



D2.1 COSMOS open schooling framework for open schooling in science education for responsible citizenship

including generic guidelines, tools and exemplifying scenarios

COSMOS Framework

Deliverable Documentation Sheet

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Introducing the COSMOS theoretical framework

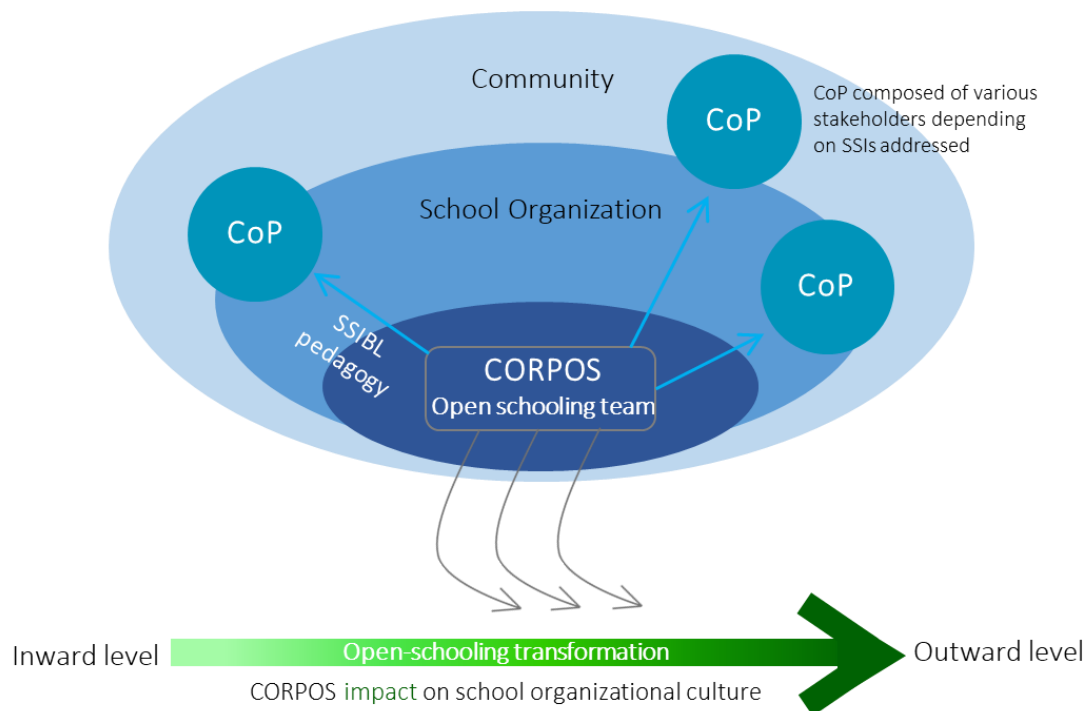


Figure 1. Components and process of open schooling transformation in COSMOS

The COSMOS (“Creating Organisational Structures for Meaningful Science education through Open Schooling for all”) theoretical framework provides the conceptual and methodological basis for understanding the COSMOS approach to open schooling, along with the main concepts composing it (Figure 1). As such, the framework provides educational decision-makers, teacher educators and practitioners, coming from different educational contexts, a common and general conceptual ground for implementing the COSMOS open schooling approach in schools. The framework accommodates and supports the other COSMOS core resources (such as the COSMOS [roadmaps](#), [policy briefs](#) available in various languages ([English](#), [Dutch](#), [Portuguese](#), [Flemish](#), [Swedish](#), [Hebrew](#), and [Arabic](#)), and the [Teacher Professional Development Handbook](#), by offering educational decision-makers and practitioners a more in-depth explanation of the COSMOS concepts, their interrelations and usability, as represented in Figure 2.

COSMOS Core products

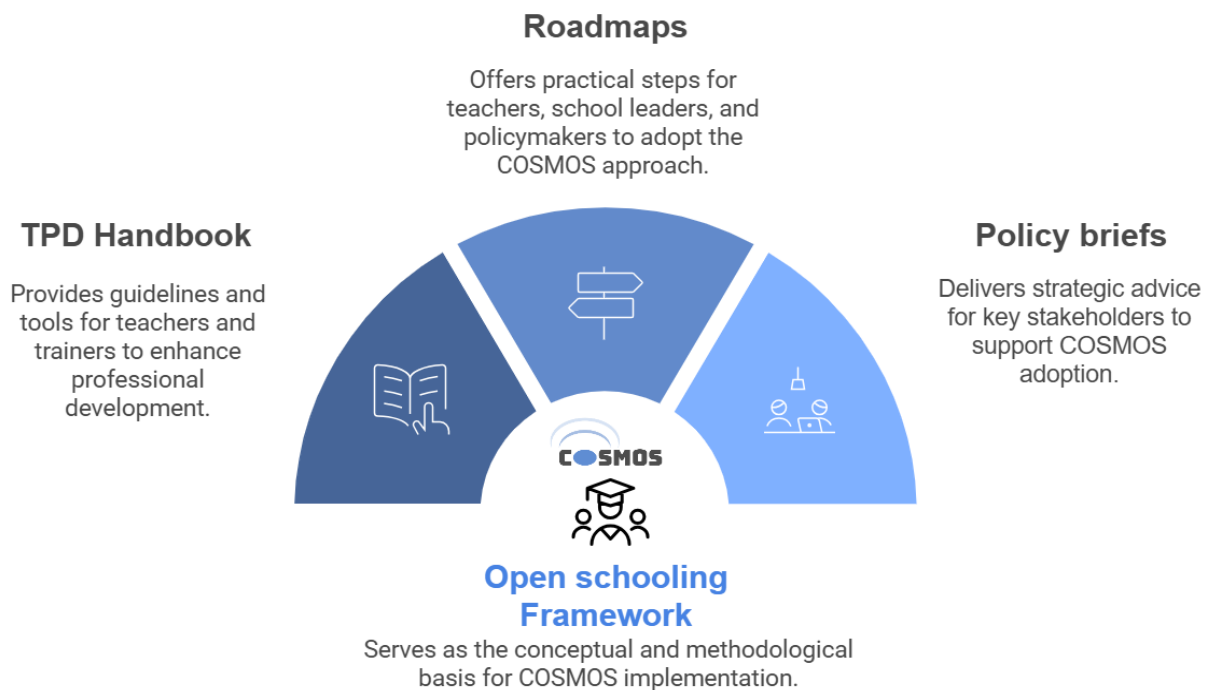


Figure 2. A summary of the COSMOS Open Schooling pathways

The COSMOS framework begins by illuminating the rationale for adopting an open schooling approach and its contributions for schools in general and for science education in particular, especially in the current sociocultural climate in Europe. In line with the European Commission’s agenda to promote meaningful science education and promote the uptake of scientific careers through open schooling, the COSMOS approach contributes to a viable and sustainable implementation of open schooling by offering a holistic and systematic understanding of how to promote organisational change toward opening schools to the community, and of the pedagogies and teacher identities supporting schools to work as, with and for the community. In the tradition of John Dewey, the COSMOS framework reflects the deep interconnections among scientific inquiry and innovative exploration, democratic engagement and responsible citizenship, individual and social growth, and the addressing of social problems. Accordingly, the COSMOS approach is in line with Vision II and Vision III of scientific literacy and science education to develop this literacy. Vision II focuses on contextualising scientific knowledge for everyday life and its societal meaning. Vision III takes this further emphasizing values, political aspects and critical global citizenship education (Sjöström & Eilks, 2018). The COSMOS open schooling approach, and the community-oriented Socio-Scientific Inquiry-Based Learning (SSIBL) pedagogy that is incorporated in it (SSIBL-CoP), is aimed at equipping young people with competences needed to deal with key societal challenges (Hodson, 2003) and to critically engage with local, global and intercultural issues through interacting respectfully with others, appreciating different perspectives and taking responsible action (i.e., “Global competences”) (OECD, 2018).

The theoretical framework elaborates on each of the core concepts of COSMOS: school openness dimensions (ecological model of school openness), CORPOS, CoP, and SSIBL and then outlines the interrelations among them for applying the COSMOS approach in schools (see Figure 1). Each core concept is first presented and discussed separately to enhance coherency and articulateness. This conceptual basis provides the infrastructure for presenting integration tools that illuminate the interconnections among the key concepts.

The exemplifying scenarios offer educational decision-makers and practitioners more practice-based resources for applying COSMOS (and a community-oriented SSIBL pedagogy) that is inspired by real experiences taken from implementing COSMOS in school as part of the project. These exemplifying scenarios offer a more practice-based understanding of the open-schooling transformation process: the mindful, gradual, and context-sensitive movement from inward to outward along the various school openness dimensions.

The framework is structured to support educational decision-makers and practitioners to find the relevant information they need to implement the COSMOS approach more efficiently and meaningfully and this includes the use of Q&A format. It aims to provide decision makers and practitioners a general conceptual understanding of the COSMOS open-schooling approach, and serves, together with the various COSMOS practice-based resources, to guide and support the implementation of the COSMOS approach in different educational contexts.

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Glossary

Alma Löv	Alma Löv Museum of Unexp. Art
BBC	Beit Berl College
COSMOS	Creating Organizational Structures for Meaningful science education through Open Schooling for all
CoP	Community of Practice
CORPOS	Core ORganisational Structure for Promoting Open Schooling
HEI	Higher Education Institution
IE-UL	Instituto de Educação da Universidade de Lisboa
KdG	Karel De Grote Hogeschool katholieke hogeschool
KU	Karlstad University
MoE	Ministry of Education
SSI	Socio-Scientific Issue
SSIBL	Socio-Scientific Inquiry-Based Learning
SOUTHAMPTON	University of Southampton
STEM	Science Technology Engineering Mathematics
TPD	Teacher Professional Development
UU	Utrecht University
WSC	Winchester Science Centre

1. Social Context and Rationale: the case for applying the COSMOS open schooling approach

‘Open schooling’ has been reintroduced in recent years as a burgeoning theme in the discourse on how to rethink education for the 21st century and transform schools into better, more relevant, and adaptable organisations (EC, 2015, 2024; OECD, 2020). This rearticulation of ‘open schooling’ has been spearheaded by recent reports by the OECD (2006, 2020), such as the OECD scenarios for the future of schooling and the European Commission’s (EC, 2015) Science Education for Responsible Citizenship, which call for transforming schools into ‘hubs of learning’ by opening school walls, fostering collaborations with the community, and engaging in innovative research. Opening schools to the community and engaging in Responsible Research and Innovation (RRI) is claimed to offer students (and society at large) the necessary knowledge, skills, and values to successfully perform in 21st century societies, and act as responsibly engaged citizens who are motivated to address a wide range of burning social issues (Sotiriou et al., 2017). This transformative shift towards developing action competent students (Sass et al., 2020) as an aim of school organisation and curriculum requires a root-and-branch reform (Sotiriou et al., 2021). Open schooling is, therefore, regarded as a sea change reform, a reschooling vision, that is aimed at rearticulating the central mission, goals and curriculum of schools, into ‘core social centres’ and learning organisations (OECD, 2020).

Decision-makers and practitioners who may (justifiably) be suspicious of yet another school reform, may question the need and practicability of considering a profound and comprehensive change in the way science is taught in schools and how school is structurally organized. Given that motivation is key in the application of any change process, in what follows we offer a rationale for applying an open schooling approach. The rationale refers to various interrelated claims regarding the present challenges of education and science education in the current sociocultural climate in Europe. The main argument here is that applying open schooling not only offers schools an innovative and favourable approach to science education and school organisation, but also can be seen as a powerful solution to deep-seated challenges facing schools in the current reality. The following are some of the central social issues that we argue substantiate the need and merits of open schooling in general, and the COSMOS approach in particular.

Social isolation, radical individualization and loss of community. The increasing processes of individualization and the breaking up of traditional social structures (e.g. religious and ethnic communities, social institutions) is a well-known phenomenon of the last several decades (e.g., Bauman, 2005). Processes of radical individualization have been enhanced, especially in the last decade, by the ubiquitous and intensive use of social media, especially by children and young people, which has led to growing social isolation, anxiety, and a sense of loss of community (at least as this concerns the non-digital world) (Haidt, 2024). Open schooling is meant to reinvigorate the ties between school and the community, and by so doing, reconnect individuals to a sense of belonging to a community, to an understanding of the merits of collaboration, of reestablishing relationships within the school and with external stakeholders. The calls to transform schools into a community are certainly not new (Sergiovanni, 1994) yet given the breakdown of real-world interactions and relationships and the increasing retreat of individuals

into a socially isolated digital space, makes the need to apply open schooling particularly critical and constitutes a central aim of education.

A mental health crisis – anxiety and depression. Closely related to the above, social psychologists have been raising awareness and deep concerns with regards to the alarming increase in mental health related issues, i.e., anxiety and depression, especially among children and teens. The causes of these phenomena are certainly complex, but a central cause that has been found to be strongly correlated is the exponential growth in the use of digital media and social media, which causes low self-esteem, social isolation, a distorted and disintegrated sense of reality, and a loss of purpose (e.g., Haight, 2024). The return to real-world social interactions and establishing deep collaborations and relationships among individuals is considered a central response to the current mental health crisis and for developing personal resilience, wellbeing, and confidence in one's own ability to meaningfully contribute to collective actions towards addressing real-world problems. Acknowledging the social-emotional (communal) aspects of learning, which are a central aspect of open schooling, is increasingly acknowledged as being essential to the uptake of knowledge by learners and for creating the necessary conditions to learn especially in a social reality that is characterized by growing instability and uncertainty (Hadar et al, 2020).

