectations. Explore various funding streams to reduce dependency on a single source. Assess available resources and potential barriers to effectively plan and mitigate challenges. Schools and educational authorities can designate specific time within teachers' schedules for CoP planning and activities, thereby reducing the additional

burden. Financial and logistical support from local government or educational bodies can be sought to cover materials, transportation, and other essential resources. Furthermore, forming partnerships with local organizations that can donate resources or spaces can mitigate funding challenges and enhance the implementation's quality.

- **Lack of Organization** – Appointing a dedicated coordinator for the CORPOS (e.g., an Open Schooling Team Leader) can help manage logistics, communication, and project tracking, alleviating administrative burdens on teachers.
- **Communication and Collaboration Problems** – Establish robust communication platforms for ongoing dialogue and updates. Utilize a variety of communication tools to ensure all members are informed and can contribute effectively. Utilizing online collaboration tools can facilitate easier planning and sharing of resources, especially in diverse communities. Use social media platforms to maintain a vibrant community presence, share successes, and recruit new members, thus keeping the momentum and visibility high.
- **Burnout and Lack of Sustained Participation** – Allowing for flexible levels of involvement in CORPOS activities can accommodate the varying availability of members, reducing burnout and ensuring sustained participation. Developing a clear framework for roles and responsibilities within the CORPOS can help ensuring active participation and minimizing workload issues. External partnerships can provide additional support and resources, mitigating time and resource constraints. Creating peer support mechanisms within the CORPOS allows to share challenges, solutions, and moral support, reducing feelings of isolation or overwhelm. Acknowledge contributions and celebrate successes to maintain motivation and commitment among members.
- **Lack of Ownership Sense** – Encourage leadership and autonomy within the CORPOS to foster a sense of ownership and commitment to the open schooling process.
- **Conflicts Between Members** – Implement strategies for addressing disagreements or misalignments in objectives among members.
- **Problems in Members' Capacity** – Focus on building the capacity of all members through shared learning experiences and cross-training. Develop and utilize impact measurement tools to demonstrate value and support continuous improvement. Providing ongoing training opportunities for CORPOS members can help address the evolving challenges of open schooling, ensuring that the group remains effective over time.
- **Difficulties Anticipating Problems and Obstacles** – Implementing regular feedback mechanisms within the CORPOS can help identify and address emerging challenges before they become obstacles, fostering a proactive approach to problem-solving. Remain flexible in planning to accommodate changes in school priorities, community needs, and available resources. Continuously assess and realign the CORPOS's goals with the evolving needs of the school community. Be prepared to adjust roles, goals, and activities based on feedback and evolving circumstances.

- **Lack of Community Engagement** – Establishing strong, mutually beneficial relationships is key. Schools can organize initial information sessions to explain the value of CORPOS and actively seek input from community members on project themes that address local needs. Engaging influential community figures or organizations from the onset as champions of the initiative can also increase visibility and support. Additionally, sharing positive outcomes with the community and recognizing partners' contributions can foster ongoing commitment. Increase efforts to engage the wider community through public events, showcasing the benefits of open schooling.

3. CoP and SSIBL: Pedagogical Elements

3.1 The Community of Practice (CoP)

3.1.1 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.

3.1.2 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.

3.1.3 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.

3.1.4 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.

3.1.5 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.

3.1.6 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

3.2 The Socio-Scientific Inquiry-Based Learning (SSIBL) approach

3.2.1 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

3.2.2 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.

3.2.3 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.

3.2.4 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.

3.2.5 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. The Teacher Professional Development (TPD)

Implementing open schooling transformation processes according to the COSMOS approach requires robust teacher professional development (TPD) initiatives. The success of these initiatives depends on effective planning, flexibility, and adaptability to different contexts. This comprehensive overview provides actionable insights to guide schools in creating successful TPD initiatives, ultimately enhancing the educational experience and fostering meaningful community engagement.

4.1 How to Implement Teacher Professional Development Initiatives with the Aim of Developing Their Understanding of the COSMOS Approach?

Implementing Teacher Professional Development (TPD) initiatives to deepen teachers' understanding of the COSMOS approach involves a structured, reflective process that builds on the COSMOS principles of open schooling and community-engaged science education. The initiative is designed to empower teachers as change agents, enhancing their capabilities to connect science education with socio-scientific issues (SSIs) through collaborative and inquiry-based learning. It should include several key aspects:

- **Familiarization with the COSMOS Approach and Core Concepts** – TPD initiatives begin with introducing teachers to the foundational principles of the COSMOS approach, emphasizing open schooling and the integration of SSIBL (Socio-Scientific Inquiry-Based Learning) pedagogy. This stage involves structured orientation sessions where teachers are introduced to the theory and goals of COSMOS—creating educational experiences that connect science education to real-world issues within the community. Teachers explore concepts such as Communities of Practice (CoPs), Core Organizational Structures for Promoting Open Schooling (CORPOS), and the open schooling model, which collectively form the basis of COSMOS.
- **Developing CoP-based Learning Units with SSIBL** – Once teachers understand the theoretical framework, they move into the practical application by forming CoPs with community stakeholders, including local experts, government representatives, and parents. Through workshops and collaborative meetings, teachers work with these CoPs to select relevant SSIs that resonate with both the students' lives and the community's needs. This phase includes co-designing learning units based on the SSIBL model, encompassing the stages of "Ask," "Find Out," and "Act." Teachers gain hands-on experience by planning activities that encourage students to investigate SSIs and propose actionable solutions, deepening their understanding of the inquiry-based learning process within the COSMOS context.
- **Facilitating Reflective Practice** – Reflection is integral to the TPD process within COSMOS, allowing teachers to critically assess their implementation of open schooling and SSIBL pedagogy. Reflection sessions are structured at each stage of the TPD process,

enabling teachers to consider their experiences, share challenges, and identify areas for improvement. Reflection workshops are organized to encourage teachers to discuss their experiences in a supportive setting. By revisiting their initial COSMOS framework understanding and reflecting on its application, teachers develop a deeper comprehension of open schooling and its benefits for science education.

- **Contextual Adaptation and Flexibility** – Implementing COSMOS-based TPD also requires adapting training to the specific contexts and needs of each school. COSMOS supports this by offering guidelines and materials tailored to different educational settings. Adaptation includes considerations such as the school's openness level, the community's needs, and available resources. For instance, rural schools may focus on SSIs that affect agricultural practices, while urban schools might address issues like pollution or urban development. Contextual adaptation ensures that TPD is relevant, feasible, and impactful, enhancing teachers' readiness and motivation to implement COSMOS concepts effectively.
- **Empowering Teachers as Community Connectors** – COSMOS TPD underscores the role of teachers as community liaisons who connect students with external stakeholders. By participating in CORPOS, teachers collaborate with community experts, ensuring that the SSIBL-based units are enriched with real-world insights and practical relevance. This empowers teachers to foster partnerships that enhance the educational experience and equip students with the skills to engage with local and global challenges, positioning teachers as facilitators of community-inclusive education.
- **Continuous Support and Resources for Sustainability** – Sustainability is a core goal in implementing TPD within COSMOS, necessitating ongoing support through resources, workshops, and feedback mechanisms. Resources include the COSMOS TPD Handbook, which provides detailed guidelines, case studies, and examples from successful implementations across various contexts in both the primary and secondary education levels. HEI partners play a vital role by offering expertise and ensuring continuous engagement through follow-up sessions and troubleshooting meetings, and teachers and schools could seek to develop relationships with HEI with experience in teacher education that can support TPD This long-term support system ensures that teachers retain their COSMOS insights and can sustain open schooling practices, even beyond the project's life cycle.