Cultural diversity and European citizenship. Europe is becoming increasingly culturally diverse with growing waves of immigration in the last two decades. This new cultural reality in many European countries necessitates a reconsideration of how to learn in more culturally diverse learning environments, which includes tackling language barriers and learning gaps. Connecting school learning to the community and its problems allows schools to transform these problems into learning opportunities and to develop among learners the understanding and competences to bridge cultural divides and to reimagine more culturally diverse identities. Rather than simply addressing cultural diversity within schools with the limited resources that are available to schools, learning in, with and as a community constitutes a favourable environment for tackling and harnessing cultural diversity as part of the curriculum, engaging learners with each other and others from the community, and transforming the problems of the community into a resource for learning. The attitudes and competences that are facilitated by applying open schooling are precisely tailored to the development of more intricate and tolerant identities and complementary modes of engaged citizenship.

Science education, RRI, social complexity and problem solving. Open schooling is inextricably tied to Responsible Research and Innovation (RRI). The idea of opening the school to the community not only promotes real-world interactions among schools and community stakeholders but is also deeply connected to the engagement of schools and their communities with social issues and problems. In line with 21st century skills discourse, open schooling is fundamentally about fostering the skills to investigate and analyse the objective and social reality by applying critical thinking, creativity and collaboration. These skills and competences are directed at social problem solving. In the context of open schooling, science education cannot be detached from authentic real-world issues, entailing the inclusion of ethical and value driven discourse emphasized in science education's Vision III. It is increasingly acknowledged that societal problem solving is becoming increasingly complex, given the complexity of social systems and ensuing issues. What is needed is a cooperative endeavour, a mode of learning, that investigates social-scientific issues by facilitating cooperation and collaboration, by analysing social problems from different perspectives and from the standpoint of conflicting interests. Tying learning to authentic problems, engaging learners with social issues through intricate and

nuanced understandings ultimately leads to ‘better’ science education. Open schooling aims to increase students’ interest in science, perceived relevance of science and possibly pursue scientific careers in the future, which in-itself is a considerable social issue that European countries are currently addressing. In the long term these efforts should develop student participation in wider society, building their knowledge of their own action possibilities, boosting their confidence in their own capacity to act and ultimately their willingness to act for a more sustainable world.

1.1 What is the specific contribution of the COSMOS approach to open schooling?

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. Three 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);
- (2) A specific focus on the creation of organizational structures to support the implementation and sustainability of open schooling (CORPOS – Open Schooling Team);
- (3) A pedagogy that supports the learning of science as, with and for the community (SSIBL-CoP).

In this theoretical framework we articulate and elaborate on 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., [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 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 to addressing social issues, thereby to an education that cultivates in individuals and communities the necessary values, knowledge and competences to both realise themselves and contribute to the society.

This comprehensive vision, however, is not detached from practice and is complemented by three principles of implementation: *multiplicity, graduality and adaptability/agility*.

- **Multiplicity** refers to the multiple dimensions of openness – as will be discussed below in the discussion of the ecological model of school openness. There are a variety of ways (dimensions) in which openness can be applied, either in terms of school organization, school pedagogy or its relations with the community. While all these aspects of openness are associated with applying open schooling, the ecological model of school openness that we developed assumes that there are different ways to open the school to the community and each school applying the COSMOS approach will or can decide to put an emphasis on different dimensions of openness.
- **Graduality** entails that opening schools and school learning to the community is a gradual process that should be seen as a movement along a continuum from ‘inward’ (schools are mostly directed to processes inside the organization) to ‘outward’ (schools engage in deep collaborations with community stakeholders). As such, each school will decide the extent to which it moves outward on each of the openness dimensions and opens itself to the community. Moreover, the precise understanding of what it means to move outward on each of the dimensions may be influenced by the specific school attributes in a specific context; many different (internal and external) factors (see [TPD handbook](#)) may be involved in the way a school moves on the open schooling continuum.
- This leads us to the last principle, **adaptability/agility**. By this we mean that applying the COSMOS approach is not a one-size-fits-all organisational change reform. The COSMOS approach is context-sensitive and is especially sensitive to the specific needs and attributes of each individual school. This may concern, for example, the professional attributes of teachers, the various attributes of the students, the organisational culture, as well as the different characteristics of the national/school curriculum and the approach to change and reform in each context. To these principles of adaptability, we include also the creative and innovative ways in which each school may choose to apply open schooling and engage the educational organisation in its transformation process. These principles of agility and agile leadership are particularly needed in the current VUCA world reality (e.g., Joiner & Josephs, 2006).

We claim that the combination of the various elements of the COSMOS approach provides a rich and holistic framework for applying open schooling in a way that complements the specific motivations and needs of educational teams, school organisation and the current sociocultural conditions. More specifically, given the community-oriented approach of COSMOS the themes of curricular co-design, collaboration, and mutual engagement are built into the very understanding and implementation of the COSMOS open schooling approach. The above three principles of implementation (multiplicity, graduality, adaptability/agility) ensure that applying COSMOS is not only viable – suitable to the specific school context and its organizational culture – but also sustainable, that is, it ensures an ongoing commitment and capacity to open schools to the community. In what follows, we elaborate on each of the different elements of the COSMOS approach. We first present the ecological school openness model (Section 2), which offers school teams a comprehensive understanding of the different dimensions of openness. The model provides the conceptual basis to explore the school’s openness attributes (inward to outward) and to make mindful decisions on how to initiate open schooling change processes in a way that complements the school’s needs and motivations. We then explore the concept of

CORPOS – open schooling team (Section 3), which constitutes an organisational structure that is responsible for continuously promoting open schooling as part of the school’s ongoing practice (just like any other disciplinary team in school). We then present the open schooling pedagogy (Sections 4 and 5) that is composed of two core concepts –Community of Practice (CoP) (Section 4) and Socio Scientific Inquiry Based Learning - SSIBL (Section 5). A central contribution of the COSMOS project is the attempt to integrate principles of learning in-and-as a community with social scientific inquiry-based learning. SSIBL contains three stages of inquiry – ASK, FIND OUT, ACT – all of which are envisioned in COSMOS as applied by the active participation of community stakeholders. In Section 6 we offer educational decision-makers and practitioners integration tools that articulate and illuminate, also through exemplifying scenarios, the relations between the different elements of the COSMOS approach (The ecological model, CORPOS, SSIBL-CoP).

2. The ecological model of school openness

The objective of the COSMOS project is to promote the uptake of an open-schooling approach to science education in a school's pedagogy and more importantly, in its organisational structures and culture. A central knowledge base for realizing the above objective is to gain a deeper understanding of what it means to theoretically and practically apply an open-schooling approach or mindset. To this end, the COSMOS project has devised an ecological model of school openness that is composed of eight dimensions (Sarid et al., 2024). These eight dimensions are based on a conceptual analysis of various interrelated literatures: community-oriented open schooling discourse (e.g., Sotiriou et al., 2017; EC, 2024), the ecological model of school-as-community and community-oriented school leadership and governance (e.g., Furman 2002), learning communities, and communities of practice (e.g., Wenger, 1998), and open system theory (e.g., Mascareñaz & Tran, 2023). The model of school openness discloses an intricate and complex picture of the meaning of openness; and it is precisely its conceptual richness and the complex articulation of openness that it offers that enables school teams to apply open schooling mindfully, authentically and practically.

There are various applications of the school openness model. First, presenting the school openness model provides a sound conceptual basis for discussing with school teams the meaning of the COSMOS open-schooling approach. Addressing each of the dimensions provides school teams an opportunity also to connect the model to the current organizational culture and pedagogical processes that are taking place in the school and to identify the contributions of applying open schooling. Identifying school openness attributes is important for determining the kinds of COSMOS interventions and change processes that are compatible with each participating school. School teams may choose to decide which dimensions are more appealing and meaningful to them and to the community. Additionally, the model can be used for assessment purposes and for school teams' ability to oversee the development of an open-schooling approach.

The following is a circular visualization of the eight dimensions (see Figure 3). The eight dimensions are organised into three distinctive categories: Organization, Pedagogy and Community Relations. It is important to stress that ***all dimensions and categories are interrelated*** – given that all reflect different modes of openness. Some are more strongly interrelated and thus together constitute a different category of openness. The openness categories are themselves strongly interrelated from the perspective of an open schooling approach, and this is indicated visually by the dotted lines separating each category.

Nonetheless, it is still important to distinguish between the categories and the individual dimensions for at least two reasons: (1) the more detailed and richly conceptualised 'openness' is, enhances the school's possibilities to engage in discussion about openness practices. As will be shown below, the openness dimensions, while interrelated, are all distinct from one another, and concentrate on different aspects of openness. Conceptual richness allows for more intricate and nuanced discussions by researchers and practitioners and thus provides the conceptual basis for more meaningful work toward openness. (2) the more detailed and richly

conceptualized openness is, the more possibilities for assessment purposes and empirical investigation.

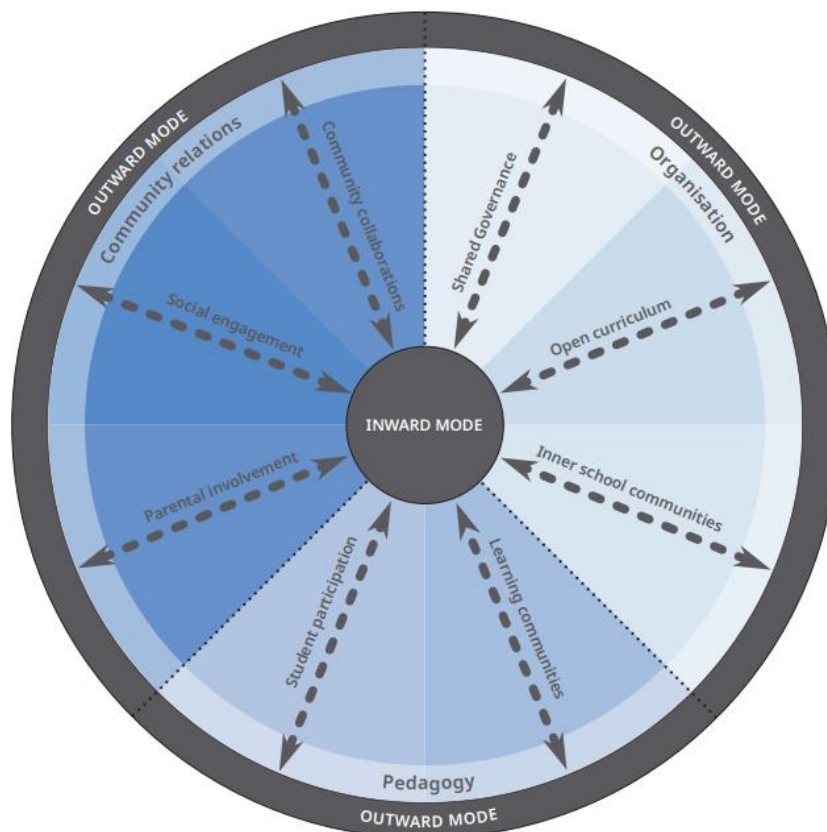


Figure 3. Ecological model of school openness

2.1 Organisational Dimensions: shared governance, open curriculum, inner-school communities

Shared Governance

‘Shared governance’ concerns the extent to which leadership is shared/dispersed/distributed throughout the school organisation and decision-making processes (Hallinger & Heck, 2010; Leithwood et al, 2009). In the present context, ‘governance’ is understood as the authority and capacity to shape the school’s organisational culture and policies and is focused more on formal leadership positions in school (superintendent, principal, formal leadership teams), and the extent to which leadership shares authority, so that others in school (and beyond) may have an impact on the school. Sharing authority is an essential property of open schooling given that open schooling requires, by definition, collaboration between the school and other stakeholders (parents, informal educational organisations, and so forth) who actively participate in decision making processes. Sharing authority has not only been shown to have positive results for team effectiveness (Wang et al., 2014) and student achievement (Leithwood & Mascall, 2008), but also

to have a positive contribution when leadership is shared with parents as well as other members of the community (Bertrand & Rodela, 2017).

Further reading – Shared governance

It should be stressed that there are multiple forms of distributive leadership and shared governance (Spillane, 2005), ranging from more centralised distributions of authority (granting autonomy to school teams or individuals) to deeply collaborative and democratic forms (e.g., Woods, 2018), in which leadership is envisioned more as an action or attribute rather than a role or formal position (Linsky & Lawrence, 2011; Spillane, 2005). From a community-based perspective, the likelihood, motivation and ability to share authority assumes that this takes place not only with stakeholders external to the school organisation, but more importantly, originates in a culture of collaboration and sharing also, and perhaps especially, with individuals within the school organisation. Furthermore, we are also assuming that sharing leadership concerns a deep cultural change in the organisation and is an ongoing process, requiring continuous reassessment and responsiveness, and thus cannot be regarded as a binary practice (Scott & Caress, 2005).

‘Shared governance’ directly impacts other dimensions as well. For example, in the case of ‘inner school communities’ (depicted below), the more impact inner school communities have on shaping policies and pedagogy, the more authority is shared in the organisation. However, the existence of communities within the school, does not necessarily mean that there is also shared authority, in the sense of direct influence on school policy and pedagogy. Thus, a continuum of shared governance can be drawn. Toward the inward pole, school principals and administrators make most or nearly all decisions, and rarely share authority with others in the organisation. At the outward pole, leadership is dispersed throughout the organisation and can mean – with strong movement toward the outward pole - democratic decision making and policy-design in which all members of the school community (including parents and students) reach decisions jointly on meaningful issues concerning school culture and curriculum. In this case, all openness dimensions will certainly be impacted. However, since it is not feasible to share all decision-making processes with all members of the community, given various limitations (Kocolowski, 2010), such as value conflicts, disruption, uncertainty, and time restrictions, ‘shared governance’ involves primarily the organisational level; and pertains to those actions and decisions that directly impact school culture and policy. This will necessarily have an impact on the other two organisational dimensions: ‘curriculum’ and ‘inner school communities’. Radical forms of shared governance must take into account the instability and disruptiveness of distributing authority and sharing leadership, although there are organisational models (i.e., the democratic school) in which shared authority is deeply ingrained in school culture and routines.

‘Shared governance’ is thus a continuum ranging from more centralised to radically collaborative forms of governance’. Inward forms of governance are reflected by the principal or formal leadership teams’ control over most school-learning schedules, exam specifications, and the overall curricular and extra-curricular issues that are addressed by the school. Movement toward the outward pole is reflected in granting teacher autonomy and responsibility around the curriculum, promoting participation of teachers and middle-leadership teams in the design and preparation of teaching materials (especially when this concerns specific school subjects). These decisions may be more strictly or leniently supervised and reviewed by school management.

Open Curriculum

'Open Curriculum' concerns the extent to which school curriculum is adaptive, flexible and accessible to emergent and ongoing changes, as opposed to a fixed or rigid curriculum that is primarily pre-designed and rarely altered to meet changing interests or needs. Generally speaking, 'curriculum' is regularly thought to refer to the body of knowledge that is to be transmitted to pupils in order to realise educational goals (Richmond, 2018). For clarification purposes, 'open curriculum' refers to the extent that the structure and content of learning subjects and the topics within these subjects are open to renegotiation, reorganisation, and innovation. Open curriculum is central to openness because it entails not only fostering relationships, collaboration and sharing authority, which can be seen to promote knowledge sharing and active participation in learning by various stakeholders, but also must include the ability and flexibility to reconsider the topics and contents of learning in accordance with authentic problems of the community, and the ability to overcome rigidly defined disciplinary boundaries that inhibit meaningful engagement with these very problems.

Further reading - Open Curriculum

The openness of the curriculum is intimately related to pedagogical practice, primarily the role of teachers, students, as well as others in deciding what should be learned and how. Yet, since the model differentiates different categories of openness, including organisation and pedagogy, 'open curriculum' primarily focuses on the contents of learning and disciplinary knowledge. To further clarify the differentiation between curriculum and pedagogy-instruction, it may be argued that engaging in alternative and innovative pedagogies can be exercised in the learning of pre-determined and pre-designed contents and bodies of knowledge. Conversely, it is possible to introduce new topics (including interdisciplinary contents) without dramatically altering conventional pedagogical practices. While there are surely overlaps between curriculum and pedagogy, especially in cases in which open schooling is more meaningfully applied, it is beneficial to make such distinctions given that most schools predominantly follow the national curriculum and thus lean more toward the inward pole of the openness continuum. Even more recent curricular reforms across Europe, while granting more autonomy and flexibility to schools to design school curriculums and distribute leadership, as in the Finnish reform (Tian & Risku, 2019), are still predominantly committed to more structured modernist national curriculums that also prioritise scientific disciplines over others (Sarid, 2017). In such cases, the distinction between 'curriculum' and 'pedagogy' becomes paramount for moving the school organisation outward in a manner that best accommodates the school's specific openness attributes.

The more outward the curriculum, the more open it is to change that is propelled by emergent needs and decisions. Curricular innovation may occur in cases where school management actively endorses curricular flexibility or in cases where changes are encouraged bottom-up, that is by students, parents or other community members. The open curriculum continuum expresses the scope of curricular change: it can be limited to certain teams, subjects, or individual teachers, and it can be practised as a whole-school approach, for which curricular openness is ingrained into school culture. Movement outward on the 'curriculum' continuum reflects a movement from 'first order' changes, that is, when the objectives and general aims of the national curriculum remain unchallenged, and some extra-curricular activities are initiated, toward 'second order' changes, that is, engagement in deep structural change in the contents of the

curriculum (e.g., Cuban, 1990). Extremely open curriculums are those in which all elements of the learning process (content, evaluation, teaching method) are negotiated by the participants in learning and are deeply emergent. From this perspective, a significantly open curriculum is one in which the community is the curriculum, or in other words, ‘building and sustaining of community must be seen as an essential part of the curriculum of the school’ (Starratt, 2002, p. 321).

Inner-School Communities

‘Inner-school communities’ refers to the extent to which organisational structures and routines operate in school that have an impact on school policy and decision-making. School organisational structures are composed of several participants that are engaged in the leadership, cultivation and development of certain aspects or themes pertaining to school curriculum and pedagogy. In most schools, leadership is distributed, to varying degrees, to various roles and positions constituting what is frequently termed ‘middle or mid-level school leadership’ (Gurr & Drysdale, 2013). Mid-level leadership roles and positions are regularly organised according to traditional school structures and hierarchies, namely, either disciplinary or age-cohort teams. In the present context, we are referring also to the creation of a dedicated open schooling team (CORPOS) that is responsible for promoting open schooling in school and sustaining open schooling processes as part of the school’s organisational culture.

Further reading - Inner-School Communities

From a community-based approach to school organisation, mid-level leadership includes a variety of forms of collaboration between actors in the school that contribute to curricular and pedagogical decision making. These collaborations may involve different compositions (e.g., Professional Learning Communities, significant PTA, student bodies, book clubs) and different kinds of themes or topics that are organisationally promoted in the school (such as promoting interdisciplinary whole-school themes such as sustainability, pedagogical innovation, or community service). The existence of such inner-school communities is an indication of the school’s organisational culture, primarily the kind of leadership and curricular openness that is espoused and implemented.

The ‘inner-school communities’ dimension is closely related to ‘shared governance’ and to ‘open curriculum’, yet it is distinctively focused on middle-level leadership and the kinds of communities that are formally and informally operating in school. The inner-school community continuum expresses the extent to which (primarily) teachers and students work in teams and collaborate to make curricular and pedagogical decisions. Thus, the boundaries between this dimension and pedagogical dimensions are less rigid (as indicated in Figure 2 by the dotted line). Moreover, moving outward on the ‘inner-school communities’ continuum may involve the participation of different types of stakeholders beyond the school community.

Thus, three modes of openness pertain to this dimension: The more outward the school is on this dimension, the number of inner school communities operating is greater, the more impact they have on policy or have visibility in school and the more diverse they are in terms of their membership. As there is no clear-cut definition of what constitutes an inner-school community as such, there are various ways that these may take form either in formal structure or routines (beyond standard disciplinary or age-specific teams). A common inner-school community is professional learning communities (PLC) composed mostly of teachers, and these may include

routines in which teachers share experiences, observe each other's teaching, and conduct regularly scheduled consultations. Disciplinary teams may collaborate with each other, and the school may conduct periodical round table meetings that are open also to external community members. It should be stressed that substantial movement outward may create tensions between various school teams – and in more extreme cases a balkanisation of school culture (Hargreaves, 1994), and so some moderating authority must remain in the hands of formal school leadership to create a more collaborative school culture (Hargreaves, 1994).

2.2 Pedagogical dimensions: Learning communities, student participation

Learning Communities

'Learning communities' refers to the kind of pedagogy and teaching methods that are practised in schools. It is possible to identify several generic features (Brown & Campione, 1996): learning communities are learner or student-centred, are characterised by collaborative practices, deal with authentic (or real-world) tasks, and are emergent and experiential (constructivist). Learning communities are composed first and foremost by teachers (may be more than one) and learners but may involve continuous change in composition and membership (Wenger, 1998). They may be either permanent or ad hoc learning environments that are constructed for dedicated purposes or themes. Learning communities constitute the central pedagogy of open schooling given its focus on community and collaboration and in the present model we highlight the active participation, not only of students and teachers, but also of external stakeholders. Learning communities are associated with creating a sense of belonging and common purpose, particular attention to relationships and interactions between individuals, curiosity, active engagement, openness to different perspectives and others, and critical awareness (Gardner, 1996). Following the theory of community of practice (Wenger, 1998), we highlight the identification of all involved with what is being learned as well as each learner's ability to negotiate meanings (i.e., have a say with regards to what and how is being learned), and the idea that a community of individuals is formed to further the investigation and practical application of a given theme or topic.

Further reading – Learning communities

The 'learning communities' continuum concerns the extent to which the above attributes of a community-based pedagogy are practised in school. This entails that teachers take on different roles and greater emphasis on learning rather than on teaching (Barr & Tagg, 1995). As with other dimensions previously discussed, 'learning communities' impacts and overlaps other dimensions. The more extensively and deeply learning communities are applied in school practice, the more they will impact both organisational and pedagogical dimensions, most notably 'student participation', as this would involve that teachers change the way they view their own authority (Sarid, 2014). To distinguish between organisational dimensions and other pedagogical dimensions (i.e., 'student participation'), the focus here is on teacher identity. This concerns an understanding of the teachers' role in promoting social and emotional aspects of learning in a community (Sink & Edwards, 2008): creating a sense of community, subjective well-being, and greater attention to cultivating relationships and dialogue, yet without relinquishing or diminishing cognitive development (Edwards, 2005). Following the connection between open schooling to RRI (EC, 2015; Sotiriou et al., 2017), we connect learning communities to an inquiry-based learning approach, which can be seen as combining formal and informal approaches to learning (Sotiriou & Bogner, 2023). The present model underscores the interrelatedness between community-based learning, mutual engagement, cognitive development and an explorative learning culture.

'Learning communities' contains therefore various foci pertaining to learning in-and-as-a-community and the extent to which this relates to the use of alternative teaching methods, primarily explorative, (social) constructivist and inquiry-based types of learning. Inward modes of

pedagogy are mostly oriented towards the success of individuals in exams and are largely pre-designed and highly structured providing little room for student participation and engagement. With the movement outward, learning may also include different forms of peer-learning (students teaching students), the participation of external stakeholders in learning, and greater focus on social-emotional aspects. More significant movement may include explorative inquiry-based processes in which students and other community stakeholders may have an impact on learning topics and engage in meaningful interactions to jointly construct knowledge.

Student Participation

‘Student participation’ refers to the diverse ways in which students can be actively involved in learning, school organisation and school-related activities. Perhaps the most prevalent form of ‘student participation’ is their active involvement in classroom learning and activities, and these can range from shallow (i.e., responding to teacher’s questions) to deep relationships and engagement (i.e., autonomous choice of learning contents, evaluation methods or collaborative work in research teams and learning communities). Student participation may take forms that go beyond the classroom such as active participation in student boards or committees (that impact school-wide decision-making processes), participation in student leadership groups (Bertrand & Rodela, 2017), planning and organising school events, ceremonies, and activities, and after-school activities that influence the school community. More engaged student participation has been shown to be connected to improved school climate and student well-being (Anderson et al., 2022).

Further reading - Student participation

Student participation has been identified as a central characteristic of open schooling (EC, 2015; Sotiriou et al., 2017) that is primarily focused on student projects and their active participation in learning. The focus goes beyond a student-centred approach to teaching and learning, which favours project and problem-solving methods of learning (Tang, 2023), by underscoring interactive aspects including students’ meaningful involvement in information-sharing, engagement in dialogue with peers and adults based on mutual respect, and the sense that they can shape the process and outcomes of learning (UN Committee on the Rights of the Child, 2009). The latter emphasis includes the impact of student participation also on organisational decision-making, rather than simply on the contents and processes of classroom learning.

The ‘student participation’ continuum thus ranges from ‘shallow’ forms of participation, i.e., voicing an opinion in classroom discussion to more open forms of student participation, which include sharing authority and a sense of belonging to the school community, identification with school vision and goals and a sense of agency. In cases in which students are more deeply engaged in decision-making, ‘student participation’ will also overlap with organisational dimensions, either in their meaningful participation in inner school communities (such as student bodies and parliaments) or representation in leadership teams (‘shared authority’), which also impacts the openness of the curriculum. The distinctiveness of ‘student participation’ is that it focuses specifically on the beliefs, values and actions of students, and this concerns aspects going beyond classroom practice to broader engagement with school organization and policy or their Organisational Citizenship Behaviours (OCB) (Oplatka, 2009).

‘Student participation’ concerns the extent that students are actively engaged either in learning or decision-making processes on school policy. This may range from more inward expressions such as the absence of a student board and no formal communication line with school management, inability to influence what and how students learn, and scarce collaboration among students within learning processes. More outward expressions include ongoing feedback of students and formative self-assessments as a basis for decision-making and curricular policy, an engaged and meaningful student council, significant peer-learning among students and the ability to propose innovation and initiatives.

2.3 Community-relations dimensions: parental involvement, social engagement, community-collaborations

Parental involvement

‘Parental involvement’ is often conceptualised as multidimensional (Boonk et al., 2018). Generally speaking, it is thought to be aimed at improving children’s achievement in schools, and this has two generic forms: parental home-based involvement and parental school-based involvement. Home-based involvement may include different ways to assist children with their homework and conducting conversations with them regarding their experiences in school; School-based involvement includes actively seeking meaningful relationships with teachers as this concerns their children’s status and experiences in school. Our open schooling model conceptualises ‘parental involvement’ as a continuum ranging from various forms of involvement at home and in school to more meaningful engagement and empowerment of parents, in which parental leadership engages in the construction of a meaningful relationship between schools, families and communities (Bertrand & Rodela, 2018).