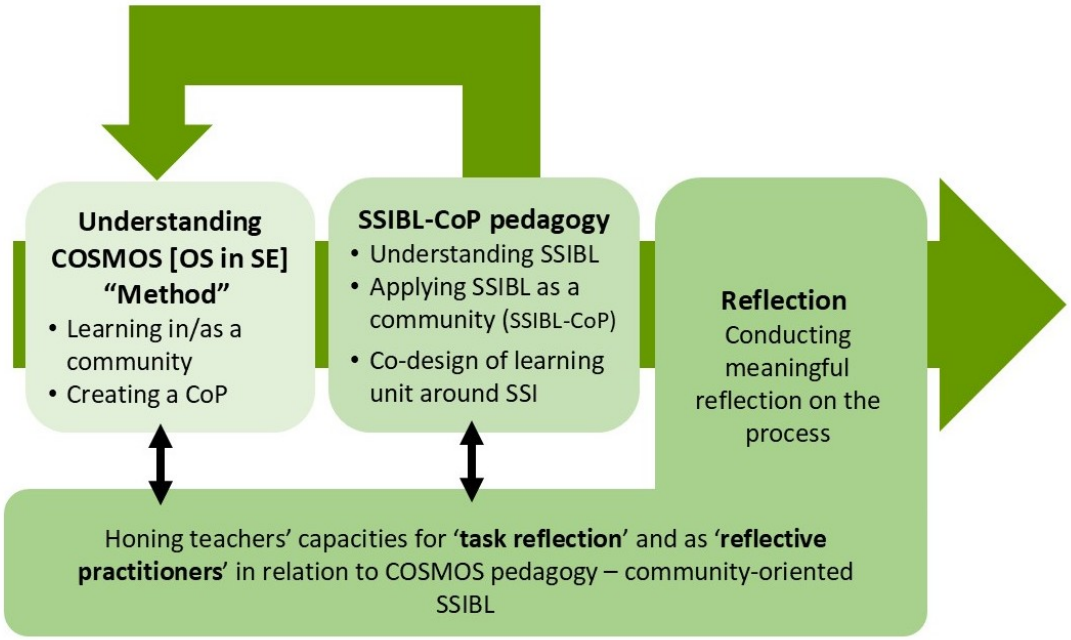

Figure 1 TPD model of conceptual components for open schooling in science education

4.2 When to implement teacher professional development initiatives?

Implementing Teacher Professional Development (TPD) initiatives to cultivate teachers' understanding of the COSMOS approach involves strategic timing that aligns with the school year, community engagement opportunities, and iterative learning cycles. These initiatives are most effective when introduced progressively, allowing teachers time to internalize the COSMOS principles and integrate them into their teaching. Some examples of optimal timing for implementing COSMOS-based TPD initiatives:

- **Early in the School Year for Foundational Orientation** – The initial stages of COSMOS-based TPD should occur early in the school year to establish a foundational understanding of open schooling, SSIBL (Socio-Scientific Inquiry-Based Learning), and COSMOS principles. This early start is ideal for orienting teachers with the COSMOS goals and framework, equipping them with a conceptual grounding before they begin integrating SSIBL activities into their lesson plans. In practice, introductory sessions can include workshops and seminars on COSMOS's core concepts, such as the importance of community integration in science education and the role of CoPs (Communities of Practice). Launching the TPD early also allows teachers to begin the school year with a fresh perspective on science education, aligning their plans and objectives with COSMOS ideals from the outset.
- **Before the Start of Collaborative SSIBL Project Planning** – The COSMOS approach involves teachers co-designing SSIBL units with community stakeholders, such as local experts, researchers, and policymakers, within CoPs. To prepare for this collaboration, it

is crucial to implement TPD prior to the actual planning and co-design phases. This timing enables teachers to understand the SSIBL model's structure—"Ask, Find Out, Act"—and appreciate its importance in addressing socio-scientific issues relevant to students' lives. Conducting TPD before collaborative planning fosters a productive and confident environment, ensuring that teachers are ready to contribute effectively to CoP meetings and align with the community partners' expertise and expectations.