Further reading - Parental involvement

The deeper the involvement, the more ‘parental involvement’ is transformed into meaningful ‘collaboration’. Parental involvement is seldom conceived by school teams and leadership as negative interference and as devaluing school leadership and teachers’ professional authority. From this perspective, the mission of school leadership and teachers is to keep parents’ involvement at bay. Yet, this way of conceiving ‘involvement’ is more prevalent in inward school cultures or in cases in which parental involvement is focused exclusively on their own children’s wellbeing, at times at the expense of other students, rather than on the wellbeing of the school community as a whole. The meaning of involvement for open schooling refers to positive parental contributions to improve learning, school climate and school organisational culture. Openness, in this sense, does not only demand a different mode of operation by school leadership and teams, but also the creation of a culture of trust, mutual respect and understanding, or in other words, a culture which conceives school organisation as a community (Furman, 2002).

Parents are peculiar representatives of the community given their special status as being both part of the school community, as an extension of their children, but also members of the ‘external’ community. The extent to which parents are considered part of the school community partnered to the school community (Cummins, 1989) and even as part of leadership (Bertrand & Rodela, 2018), is dependent on the type of leadership and school culture, particularly when the school is organised as a community.

‘Parental involvement’ can also be connected to organisational dimensions, primarily ‘shared governance’ and ‘inner-school communities’ when these move more outward to include also the collaboration of external stakeholders and may overlap also with the ‘Learning communities’ dimension in cases when parents participate as learners/teachers in learning processes.

Thus, the ‘parental involvement’ continuum encompasses a wide range of actions. More inward expressions include keeping parental involvement at arms’ length (e.g., extra-curricular activities and fund raising). More outward expressions include engaging in organising school events and meetings, involvement in formulating official school proclamations influencing policy, active parental committees and active involvement in planning and implementation of parent-teacher meetings (such as routine round-table events).

Social Engagement

Social engagement concerns the school’s active participation in addressing community needs and problems and working toward the community’s development and well-being. Similar to other concepts such as ‘service learning’ and ‘community-learning’ (Dryfoos, 2000; Heers et al., 2016), ‘social engagement’ takes place when schools participate in activities for the community, such as aiding special needs children, addressing issues of marginalisation and discrimination (i.e., inclusion), promoting environmental sustainability, assisting senior citizens, and connecting learning to issues concerning the community and the betterment of society at large. At the inner-school organisation level, social engagement may concern awareness of social issues that directly impact the school community, such as addressing concerns regarding cultural diversity of school staff and students. The question of ethnic, gender and religious diversity and inclusion has become a major concern in recent years (i.e., Capper and Young, 2014). Yet, movement on the ‘social engagement’ continuum means moving beyond the boundaries of the school community, to address issues that concern the immediate community and possibly regional, national, and global concerns (e.g., social and environmental sustainability). The more outward the school is on the social engagement continuum, the more involved the school is in taking action to effect societal (transformative) change, engaging in civic action, and responding to problems affecting the school’s community as part of the school’s vision and pedagogy. More deeply engaged schools take part in various forms of activism (from implicit to strategic activism) (Berkovich, 2014), in which the school community engages at times in unconventional actions to change existing cultures, norms and rules that cause injustices, inequities and harm (Ryan & Higginbottom, 2017).

Further reading - Social engagement

Taking action for the community is an integral feature of opening schools to the community also given its connection to RRI. In the present model, inquiry-based learning centres not only on the investigation of socio-scientific issues, but also the development of competences to take action on these issues (Levinson, 2018). Social engagement might take place without necessarily collaborating or creating partnerships with the community – as is regularly the case in many ‘social service’ volunteer programs. Nonetheless, in the present model, promoting community empowerment is a holistic and comprehensive endeavour that is connected to leadership, parental involvement, school organisation and community collaboration (e.g., Edwards et al, 2020), and thus connects to various openness dimensions.

The ‘Social engagement’ continuum consists of various actions, all of which are aimed at addressing social issues and community wellbeing. More inward expressions include very limited participation in community service projects and initiatives, and in case they do exist, they are mostly extra-curricular so as not to interfere with the expectations of the national curriculum. More outward expressions may include regular meetings with civil society organisations to consider how schools may promote important social causes as part of the school curriculum; an active student council that operates to prevent student bullying as part of a weekly routine; and making volunteer work an obligation for graduation.

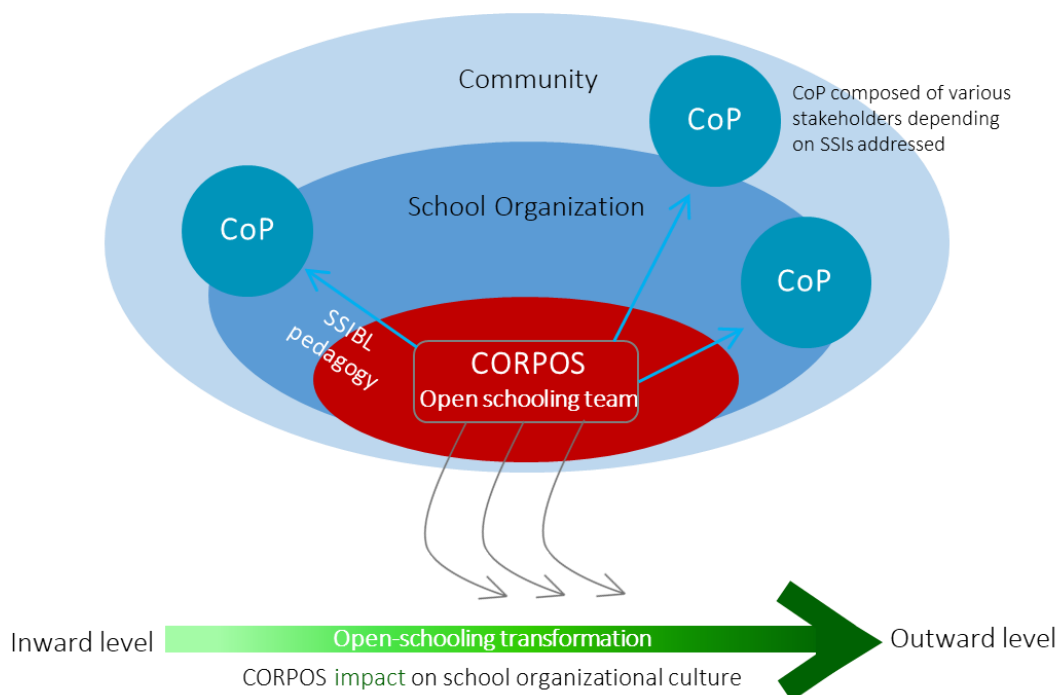
Community Collaborations

‘Community collaborations’ refers to the extent to which school engages in collaboration with community stakeholders and other social actors such as public services, science centres, local businesses, museums, higher education institutions. The community collaborations continuum incorporates both the extent (i.e., who participates and how frequently) and the depth of the relationships that are fostered by the school. Openness in this context is determined by the nature of relationships with those who are not an integral part of the school community. ‘Collaboration’ means that external stakeholders have some impact on various aspects of school learning, and this may include where learning takes place, the disciplinary topics or social issues that are investigated and how knowledge is acquired through mutual engagement. The continuum here points to a movement from simple interactions or connections with community stakeholders (e.g., a lecture given by a professional), toward more meaningful collaborations, in which community stakeholders or social actors participate in decision-making processes and are active in the design of learning or interventions.

Further reading - community collaborations

The ‘community collaborations’ continuum connects to nearly all openness dimensions. Most directly perhaps to the ‘social engagement’ dimension particularly when collaboration is deep and extensive. However, the idea here is that openness is tied to the kind of relationships taking place between school and the external community – and the more meaningful the collaboration, the more influence community actors and stakeholders have on school learning and organisation. Thus, ‘community collaborations’ can be regarded as deeply connected to the ‘shared governance’ dimension, given that external actors are considered strategic partners and serve as community representatives within formal decision-making processes. The more outward a school is on the ‘community collaborations’ dimension, the more aligned it is with collaborative school leadership (Hallinger & Heck, 2010; Woods, 2018).

The ‘Community collaborations’ continuum accounts for a range of interactions taking place between the school community and external stakeholders. These can range from simple interactions between individual teachers and other individuals (professionals) that may enhance disciplinary knowledge, field trips (e.g., a museum, community centre) and generally take part on learning communities (CoPs), to more meaningful collaboration in which social actors (e.g. universities, SMEs, local police department), engage in dialogue with the school community as part of school leadership or inner-school communities.



3. CORPOS (Open schooling Team)

3.1 What is a CORPOS?

CORPOS is short for Core ORganisational structure for Promoting Open Schooling. The CORPOS is an organisational school structure that functions as an open-schooling team 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 organisation. In the COSMOS project, the focus is specifically on employing the open-schooling approach in the context of science education, with the possibility that the open-schooling process extends beyond science to include other disciplines or subject matters.

It is important to stress that meaningful and deep change processes are regularly met with resistance and suspicion by school teams, given that change is always uncomfortable and taxing in terms of the psychological and practical resources that it demands. Creating a CORPOS is no exception in this regard and therefore it is critical to talk about the CORPOS by using context-specific language (i.e., viewing the CORPOS as an open schooling team that operates like any other disciplinary team).

Before elaborating on the CORPOS open schooling team, its creation, central attributes and responsibilities, it is crucial to stress the rationale or the importance of the CORPOS 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 open schooling team addresses three main failures: (1) that there is 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 (Cuban, 2010); (2) The second factor is the disregard for specific context (needs and values), that is, regarding schools as homogenous entities and thus the reform as universally applicable (Burch, 2007); (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 (Sarason, 1990), especially teachers and students (Biesta, 2007).

The CORPOS open schooling team addresses these three factors by creating a structure (and complementary routines) for school teams to discuss the change process so that open schooling is contextualised 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 organisation such as Higher Education Institution (HEI) representatives, science museums, researchers and parents, to share ideas, views, values and opinions regarding learning, what open-schooling means and how it impacts each one of them. When the CORPOS open schooling team is truly diverse it functions as an open-schooling professional learning community (PLC), 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.

The CORPOS open schooling team is able to do so by functioning as an inner school community that has the following three main attributes (Wenger, 1998):

Aim (joint venture): To embed open-schooling in schools specifically in science education by creating a school culture that is supportive and accommodates open-schooling as part of its ongoing functioning and routines, and the continuous creation of communities of practice (CoPs) (each addressing a different SSI). Moreover, the CORPOS open schooling team aims to create fruitful and ongoing relations and partnerships between the school and the community. Sustainable embeddedness of new forms of learning and organisation requires complementary school structures and routines (Epstein, 2011; Fullan, 2002; Furman, 2002; Smrekar & Mawhinney, 1999; Spillane et al., 2002; Spillane et al., 2011). These include for example: teacher collaboration structures, staff professional and social networks, norms and procedures for decision making, and the continuity of roles within decision-making teams (Kaul, Comstock & Simon, 2022). Essentially, distributing leadership and creating collaborative decision-making structures facilitate the embedding of change in the school organisation.

Practice (Mutual engagement): Erecting effective organisational structures, however, is insufficient if the culture, conditions (or behavioural routines) are not tailored to the change process (Sarason, 1990; Kaul, Comstock & Simon, 2022). Particularly, collaborative and distributive leadership practices are more effective in introducing organisational change (Leithwood, et al, 2020; Spillane et al., 2002). Thus, CORPOS members deliberate on how to facilitate open-schooling in the school, discuss possibilities for expanding membership (and thus also expand inner-school coordination and cooperation as well as school-community relations), discuss how to improve science learning in SSIBL-CoPs and support the creation of new CoPs. These processes also involve thinking about questions regarding CORPOS membership. The

essence of the CORPOS, as is community-building in general, concerns the kinds of relationships that take place within it.

Knowledge and professional development (Shared repertoire): CORPOS members engage in ongoing deliberations regarding the skills and knowledge that are needed in order to create effective learning in CoPs (in this project the focus is on science education, SSIBL pedagogy and the investigation of SSIs). This knowledge base is then communicated within and outside the organisation for furthering teacher professional development. Additionally, co-producing and sharing knowledge regarding how to promote school-community partnerships is an essential element of the CORPOS.

3.2 General attributes of the CORPOS

As an organisational structure aimed at promoting open-schooling [the idea of school as, with and for the community], CORPOS “is a creation of [local] participants involved in the processes of community-building. It develops idiosyncratically from the local context, when and if the processes of community are facilitated”. (Furman, 2002, p. 285). An abundance of empirical evidence has shown that creating permanent organisational management structures are vital for facilitating change processes and their ongoing sustainability in schools (Epstein, 2011). Building on previous work on organisational structures specifically those facilitating school-community partnerships and school-as-community governance (Epstein, 2011; Furman, 2002; Smrekar & Mawhinney, 1999), the CORPOS can be seen as a leadership team or Action Team for promoting partnerships (Epstein, 2011) and for applying a ‘social capital’ mindset within schools (Driscoll & Kerchner, 1999). Social capital refers to goods that are produced in the interactions between organisations and individuals. It makes possible “the achievement of certain ends that would not be attainable in its absence” (Coleman, 1990, p. 302). The basic understanding is that sharing knowledge, engaging in collaboration and interaction creates possibilities that cannot be achieved in non-collaborative settings. The uniqueness of the CORPOS rests primarily in its composition, namely, the combination of internal and external stakeholders and its focus on changing pedagogy and instruction. The commitment to community-building and service to the community aspects of the CORPOS reflects the community-civic responsibility mindset of the SSIBL pedagogy.