- **Mid-year for Reflection and Adaptation** – Midway through the academic year is an ideal time for TPD sessions focused on reflective practice. As teachers implement initial SSIBL-based lessons, they benefit from structured reflection sessions facilitated by different stakeholders. These sessions help teachers to assess their progress, share challenges, and identify areas for adaptation or improvement. Implementing TPD at this stage capitalizes on teachers' recent experiences, offering them a timely opportunity to reflect on their engagement with students and CoPs. This reflective practice is integral to refining their understanding of COSMOS and ensuring that their teaching methods align with the project's objectives.
- **At Key Points of Community or CoP Engagement** – COSMOS emphasizes strong community involvement, and TPD sessions are most impactful when timed to coincide with critical moments of community engagement, such as planning phases, stakeholder meetings, or feedback sessions. For example, holding TPD workshops before major CoP meetings can reinforce teachers' understanding of their roles as facilitators and help them strategize on effective collaboration with external partners. Aligning TPD with these key community interaction points ensures that teachers are well-prepared to represent their educational goals, foster constructive dialogue, and sustain relationships with community members who contribute to the open schooling approach.
- **End-of-Year Sessions for Consolidation and Future Planning** – As the school year concludes, TPD initiatives can focus on consolidating teachers' learnings, assessing the impact of SSIBL implementations, and preparing for future cycles. This stage allows teachers to reflect on the year's achievements and challenges and consider improvements for the upcoming academic year. End-of-year TPD sessions often involve a comprehensive review of COSMOS principles, sharing best practices across schools, and discussing ongoing support needs. This timing is beneficial for fostering a sense of accomplishment, promoting sustainability, and establishing goals for deepening the COSMOS approach in the following year.

4.3 Where to implement teachers' professional development initiatives?

Implementing Teacher Professional Development (TPD) initiatives focused on deepening teachers' understanding of the COSMOS approach is most effective when strategically situated in diverse educational and community settings. COSMOS-based TPD aims to foster open schooling through place-based learning environments that enable meaningful connections between schools, communities, and local experts. Some examples of optimal settings for COSMOS-based TPD initiatives:

- **School-Based Learning Environments** – TPD sessions held within the teachers' own schools provide a familiar setting that supports immediate practical application and contextualization. School-based training allows TPD facilitators to tailor COSMOS principles, such as Socio-Scientific Inquiry-Based Learning (SSIBL), to the unique needs of each school's educational environment. When teachers engage in TPD sessions on campus, they can readily discuss specific challenges and opportunities related to their own classrooms, making it easier to incorporate SSIBL practices. Additionally, implementing TPD directly in schools reinforces the establishment of Communities of Practice (CoPs) with internal stakeholders, including school administrators and colleagues, fostering a strong support network essential for the sustainability of open schooling.
- **Community-Linked Settings for CoP Collaboration** – Community-oriented locations, such as libraries, community centres, or environmental organizations, provide valuable contexts for TPD sessions, especially those focused on establishing and collaborating with CoPs. Conducting TPD outside school premises helps teachers connect with local experts and community partners who bring additional insights into relevant socio-scientific issues (SSIs). For instance, a TPD session held at a local science museum or environmental organization enables teachers to explore how their curriculum can include hands-on activities related to sustainability, biodiversity, or public health. These community-linked settings encourage teachers to expand their educational perspectives and recognize the importance of integrating external expertise into student learning.
- **Higher Education Institutions for Access to Academic Expertise** – Higher Education Institutions (HEIs) serve as an ideal venue for TPD sessions aimed at grounding teachers in the theoretical aspects of the COSMOS approach. HEIs provide access to academic experts, researchers, and resources that enhance teachers' understanding of open schooling, SSIBL, and inquiry-based pedagogy. Sessions held in universities or colleges often include workshops, lectures, and discussions facilitated by experts who can guide teachers in aligning COSMOS principles with broader educational research and pedagogical theories. Additionally, HEI-hosted sessions reinforce collaboration between teachers and academic partners, fostering a network that supports continuous learning and professional growth.
- **Virtual Platforms for Flexible, Ongoing Support** – Online platforms are increasingly valuable for delivering flexible and accessible TPD, particularly for schools in remote areas or those requiring ongoing support. Virtual TPD sessions, webinars, and discussion forums allow teachers to engage with COSMOS principles regardless of geographic limitations, making these sessions highly inclusive. Virtual settings also enable HEI partners and TPD facilitators to offer regular check-ins, share resources, and encourage peer-to-peer exchanges across schools and regions. This online format is particularly effective for follow-up and reflection sessions, where teachers can discuss implementation challenges, share successful practices, and reinforce the open schooling approach within their specific contexts.

- **Environmental and Real-World Contexts for Experiential Learning** – Taking TPD initiatives into real-world settings related to SSIs—such as nature reserves, conservation sites, or healthcare facilities—provides experiential learning that enhances teachers' understanding of SSIBL's real-world relevance. In these environments, teachers can observe the impact of socio-scientific issues firsthand, allowing them to better relate these issues to classroom learning. For example, a TPD session at a local conservation area could focus on sustainability and biodiversity, showing teachers how to translate these themes into inquiry-based classroom activities. These settings reinforce COSMOS's objective to bridge science education with community engagement, equipping teachers to bring relevant and impactful learning experiences to students.

4.4 How to structure teacher professional development initiatives?

Structuring Teacher Professional Development (TPD) initiatives to deepen teachers' understanding of the COSMOS approach requires a phased, collaborative, and reflective framework. This structure enables teachers to gradually adopt the open schooling principles of COSMOS and effectively implement Socio-Scientific Inquiry-Based Learning (SSIBL) within their classrooms and communities. By integrating theoretical foundations, practical application, and ongoing support, the TPD framework promotes sustainable and meaningful science education. The key components for structuring COSMOS-based TPD are:

- **Phase 1: Conceptual Foundations and Orientation** – The initial phase of TPD focuses on introducing teachers to the core concepts and goals of the COSMOS approach. This includes in-depth exploration of open schooling, SSIBL, and the role of Communities of Practice (CoPs) in fostering collaboration among educators, students, and community stakeholders. Orientation sessions should emphasize how the COSMOS approach links science education with socio-scientific issues (SSIs), relevant to the students' lives and local context. Through workshops and seminars, teachers develop a strong theoretical foundation that situates their work within the broader objectives of community-focused science education. This phase is also an opportunity to introduce teachers to resources and materials that will support their learning journey.

- **Phase 2: Practical Application through Co-Design and Collaborative Planning** – After gaining a conceptual understanding, teachers move to practical application by collaborating with CoP members, including local experts, stakeholders, and community representatives. In this phase, teachers co-design SSIBL-based learning units centred around SSIs, employing the SSIBL model's stages: "Ask," "Find Out," and "Act." Teachers are encouraged to work together to identify relevant SSIs and develop lesson plans that involve students in inquiry-based learning processes. This stage includes hands-on workshops, group activities, and planning sessions that support teachers in translating theoretical knowledge into actionable teaching strategies. This phase benefits from the inclusion of HEI facilitators, who guide teachers in aligning their curriculum with the open schooling principles of COSMOS.

- **Phase 3: Implementation and Observation in the Classroom** – Implementation is structured to allow teachers to apply SSIBL-based lesson plans in real classroom settings while receiving support from TPD facilitators. Teachers conduct SSIBL activities with students, engaging them in inquiry-driven learning experiences that address chosen SSIs. This phase involves observation by TPD facilitators, CoP members, or HEI partners, who provide constructive feedback to help teachers refine their approach. To support adaptation to specific school contexts, TPD sessions can be customized, providing flexibility in lesson structure, duration, and resources. This experiential phase is essential for teachers to see the impact of COSMOS principles firsthand and to build confidence in implementing open schooling methodologies.
- **Phase 4: Reflective Practice and Peer Feedback** – Reflection is a core component of COSMOS-based TPD, encouraging teachers to critically analyse their experiences in implementing SSIBL and working within CoPs. Structured reflection sessions provide teachers with the opportunity to evaluate what worked well, discuss challenges, and identify areas for improvement. This phase often includes peer feedback sessions, facilitated by TPD coordinators, where teachers can share insights and learn from each other's experiences. Reflection deepens teachers' understanding of open schooling, reinforcing their role as facilitators of inquiry-based science education and helping them refine their approaches for future SSIBL projects. However, the implementation and observation and reflective practice phases are not rigidly separated but occur in an interconnected manner.
- **Phase 5: Continuous Support and Resources for Sustainability** – To ensure that teachers continue to apply and evolve in their use of the COSMOS approach, ongoing support is crucial. This phase involves continuous access to resources, refresher workshops, and follow-up meetings. HEI partners and TPD facilitators play a key role in offering guidance, troubleshooting, and updates on best practices in open schooling and SSIBL pedagogy. Teachers are also encouraged to remain active in their CoPs, sustaining connections with community partners and exploring new SSIs that can enrich students' learning experiences. This support system strengthens the sustainability of the COSMOS approach, allowing teachers to adapt their methods and deepen their engagement with open schooling over time.
- **Additional Structural Elements**
  - **Blended Learning Opportunities**: COSMOS TPD combines in-person workshops, community-based activities, and virtual sessions, providing flexible learning options. This blend allows teachers to engage at their convenience while receiving the full range of training and support.
  - **Resource and Reflection Guides**: Structured reflection guides and instructional resources are provided throughout each phase, enabling teachers to systematically build on their understanding of COSMOS and adapt materials for diverse educational contexts.