3.3 Developing CORPOS capacity-building

Creating a CORPOS - a dedicated open-schooling leadership team, is vital for developing and sustaining an open-schooling mindset and practices in schools. However, it is not sufficient. Creating and changing organisational structures does not ensure that the desired changes will take place (Elmore, 1995). If it is to have the desired impact, what is needed is a change in the norms, knowledge and behaviours of the stakeholders involved. The CORPOS should operate according to the three forms of social capital: Trust, Knowledge and Authority (Coleman, 1990). For real impact to occur, the CORPOS should be inclusive, engage in interactions based on mutual trust, open and authentic dialogue and an overall culture of reciprocity (Trust), interact with the aim to share knowledge which augments the information actors need to guide decision-making and action (Knowledge), and exercise power-sharing and distributive leadership actions

(Authority). The relevance of underlying power structures cannot be overlooked, yet at its core, the CORPOS should aspire for collective action that is based on shared decision making reached through collaboration and sharing authority. CORPOS capacity-building is incremental and emergent. However, members of the CORPOS should initially be good communicators, committed to the idea of open schooling, participate in good faith and have a good track record in forming collaborations (Epstein, 2011). The specific nature of mutual engagement (Wenger, 1998) in each CORPOS is definitely dependent on the participants, but the above three capacity-building attributes of CORPOS are necessary conditions for its effective functioning.

3.4 How to create a CORPOS and who can be a member of the CORPOS-community?

The first step in creating a CORPOS rests on the motivation of school leadership or dedicated teaching staff to promote and implement an open schooling approach. The composition of the CORPOS may vary depending on the context and the school's openness attributes, yet ideally membership should consist of both internal stakeholders (e.g., school leaders, teachers, students) and external stakeholders (e.g., HEI representatives, parents, local SMEs, non-formal education representatives, science learning centres). Thus, creating a CORPOS is made possible by: (1) identifying/locating school staff (e.g., science teachers, principals, science coordinators, superintendents) dedicated to the idea of open-schooling and school partnerships (Epstein, 2011; Fullan, 2002); (2) approaching school staff who have been involved in previous collaboration and projects with external stakeholders (such as HEI representatives); (3) work with and engage local authorities (local government, region or municipality); (4) tap into existing school collaborations (including parents who tend to be involved in school projects). Several considerations should be accounted for in the creation and implementation of the COSMOS:

- 1) CORPOS is a technical term used for the COSMOS project. **'Language' is a central concern** when connecting with schools and the kind of terms used in reference to the CORPOS will vary according to context. Also, issues regarding legal and statutory status of organisational structures must be explored in each context. For example, in some cases, existing organisational structures may be applied or accommodated to facilitate open-schooling processes. In Sweden, for example, there are inner-school teams of teachers (*arbetslag*) that may be used for such purposes. In other cases, new organisational structures may be created, such as an open-schooling team, inner-school community, science community network, or school committees – again, depending on the language used in the specific school.
- 2) It is important to create an open dialogue with school teams so that the COSMOS approach will not be seen as imposed on the school, but rather a cooperative endeavour that benefits everyone involved. For example, the teachers will benefit from professional development by applying innovative pedagogies and evaluation, the students will be more involved and active in their learning, will experience more meaningful science education and will experience better satisfaction from their studies in schools; the school will benefit from collaborations with community stakeholders and the community may find inquiry-based solutions to the problems it faces. Authority is a crucial aspect and could be seen from two perspectives: the sense that those who take part are not forced or

pushed to participate and that everyone involved has the feeling that he or she can contribute and have ownership in the shaping of the open-schooling process (*shared authority*).

- 3) There are several stakeholders that might be central for the operation of the CORPOS:
 - a) **School leadership** (either principal or leadership team) is crucial for the functioning of the CORPOS and creation of CoPs on the chosen SSIs. Leadership is important to ensure commitment on the part of all involved and for providing the resources and support necessary for leading a change process in science education. The CORPOS is essentially a leadership group for open schooling. Issues of authority can be perceived from a dual perspective: on the one hand, open-schooling change processes need guidance supported by school authority and must be seen to be part of school policy, on the other hand, authority should be shared so that all involved have a sense that they have a say on the nature of the process.
 - b) **Parental involvement** (partnerships) is significant in terms of both the capacity to represent the community and its needs, as well as for understanding the development of students' learning in a given school. In educational leadership literature, community leadership (particularly parents) are identified as critical for facilitating greater effectiveness in addressing social problems and inequities (Bertrand & Rodella, 2018). This is also true in the case of youth leadership and student involvement.
 - c) **Student participation** is important in order to ensure their intrinsic motivation, and in the context of a community of learners, a central role in making choices regarding their own learning. This is essential particularly given the ultimate aim of raising interest and motivation in sciences. Allowing students a voice in decision-making promotes self-regulation, self-directedness and self-determination, all of which are key factors for enhancing motivation. Representatives of student committees may take part and give voice to the students in the CORPOS.
 - d) **Community stakeholders** should be identified and introduced as members of the CORPOS that contribute or are pertinent to the needs of the community.

3.5 What are the responsibilities of the CORPOS?

The responsibilities of the CORPOS will depend on various contextual features concerning the school's organisational culture, openness attributes and policies. However, there are various responsibilities that the COSMOS framework envisions for the CORPOS, even though not all of these responsibilities will be endorsed in each school and at different stages of the COSMOS implementation. The following are the essential responsibilities: (a) CORPOS members convene regularly or periodically as part of a **routine**. The intensity of meetings (intervals between them) and the timeframe dedicated to each meeting will vary among schools. The main point is that an organisational structure is embedded within the school. (b) The CORPOS members discuss possibilities for **creating CoPs in school and discussing the continuation of existing CoPs**. (c) The CORPOS is responsible for expanding the school community (or school-community relations), and this means expanding or continuously rethinking CORPOS membership. (d) The CORPOS members continuously explore and deliberate about pressing socio-scientific issues

that are locally relevant for the school and its community. (e) CORPOS members continuously explore how to improve learning in CoPs based on previous implementations and this includes considering the aspects of **teachers' professional development (TPD)** that are needed for improving the learning process. This also may include assisting in identifying CoP membership and mapping the different levels of engagement of CoP members (f) CORPOS members discuss the experiences of previous or ongoing implementations, identify enabling factors (and how to build on them) as well as obstacles (and how to overcome them) and based on accumulated knowledge and deliberation, **create summaries** for communicating results throughout the school and beyond and further teacher professional development.

3.6 Who makes decisions in the CORPOS?

In principle, decisions should be reached through dialogue and shared decision-making processes aimed at shared agreements. The idea is to create a “holding environment” in which everyone feels secure and has the ability to negotiate meaning and have an impact on the decision-making process. A holding environment is a place where “people feel safe enough to address problems that are difficult, not only because they strain ingenuity, but also because they strain relationships” (Heifetz & Linsky, 2017). In rare cases in which disagreements and conflicts occur, school staff (teacher, principal) will have the ‘final word’ given that the decisions reached largely impacts the school.

3.7 What are the main obstacles for creating and operating a CORPOS? What are possible responses to these obstacles?

In every school context it is possible to identify factors that both inhibit and facilitate the creation and smooth functioning of a CORPOS open schooling team. In order to address in advance possible barriers or obstacles, the table below (Table 1), specifies some possible obstacles and responses to them that have been identified either from previous experiences, school change literature, or from implementing CORPOS as part of the COSMOS project lifecycle. These are generic obstacles and responses yet are likely to be pertinent to most if not all school contexts, in varying degrees.

Table 1 – *Obstacles and Possible responses in creating and operating a CORPOS*

Possible Obstacle	Possible responses
Motivation is key. If members do not identify with the idea of open- schooling it is most likely that the CORPOS will not be able to function properly. Without this basic motivation chances are the open-schooling process will not be long lasting. There might be other, more instrumental, motivations for wanting to be a member of the CORPOS (status in school, hours that afforded for a position, or <i>ad hoc</i> motivation to collaborate with a given stakeholder). Such motivations are not optimal for creating a healthy dialogue and for the continued functioning of the CORPOS.	For the CORPOS to work properly, members must be intrinsically convinced that a change in the way science is taught in their schools is needed and that the idea of learning science through a community exploring SSIs is beneficial for various reasons. Make sure to explore the motivations of those involved, and to ensure that they are motivated for the right reasons, and most importantly, see to it that the CORPOS responsibilities are compatible with the schools' openness levels and goals.

<p>Time constraints and work overload are crucial issues. If time is not properly allocated, if CORPOS members feel that they are not compensated and feel pressed by the additional responsibilities and actions, they will not be willing to take part. Working additional hours (either during or after school) and taking on additional requirements will likely be met with some resistance and cause demoralization.</p>	<p>Routines should be accommodated to the needs of the CORPOS members. This means making time within working hours to convene. Also, a specific role in school may be created (Open schooling coordinator) that may be compensated for working hours. CORPOS members who are school employees may also be compensated for their time by measures other than wages (at the discretion of the principal).</p>
<p>The process may include various bureaucratic operations: filling out forms, conducting evaluations on implementation, being in touch regularly with various stakeholders. If CORPOS membership is too taxing, members will lose interest.</p>	<p>Keep bureaucracy to a minimum. Appoint someone that is willing to take responsibilities for administrative issues instead of teachers. This may include the open schooling coordinator who is organizationally responsible for bureaucratic operations. In first stages, HEI representative may act as a broker of learning and take on the task of summarizing and documenting important issues.</p>
<p>Unproductive relations in the CORPOS and possible power-struggles and disagreements over strategy (especially when CORPOS expands and includes more and different stakeholders) will have a debilitating effect.</p>	<p>It is highly recommended that CORPOS members participate in TPD seminars and workshops throughout the process for two main reasons: first, to gain a better understanding of the process and the need of teaching staff, and second, as TPD processes will include also capacity-building for working in a community (including how to make joint decisions and collaborate), the TPD workshops can provide tools to create an open and dialogic environment in CORPOS. Additionally, while collaboration and shared decision making is key to the process, CORPOS members must be aware of the special responsibilities of school staff in the process. Ultimately, everyone should agree on this at the outset.</p>
<p>Failure inhibits motivation. If CoP implementation does not meet expectations, and if teachers do not feel open schooling is worth the effort, this will have a debilitating impact on the continued operation of the CORPOS</p>	<p>Make sure that success is communicated, disseminated in school and emphasized. This means that a gradual process of implementation in CoPs is recommended, certainly one that is accommodated to the school openness levels. Do not try from the start to implement a CoP that is too complex, difficult or unrealistic for all involved. Begin with initial successes and build on them for later implementation.</p>

3.8 CORPOS toolkits: Open Schooling SWOT analysis

The CORPOS leadership team is responsible for engaging in systematic and organisational thinking about how to embed open schooling in the school's culture, policy and pedagogy. One way that CORPOS teams can assess and evaluate how to embed open schooling is by employing assessment methodologies and tools supporting a systemic thinking process. Figure 4 provides one possible application of a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis that CORPOS members can use to better articulate objectives and road maps to move forward in the implementation of the COSMOS open schooling approach. Naturally, other assessment or evaluations tools can be used, depending on the given context.