4.5 Possible Necessary Adaptations to Teachers' Professional Development Initiatives Conducted by Partners in Each National or School Context

Implementing Teacher Professional Development (TPD) initiatives within the COSMOS framework across diverse national and school contexts requires tailoring strategies to meet specific cultural, logistical, and educational needs. By adapting TPD initiatives to the unique characteristics of each context, the COSMOS project supports meaningful engagement and sustainable adoption of open schooling and SSIBL (Socio-Scientific Inquiry-Based Learning) methodologies. Some examples of possible adaptations for TPD initiatives in national and school contexts:

- **Customization of Content Based on Socio-Cultural Relevance** – COSMOS TPD initiatives often need to adapt the chosen socio-scientific issues (SSIs) and content to align with locally relevant topics that resonate with both students and community stakeholders. For instance, in Sweden, themes like environmental conservation and biodiversity are emphasized to align with local ecological priorities, while in Portugal, topics may include seismic activities due to the region's susceptibility to earthquakes. Adapting SSIBL topics to the socio-cultural context enhances the relevance of COSMOS by ensuring that teachers and students are investigating issues that directly impact their communities.
- **Adjusting Training Methods to Teachers' Familiarity with Open Schooling** – In countries where open schooling is less common, such as some regions in Belgium, TPD sessions may need to focus more on introductory concepts, such as building an understanding of community-based education and developing partnerships with external stakeholders. By contrast, in contexts where open schooling and community engagement practices are already more integrated, such as some schools in the Netherlands, TPD can be more personal needs-based with individual meetings, including SSIBL methodologies and refining existing practices. This adjustment helps build a solid foundation where needed, while allowing for more sophisticated exploration in contexts with an established background in open schooling.
- **Adapting TPD Duration and Intensity to School Schedules and Resources** – School schedules, available resources, and time constraints vary significantly across different national and school contexts. For instance, in Israel, where teachers may have heavier teaching loads, TPD initiatives are adapted to shorter, more intensive sessions that fit within the school year's calendar. In settings where teachers can commit more extended time, TPD may include additional workshops, peer collaboration sessions, and more in-depth SSIBL lesson planning activities. This flexibility ensures that COSMOS-based TPD remains accessible and practical for teachers in varying educational contexts.
- **Language and Terminology Modifications** – Language adaptations are crucial, particularly in countries where English may not be the primary language. For example, in Sweden, COSMOS terminology related to Communities of Practice (CoPs) was adapted, as there is no direct translation for the term; instead, a locally understood equivalent was used to convey the concept of collaborative learning communities effectively. Similarly,

resources and materials are translated and adjusted to ensure that teachers can fully grasp the COSMOS principles without language barriers, which promotes inclusivity and comprehension.

- **Integrating Local Community and Stakeholder Involvement** – COSMOS emphasizes building CoPs that include a diverse range of local stakeholders; however, the availability and engagement level of these stakeholders can differ by context. In urban contexts, such as schools in the UK, partnerships with local museums or environmental agencies are more accessible, while rural schools may focus on engaging local farmers or smaller community organizations. Partners adapt TPD by identifying and involving stakeholders who are relevant and readily available within each community, ensuring that the COSMOS approach is viable and impactful for each school's unique environment.
- **Flexibility in Reflective Practice and Follow-up Support** – Reflective practice is a core element of COSMOS TPD, but how it is structured and followed up varies to align with local educational practices. In contexts like Portugal, TPD follow-up sessions emphasize structured group reflections facilitated by Higher Education Institution (HEI) partners, whereas in other contexts, like Sweden, reflection may be more individualized and integrated into ongoing feedback loops. Moreover, some countries may require additional online support due to geographic limitations or scheduling conflicts, allowing teachers to engage with facilitators and CoP members remotely and ensuring sustained reflection and growth in their SSIBL practices.
- **Tailoring Resources to National Curriculum Requirements** – Each country's educational system has specific curriculum requirements, necessitating adaptations in COSMOS TPD to align with national standards. For example, in Israel, TPD resources are aligned with national science curriculum objectives to ensure that SSIBL units can be seamlessly integrated without compromising mandated content. Conversely, in contexts with more flexible curricula, such as the lower-secondary school levels in the Netherlands, teachers have greater freedom to experiment with SSIBL and open schooling approaches, allowing for more innovative adaptations within the COSMOS framework. Aligning TPD resources with curriculum standards ensures that teachers can implement COSMOS without conflicting with their school's academic goals.

4.6 How to Solve Some Problems associated with Teachers' Professional Development Initiatives?

Implementing Teacher Professional Development (TPD) initiatives within the COSMOS framework has presented several challenges that vary across educational and cultural contexts. Recognizing these weaknesses, obstacles, and difficulties is essential for developing strategies that ensure TPD initiatives can effectively support teachers in adopting COSMOS's open schooling and inquiry-based approaches. Here are some of the significant issues encountered, along with suggested solutions to address them:

- **Limited Time and Scheduling Conflicts** – Teachers often have demanding schedules with minimal time available for additional training, making it challenging to engage consistently in TPD sessions. In some contexts, teachers juggle high teaching loads and

may lack flexibility in their schedules, which limits their ability to fully participate in COSMOS TPD. To address time constraints, COSMOS TPD can be structured as modular, flexible training with short, intensive sessions that fit into teachers' schedules. Virtual TPD components, such as webinars and online resources, can supplement in-person sessions, allowing teachers to engage asynchronously. Additionally, incorporating TPD into existing professional development days within the school calendar can help maximize attendance and minimize disruptions.

- **Insufficient Familiarity with Open Schooling Concepts** – In many schools, teachers may have limited prior experience with open schooling and community-based science education. This unfamiliarity can lead to hesitancy and slow adoption of COSMOS principles, as teachers may feel unprepared to connect classroom learning with community-based SSIBL activities. To overcome this, COSMOS TPD initiatives should start with foundational workshops that introduce open schooling concepts through relatable examples and step-by-step guides. Interactive sessions where teachers work with case studies or simulated SSIBL scenarios can boost confidence and familiarity. Pairing teachers with mentors or experienced educators who can provide guidance on community engagement and open schooling integration is also beneficial.
- **Difficulty in Securing Community Partnerships** – Establishing and sustaining relationships with community stakeholders, such as local experts and organizations, is a core aspect of the COSMOS approach. However, in some regions, these partnerships can be challenging to secure due to a lack of readily available stakeholders or insufficient resources to support collaboration. TPD initiatives can include training on building and managing community partnerships, providing teachers with networking strategies and templates for outreach communication. Encouraging schools to appoint a dedicated community liaison can streamline stakeholder engagement and ensure consistent communication. Additionally, virtual partnerships (e.g., webinars with external experts or virtual field trips) can serve as alternatives where local community partnerships are not feasible.
- **Resource Limitations and Lack of Funding** – Implementing SSIBL activities often requires materials, transportation, or external resources, which may be beyond the budget of some schools. Resource constraints can limit the scope of TPD sessions and the practical application of COSMOS principles, particularly in under-resourced educational settings. COSMOS can seek to provide resource kits or low-cost activity ideas that allow teachers to conduct SSIBL with minimal materials. Additionally, offering training on grant writing or identifying local sponsorships can empower schools to secure additional funding. Virtual components of SSIBL activities, such as online data resources or virtual experiments, can also help reduce dependency on physical resources while still providing an interactive learning experience.
- **Resistance to Pedagogical Change** – Teachers accustomed to traditional science education methods may be resistant to adopting new pedagogies, particularly if these methods demand significant changes to their teaching style. The COSMOS approach, which emphasizes community-oriented and inquiry-based learning, can be perceived as