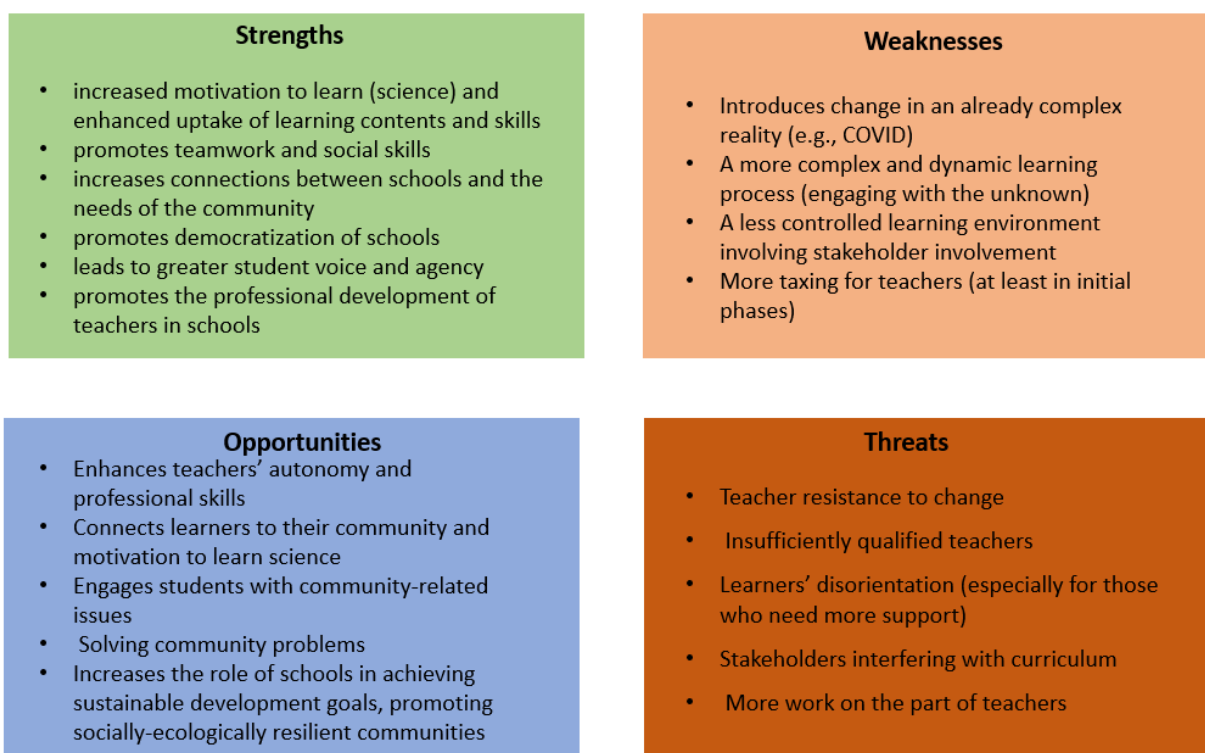
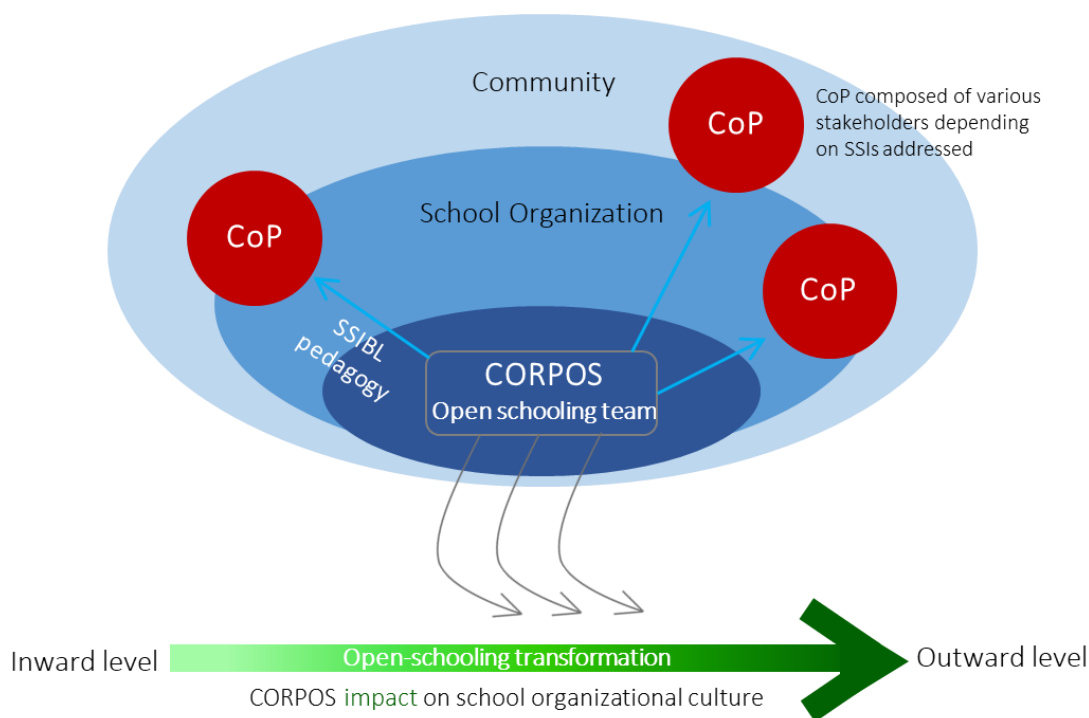


Figure 4. SWOT analysis for implementing open schooling



4. Community of Practice (CoP)

4.1 What is a Community of Practice (CoP) and what is its main aim in COSMOS?

The community of practice (CoP) represents a distinctive element of the COSMOS open schooling approach to science education as it unites 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** (Wenger-Trayner and Wenger-Trayner, 2015).

The aim (in COSMOS): 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 scale: A CoP 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 by definition 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.

4.2 What first steps each CORPOS should consider doing to get a CoP started?

Each CORPOS will instigate a community of practice for engaging in SSIBL. The establishment of a CoP can be facilitated by:

- i. **Identifying possible SSIs that could be the focus of the CoP** (e.g., socio-economical & mental health implications of COVID-19, local environmental issues, medical care). Preferably, the SSIs are suggested by the students, but they can be suggested by teachers or taken from the school activities' program;
- ii. **Conducting knowledge exchange events** (e.g., round-table discussions, online forums, parent evenings) to discuss and select a SSI and to identify additional stakeholders (e.g., other schools, scientists, companies, local authorities/policy makers, parents with specific expertise, informal science learning centres) in order to establish a CoP suitable for addressing the SSI collectively;
- iii. **Finding some potential members** who are willing to join the CoP and to invest their competences and time in making this happen. This implies the need to have a series of conversations with potential members;
- iv. **Engaging a dedicated core group** in designing a facilitating process by which the community can get going (e.g., organizing a launch event or just start working on an issue and letting the process attract others). This core group must be constituted by members (e.g., some students together with a teacher and another stakeholder) motivated to address the selected SSI.

4.3 How big can a CoP become?

Being a community of practice does not depend on size. It depends on identification with the domain and enough mutual engagement to produce learning value. In COSMOS, the CoP can integrate one or more teachers, students from one or more classes, students from one or more age groups, and additional stakeholders (e.g., scientists, local authorities/policy makers, parents with specific expertise, science learning centres' representatives).

Of course, if a community is very small, members will likely have heard each other's stories and opinions after a while. Without 'new blood' or more people, interactions often become stale, unless the domain is extremely dynamic and presents new, exciting challenges all the time.

If a community becomes very large, intense interactions will be more difficult. The community will tend to spawn smaller subgroups based on specialized interest or geographical proximity. But if one considers different levels of participation, as long as an active core group sustains enough engagement, there is no limit to the number of people who might benefit from the learning that takes place (especially with new technologies that enable peripheral participation across time and space).

4.4 What level of participation should one expect in a CoP?

Communities of practice usually involve multiple levels of participation (learning can happen through different kinds of involvement; the domain is not equally relevant to different people) (Wenger-Trayner & Wenger-Trayner, 2015). This means that participation will likely be quite different for different people. It is common to have a smaller core group of members who identify very strongly with the community and contribute most of the activity—with concentric bands of participation from very active members to merely passive observers. In a healthy community there is a flow of people moving across these levels of participation. Typical categories of membership and participation include:

Core group: a small group of people whose passion energises and nurtures the community (they don't have to be experts on the SSI they are addressing, but they must be conscient of their role) (e.g., a science class; members of a school's science club; student representatives from different classes;).

Active participants: members who are recognised as regular practitioners and define the community (e.g., classes who have been identified as part of the learning process, parents who have expressed interest in becoming members of the CoP, school teaching staff – from various disciplines – that are central to the SSI explored).

Occasional participants: members who only participate when they have something specific to contribute (researchers or experts on a given issue, teachers who bring in a specific skill set or knowledge to the community, external stakeholders from the community who share experiences and knowledge regarding a certain issue).

Peripheral participants: people who have a sustained connection to the community, but with less engagement and authority (newcomers or less committed such as municipality representatives).

Transactional participants: outsiders who interact with the CoP occasionally without being members themselves, to receive or provide a service or to gain access to CoP artifacts (these may include small and medium businesses, school staff who may connect to the CoP as part of their own separate curriculum).

4.5 Should participation be voluntary or compulsory?

In general, it is much better to let participation be voluntary. This way, communities of practice live on because they create value for members, not because of an edict or a box to check. It does not mean that one cannot strongly encourage participation. But making participation compulsory more generally runs the risk that communities become just another meeting to go to and survive. This is likely to deflate the very social energy that makes healthy communities of practice places of meaningful learning.

In COSMOS, the participation can be voluntary (e.g., the members of a school's science club) or compulsory (e.g., all the students of one or more classes), depending on the specific situation. In each case, CoP members must be conscient of the respective pros and cons and allow varying margins of autonomy, independence, and responsibility so that each member has a sense that they have agency and not forced to comply to pre-given learning tasks.

4.6 What are the key success factors for CoP?

CoP are complex social structures, whose voluntary and self-governing nature makes them quite sensitive to subtle dynamics. So, several factors can contribute to their success (and to their failure) (Sherer et al., 2003; Wenger et al., 2002):

Identification/ownership: Passion for the domain is key. This makes the negotiation of the domain a critical success factor. In COSMOS the selection of the SSI to be addressed is critical.

Leadership: A key success factor is the dedication and skill of people who take the initiative to nurture the community and to take care of logistics.

Time: Time is a challenge for most communities, whose members need to handle competing priorities. A "high value for time" must be ensured. In COSMOS, CoPs can be limited in time and

restricted to a specific SSIBL implementation. However, if interest exists, the possibility for continuing the CoP can be discussed (in the CORPOS open schooling team) ensuring the sustainability of a CoP.

Other factors for success: self-governance, a sense of ownership, the level of trust, recognition for contributions (making visible the work of different members), co-agency (joint agency; cooperating power), visible support of organizational leaders (but without their excessive supervision and control) and interactions with other communities.

4.7 What can propel the CoP forward?

CoPs can be propelled forward by energising tasks and expectations; and they can be terminated by de-energising ones.

Energising tasks and expectations: allow practitioners to make a difference with their expertise; help practitioners to connect with each other around their common desire; have visibility in the organization. Typical examples include solving hard problems or debating a burning issue.

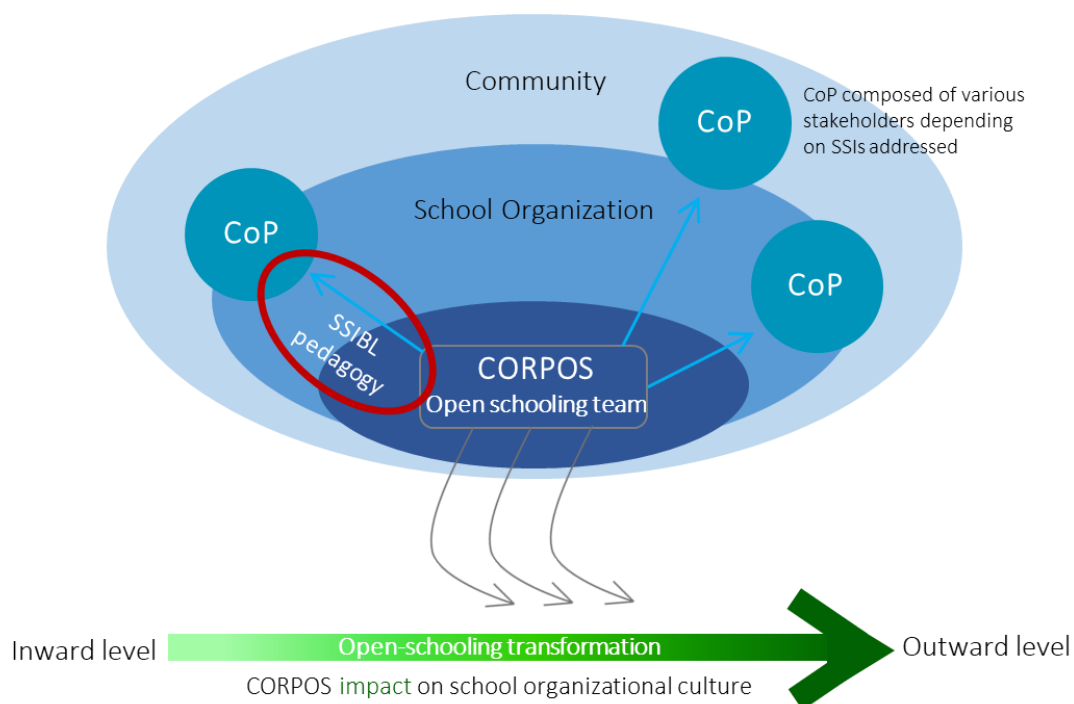
De-energising tasks and expectations: a sense of imposition and making community participation seem like work as usual; are repetitive and boring; do not entail much learning; do not reflect the real value of the community.

4.8 Can a CoP exist only online?

A community of practice is not defined by the medium through which members connect. Mutually relevant challenges of practice are much more important than modes of interaction. The key to a community of practice is the ability of participants to act as learning partners and online interactions allow people to do this in meaningful ways.

4.9 When does a CoP end?

In COSMOS, the CoP is by definition limited in time for the duration of the SSIBL design and implementation. So, it will finish when SSIBL implementation will be over. However, the CoP members can decide to continue their collaboration, focusing their process of inquiry and action in other socio-scientific issue(s) and prolonging the CoP's duration.



5. Socio-scientific Inquiry-Based Learning (SSIBL)

Socio-scientific Inquiry-Based Learning (SSIBL), enhanced with the Communities of Practice approach, serves as a pedagogy that fosters Open Schooling through science education in COSMOS. In this section we discuss the rationale for, and key concepts of the SSIBL pedagogy, and then outline the three key stages of SSIBL: ASK – FIND OUT – ACT.

5.1 Why SSIBL?

SSIBL is a research-informed pedagogical framework promoting meaningful science learning and responsible citizenship for all (Levinson et al., 2017; Levinson, 2018), irrespective of gender, ethnicity or cultural background. It addresses the challenge of current science education in which students often perceive a lack of relevance and a stereotypical view of science subjects as masculine and disconnected from society (Struyf et al., 2017), resulting in a low interest in science (Osborne & Dillon, 2008).

Science education for the 21st century, needs to consider not only how learning science can support functional scientific literacy through the use of science in everyday life (**Vision II** of science education, Roberts, 2006) but also move towards a more eco-reflexive perspective that focuses on learning both scientific knowledge and developing the competences required for critical-democratic and socially just participation in society (Sjöström & Eilks, 2018), that is **Vision III** of science education. By promoting scientific literacy and responsible citizenship, SSIBL aligns with such a demand for transformation of current science education. SSIBL bridges the gap between science education and societal needs and supports young people to develop and use the knowledge, skills and values needed to critically engage with global scientific and societal challenges such as the climate crisis and biodiversity loss in a socially just manner.