a departure from conventional curricula, leading to hesitation. To ease this transition, TPD can include gradual, scaffolded training that allows teachers to integrate COSMOS principles incrementally. Starting with small, manageable SSIBL activities within the classroom before moving to full community-based projects can help teachers adapt comfortably. Showcasing success stories and testimonials from other teachers who have implemented COSMOS successfully can also help reduce resistance by demonstrating the approach's practical benefits.

- **Language and Cultural Barriers** – In multilingual or multicultural contexts, language barriers and cultural differences can hinder teachers' understanding of TPD content and their ability to implement it effectively. In some regions, there may not be direct translations for key COSMOS concepts, leading to potential misunderstandings. Providing TPD materials in multiple languages and adjusting terminology to be culturally relevant are crucial steps. COSMOS should involve local facilitators who understand cultural nuances and can translate concepts into locally resonant ideas. Visual aids, simplified language, and real-world examples can further support teachers' understanding, especially when direct translation isn't feasible.
- **Challenges in Aligning TPD with National Curriculum Standards** – Different countries have specific curriculum standards, and teachers may struggle to reconcile COSMOS's open schooling principles with rigid national curricula. This can limit the degree to which teachers feel they can apply COSMOS methodologies within their prescribed teaching frameworks. COSMOS TPD should include a curriculum-mapping component that guides teachers on how to align SSIBL activities with existing curriculum standards. Providing templates and examples of how COSMOS principles can support national learning outcomes can help teachers see the compatibility between open schooling and their curricula. Flexibility in SSIBL topic selection, allowing teachers to choose themes that naturally complement national standards, can also facilitate alignment.

NOTE: For more information on the COSMOS Teacher Professional Development, please access this link: https://www.cosmosproject.eu/assets/front/files/repository/tpb_handbook_cosmos.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

Policymakers play a vital role in supporting the sustainability of the COSMOS approach by integrating open schooling principles into national education frameworks. This may include revising curricula to encourage SSIBL-based inquiry and project-based learning as core components of science education. Policies that incentivize or fund professional development opportunities in open schooling can further support schools in adopting and maintaining the COSMOS approach.

5.2 Strengthening Community and Stakeholder Engagement

Policymakers can foster sustainability by supporting policies that incentivize community involvement in schools. Grants, tax benefits, or recognitions for organizations that actively participate in school activities can encourage more community members to engage with the COSMOS approach. Creating platforms for networking between schools and local organizations also makes it easier for schools to connect with potential partners.

5.3 Ensuring Continuous Teacher Professional Development (TPD)

Sustaining the COSMOS approach requires that policymakers support PD programs focused on open schooling. Funding PD programs, establishing regional centres for SSIBL training, or offering accreditation for teachers skilled in open schooling methods incentivize continued growth. Furthermore, policies that mandate PD in inquiry-based and community-focused learning make it easier for schools to maintain the COSMOS approach.

5.4 Integrating COSMOS into School Curricula and Policies

Policymakers can support curriculum integration by creating flexible standards that allow for the inclusion of open schooling and SSIBL activities. Funding pilot programs that test SSIBL integration in different subjects can provide insights into effective strategies for implementation. Policies that acknowledge and reward schools successfully using SSIBL practices encourage the adoption of COSMOS at a systemic level.

5.5 Monitoring and Evaluating Impact

Policymakers play an essential role in sustaining COSMOS by supporting research initiatives that measure the long-term impacts of open schooling. Establishing metrics for SSIBL success, funding longitudinal studies, and disseminating findings at national or regional levels help create a data-driven foundation for COSMOS's ongoing implementation. Publishing case studies of successful COSMOS schools provides valuable models for others to follow.

Project partners

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Universiteits Museum Utrecht

Winchester Science Centre & Planetarium

Winchester Science Centre (WSC), England

Alma Löv Museum, Sweden

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