SSIBL's emphasis on learning science within socio-scientific contexts and for responsible and active citizenship, and its requirement for action as an inherent dimension of the learning process means that **SSIBL is a pedagogy that can bridge Vision II and Vision III of science education**, by enabling children and young people to critically engage with local, global and intercultural issues, understanding and appreciating different perspectives, interacting respectfully with others, and importantly, taking responsible action (Hodson, 2020; OECD, 2018). Therefore, SSIBL is well suited to pursue the ambitions set out by the European Commission for open schooling through science education to foster young people's interest and attitudes towards science and support the development of agency so that young people can be active and responsible citizens within their local communities and society (EC, 2015).

SSIBL aims to promote the principles and values of **responsible research and innovation** through science education by integrating **responsible citizenship** with **inquiry-based learning of socio-scientific issues** through a pedagogical process that can be organised around three stages (ASK – FIND OUT – ACT), as presented in Figure 5 (Levinson et al., 2017; Levinson, 2018). In this way, SSIBL supports the learning of scientific knowledge and practices, as well as how to take responsible action and effect change utilising this scientific knowledge and practices. These key concepts, and their interrelationship are explained next.

5.2 SSIBL: Key concepts

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 (Levinson et al., 2017), which aimed at operationalising, and promoting the principles of **Responsible Research and Innovation (RRI)** in the context of science education. RRI engages the public and stakeholders with scientists in scientific enterprises aiming to create ethically acceptable, socially desirable and sustainable products and advance scientific fields based on these principles (**ethical acceptability, social desirability of products, and sustainability**). In this context, RRI leads to scientific developments *in, with* and *for* society (Owen et al., 2009) by adopting and embedding values such as (a) diversity and inclusion, (b) openness and transparency, (c) anticipation and reflection, and (d) responsiveness and adaptive change in the R&I process. The RRI principles and values promoted by the EC under the 'Science with and for Society' work programme (SwafS) put greater emphasis on responsibility, individual, collective and at corporate levels, and thus created the need to consider issues of science and society *within education*. The PARRISE consortium focused on how these ideas can inform science education and be supported by it. Therefore, SSIBL was designed with these guidelines and values in mind to support teachers and students consider science and its role within society and to bring together private, public and civil society stakeholders in tackling societal challenges (Owen, von Schomberg & Macnaghten, 2021).

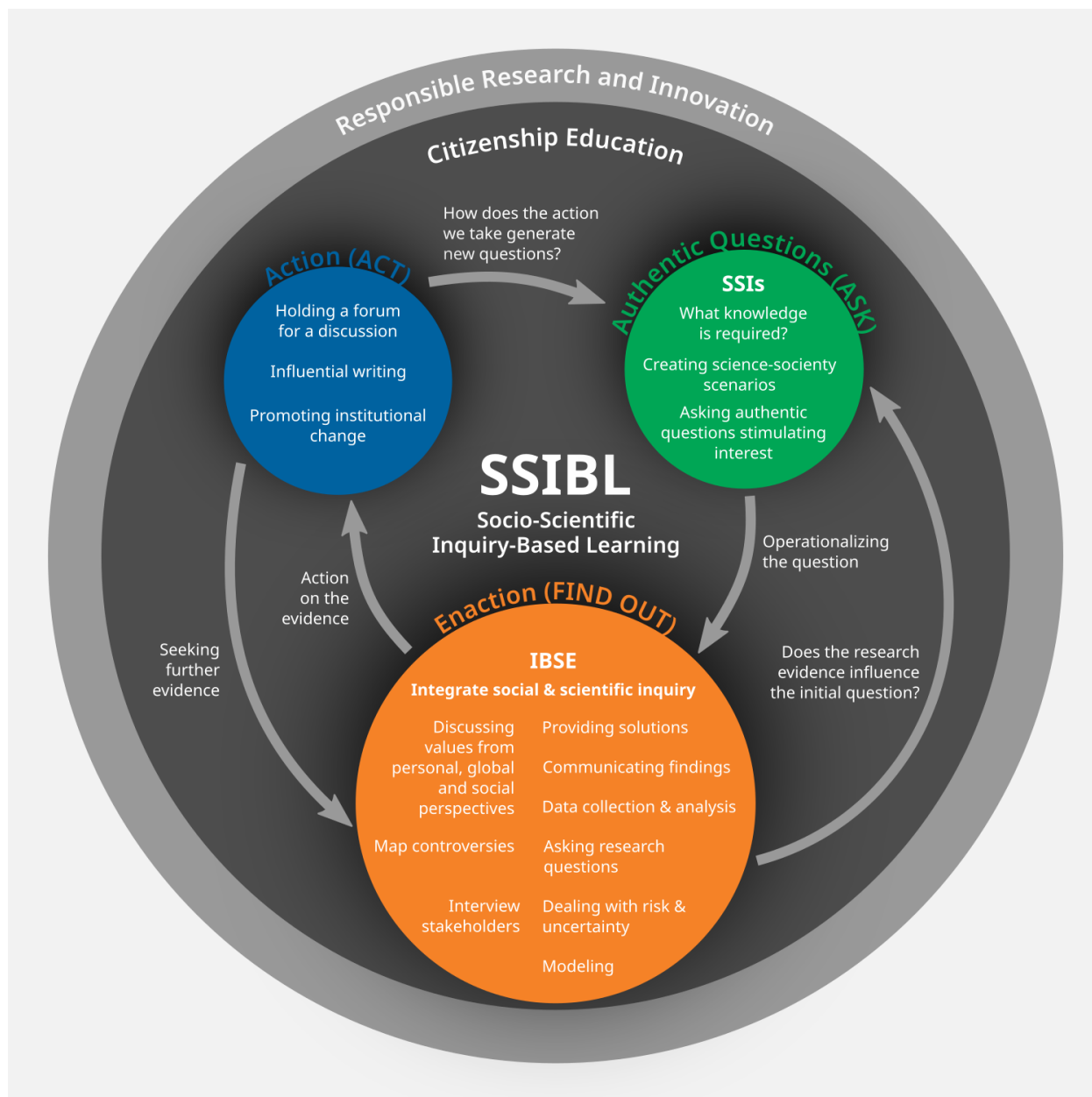


Figure 5. Socio-Scientific Inquiry-Based Learning. Figure based on Levinson et al. (2017) (p.15-16), adapted by Knippels and van Harskamp (In: Ariza et al., 2021), graphic redesign by COSMOS

SSIBL builds on, and extends, socio-scientific issues-based education, an approach to science education previously labelled as ‘science for citizenship’ (Ratcliffe & Grace, 2003). Socio-scientific issues (SSIs) have a basis in science, but they also have a potentially large impact on society (Ratcliffe & Grace, 2003; Zeidler, Herman & Sadler, 2019). SSIs involve values and ethical reasoning, forming opinions and making decisions at a personal or societal level. SSIs are controversial in nature, as there is often not a definitive answer or solution to them. Instead, different views or possible explanations might be put forward and are often presented in opposition to each other. This means that students need to be able to evaluate risk and consider the uncertain nature of knowledge in their decision-making process about SSIs and understand the role and use of evidence in scientific practices (Levinson, 2010). Zeidler and Sadler (2023, p.900) provide the following key characteristics of SSIs:

- a) SSIs are ill-structured, controversial and personally relevant issues that require scientific, evidence-based reasoning to inform decision-making.
- b) Framed within sociocultural perspectives to teaching and learning employing strategies such as dialogue, debates and argumentation
- c) Require some degree of moral reasoning as ethical and social dimensions need to be considered
- d) Emphasise the formation of virtue and character as long-term pedagogical goals

The need to consider values as part of the learning process in SSI-based education means that it is well-suited to address the values of RRI as put forward by the European Commission. SSIBL incorporates the key characteristics of SSIs into the teaching and learning of science, and extends them by not only supporting students to engage with science *in* society, but also science *for* and *with* society, which also has implications for how citizenship is conceptualised and forms an aim for the SSIBL pedagogy.

Citizenship can be conceptualised on a continuum from citizens that are *personally responsible* (e.g. behaving responsibly without questioning why), to *participative citizens*, who are those that behave responsibly within their community and take action, and finally, *socially responsible citizens* that critically consider and reflect on issues of social justice and take action accordingly (Westheimer & Kahne, 2004). **Socially responsible citizenship** is the type of citizenship the SSIBL pedagogy is aiming for, informed by RRI principles and values. Therefore, socially responsible citizenship forms the backdrop within which the SSIBL stages take shape (Figure 5). SSIBL encourages participation and dialogue throughout the learning process from raising questions in socio-scientific contexts, through carrying out an inquiry to answer these questions, to proposing solutions and taking action to solve problems arising from SSIs in responsible and socially just ways. This is done through social science research practices, what is labelled as ‘social inquiry’ in the SSIBL framework, where stakeholder perspectives, values and knowledge are investigated, considered and taken into consideration in order to understand an issue from its global, social and personal perspective. Ensuring all stakeholders can contribute to SSIBL activities addresses the RRI values of diversity and inclusion. Encouraging participation, dialogue and criticality addresses openness and transparency.

The process of learning science when employing the SSIBL pedagogy, is informed by **inquiry-based learning (IBL)**, which involves an authentic open-ended question or hypothesis formulated by students and/or teachers. Inquiry is about seeking knowledge through evidence to answer authentic questions, and it is underpinned by: student interest, research, questioning and the collection and interpretation of evidence (Crawford, 2014; Pedaste et al., 2015). The authenticity of SSIs, as issues that are controversial and without one “correct” answer creates affordances for combining SSIs with IBL, which also requires authenticity as part of the science learning process. The inquiry process can support students to learn scientific knowledge and engage in scientific practices, relevant to the SSI they are investigating. Students need to feel empowered to direct their own learning, but this needs teacher support (scaffolding). The level of support provided can vary depending on the context, topic and pupils (e.g. open inquiry, guided inquiry, structured inquiry, confirmation inquiry) (Toma, 2022; Banchi & Bell, 2008). Within science classrooms, science investigations (**science inquiry**) can take different forms stemming from the nature of scientific work across disciplines (e.g., controlling variables investigations,

identification and classification, using secondary sources such as doing online research, surveys and correlations, using experimental models and analogies to explore an explanation).

In summary, SSIBL presents a more socially responsible approach to science education compared to previous SSI-based education approaches. SSIBL is learning through asking authentic questions (ASK) about controversial issues arising from the impacts of science and technology in society. These questions are open-ended, involve participation and engagement with multiple stakeholders and concerned parties and require inquiry (FIND OUT) that is personal, social and scientific (Knippels & van Harskamp, 2018) to identify solutions to the issues explored at personal, local and global levels. Action to implement identified solutions and effect change is an inherent dimension of the SSIBL pedagogy as it is guided by socially responsible citizenship (ACT).

5.3 How do we create SSIBL environments?

As part of the PARRISE project, which had science teacher education as a focus, the SSIBL framework has been operationalised into a simpler, practice-based model that can support the design of SSIBL environments and guide teachers in designing SSIBL environments (TPD). This simplified representation of the SSIBL framework, consists of three stages as shown in Figure 6 (Levinson et al., 2017) with the background of social desirability, ethical acceptability and sustainability (RRI principles). We will explain the different stages in more detail and provide examples below.

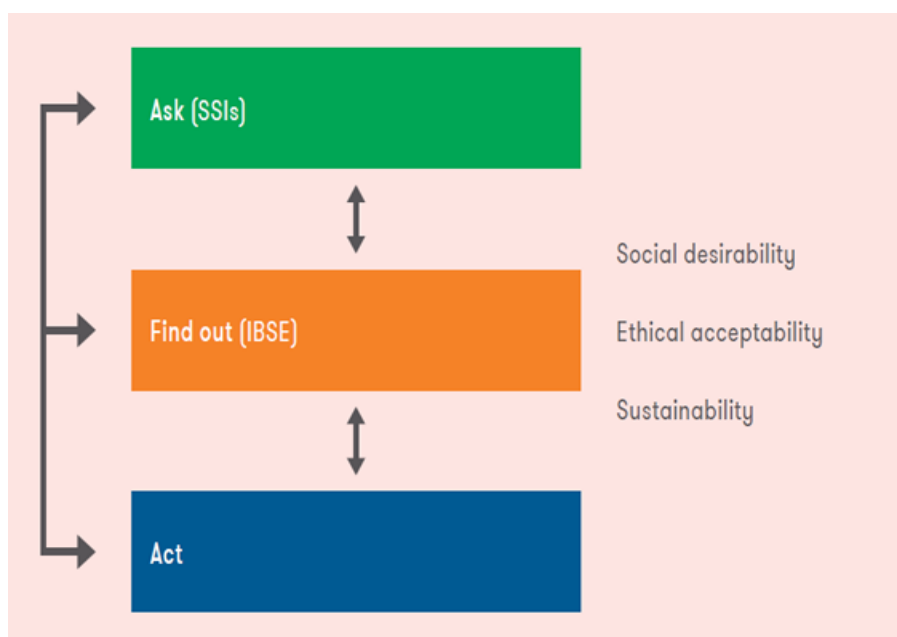


Figure 6. SSIBL stages simplified (figure from: Levinson et al., 2017; Amos et al., 2020)

5.3.1 ASK: Identifying authentic questions

SSIBL issues should be 'authentic', i.e., problems and issues relevant to students in the 'real world', which students want to engage with and solve. Authentic situations are often complex and

controversial, as there might not be overall agreement about solutions. It is important to tap into students' interests (Sadler, 2011) but also generate scenarios in which students can position themselves and hence invoke interest. When students have polarised views, this can often stimulate interest in other students because they can reflect on where they stand in relation to extreme positions. Authenticity is addressed through ensuring that the issues discussed are personally relevant for the students. This means that the teacher needs to know their students well, and need to engage them in the process of identifying SSIs to investigate collaboratively.

Students and science teachers will *raise specific investigative questions connected to SSIs*, which require the involvement of multiple stakeholders identified, as part of understanding the controversial nature of the SSI in focus. These might be questions that emerge from **the students**, and that are of interest to students, so they are willing to engage with them. Issues that are in the news or are of importance to the neighbourhood or school community (e.g. waste problems in the neighbourhood, biodiversity in their school yard, healthier food choices in their school canteen, sustainable school buildings) can also be good starting points for consideration. Raising these kinds of questions can be scaffolded by the teacher. Teachers can brainstorm with students about their interests, about science topics they are interested in, and they have heard about, and they would like to know more about. Involving the students and considering their perspectives and views is important, while also balancing this with the realities of school teaching (e.g. links to the curriculum) and teachers' needs. This means that at times, the SSI might be identified by the teacher, or even the school if the students are to engage in learning that might effect change to their community.

5.3.2 FIND OUT: Integrating social, personal and scientific inquiry to explore socio-scientific questions

The FIND OUT stage focuses on students enacting or carrying out different types of *socially responsible inquiries* (Amos & Christodoulou, 2018) to collect evidence and unveil different perspectives so as to answer the questions raised during the ASK stage. Socially responsible inquiries are the investigations students engage in as part of learning science in socio-scientific contexts, and with the aim to identify potential solutions and take socially-responsible action to address the SSI (i.e. the learning that takes place during a SSIBL lesson).

When learning about socio-scientific or socio-environmental issues such as the use of genetically modified organisms, climate change and biodiversity loss, it is critical that students are exposed not only to the scientific evidence related to the issue, but also to the issue and its multiple perspectives, so as to understand the controversy surrounding it, the complexity of it and the various (often competing) perspectives that exist. For example, if students are learning about biodiversity loss, they should not only investigate and learn scientific concepts such as biodiversity, food chains and species interdependence. They should also learn about the social implications and reasons for biodiversity loss, due to the need for housing, and the development of agricultural practices to support food production. They should learn how the loss of biodiversity creates social injustices. Understanding what the issue is surrounding a scientific concept is an important aspect of SSI-based education, and of SSIBL. SSIs should not simply be the hooks that trigger interest in a lesson (Christodoulou & Grace, 2019). Further, students should be supported in identifying where they stand on the issue explored, and what their personal

values and beliefs are. Therefore, when learning within a SSIBL environment, inquiry takes three different types: scientific, social and personal inquiry as shown in Figure 7 (Christodoulou & Grace, 2024; Knippels & van Harskamp, 2018).

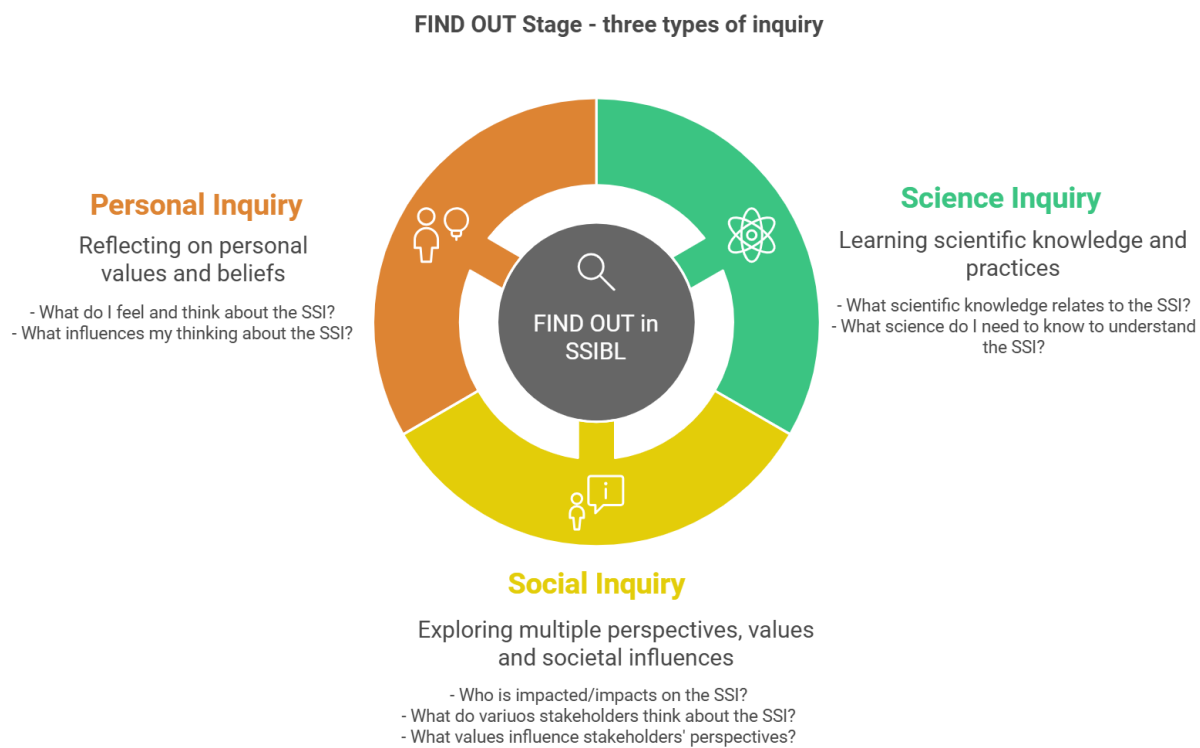


Figure 7. The types of inquiry addressed through FIND OUT in SSIBL

As discussed in Section 5.1, **Scientific inquiry** consists of students doing investigations in order to answer questions arising from the SSI, using processes such as pattern seeking, analysing and interpreting secondary data (e.g., from online resources, or data provided to them from teachers), identification and classification, primary data collection and control of variables (fair testing), using and evaluating a technique, or using experimental models and analogies to explore an explanation, hypothesis or theory. **Social inquiry** requires students to identify, investigate and critically consider the diverse perspectives, arguments, and possible solutions that exist on an issue (e.g., economic, social, political, moral), and the values that guide stakeholders' perspectives, decision-making and action. Finally, **personal inquiry** requires students to reflect and identify their own perspective and attitudes on the issue investigated, and the values that guide their perspectives and consequent action. Opportunities for all three types of inquiry need to be included in SSIBL environments, and scaffolded through dialogue, discussion and argumentation by teachers.

Scaffolding is a central part of social constructivist learning (Wood, Bruner & Ross, 1976; Shvarts & Bakker, 2019). It is the process of giving appropriate support to students to help them learn something which they could not achieve on their own. Support is withdrawn gradually as students become more competent and confident in their learning and are able to work autonomously (Vorholzer, & von Aufschnaiter, 2019). The nature of the support required depends on the

students' existing knowledge, skills, experience of the context, etc. For instance, **scientific inquiries** can have a high level of scaffolding through structured inquiries, to guided inquiries to more open inquiries where the scaffolding provided by the teacher is minimized (e.g., Bunterm et al., 2014; van Uum, Verhoeff & Peeters, 2017).

Within the SSIBL pedagogy scaffolding should take into consideration not only knowledge and skills but also values. Zeidler et al. (2019) discuss the importance of using moral reasoning and investigating ethical and social dimensions of the SSI in focus. This requires understanding individual's own positioning, achieved through **personal inquiry**, and understanding of the various convergent or divergent perspectives morally, socially and culturally, which is addressed through **social inquiry**. Knippels and van Harskamp (2018, p.49) provided a range of roles that the teacher can adopt to scaffold the exploration of values with students, depending on whether they focus on transmission of values, clarification or supporting student communication when engaging with SSIs (Table 2). For example, with students who are able to identify and share their views/values within a group, the teacher can take the role of an impartial observer, without interfering in the dialogue that students are engaging in.

Table 2: *The teacher's roles in dealing with the value component of socio-scientific issues (SSIs) in classroom dialogue; the various roles are more (++) , somewhat (+) or not () appropriate depending on the nature of value formation aimed at (transmission, clarification or communication)*

Role of teacher	Role description	Development of values through:		
		Teacher as transmitter	Teacher supporting clarification	Teacher supporting student communication
Participant	You are free to express ideas, opinions and emotions, like the pupils. (This can be confusing for pupils, since teachers are the professionals.)	+	+	+
Impartial observer	You do not interfere in the dialogue, but only observe the pupils.		+	++
Instructor	You clarify relevant information, concepts and ideas. You ask questions to assess the level of understanding. You give positive or negative feedback to input from pupils.		+	+
Devil's advocate	You take on contradictory points of view to stimulate the dialogue.		+	++
Advocate	You present all possible points of view and conclude with your own opinion, supported by arguments.	+		+
Impartial chair	You stimulate pupils to contribute to the dialogue and keep an eye on the rules of the dialogue, but do not give your own opinion or positive/negative feedback on the input of pupils.		++	++

The role of the teacher is to be knowledgeable of their students' knowledge, skills and values, and use them as a starting point when planning SSIBL lessons (e.g., how can the teacher differentiate the way in which they have designed their lesson and resources to support students during their inquiries?) or when teaching SSIBL lessons (e.g., what questions are teachers going to ask different groups? How is teacher questioning going to scaffold students in constructing, justifying

and evaluating their ideas, investigations, conclusions? How is teacher questioning going to address personal beliefs, and support students identify their own positioning in relation to the issue?). Depending on the role that the teacher adopts, they should also adjust and plan for scaffolding students' conceptual understanding and value exploration.

5.3.3 ACT: Formulate solutions and enact change

A distinguishing feature of SSIBL is the ability to produce opportunities for action taking as a component of the learning process, and action competence (Sass et al., 2020, Figure 8) as a learning outcome. SSIBL thus promotes action as an inherent dimension of the learning process, allowing learners the opportunity to affect change within their surroundings and communities, and thus supporting agency. Formulating solutions and enacting change to address the SSIs investigated also makes socially responsible citizenship a concrete part and outcome of the learning process when adopting the SSIBL pedagogy. However, actions in themselves are only authentic if they emerge from the inquiry through deliberation and reflection. For example, if students are considering how to address the issue of air pollution around their school community, they can investigate when air pollution is at its highest and in what specific areas of the school, and then can discuss solutions to reduce this, such as campaigning for car-free zones around their school, writing to the school leadership and local council to help students find alternative means of getting to the school, and considering personal actions (e.g., what they will do personally).

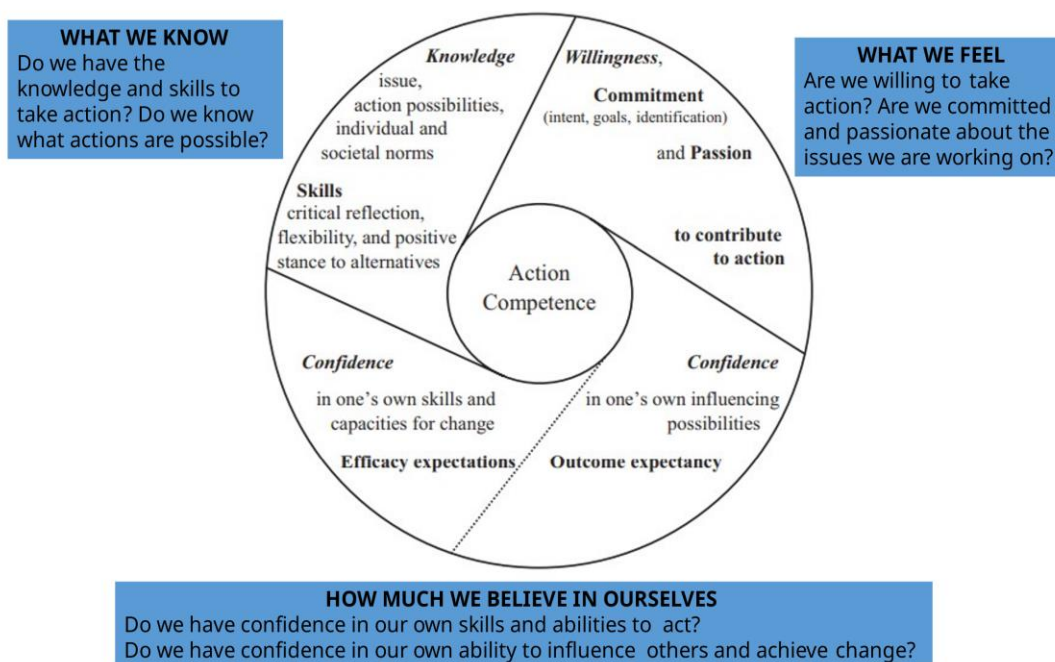


Figure 8. The action competence for sustainability framework (based on Sass et al., 2020, p.301)

Thus, as a result of learning science through SSIBL, students can 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 within their communities. The process of having to reflect and deliberate on possible solutions, and then enact those solutions can support students in developing the necessary competences needed for taking action across

contexts, as they become accustomed to considering and expecting action, as part of their science learning.

Learning environments that support students' action taking should employ an action-oriented approach. Sinakou et al. (2019) developed a framework in the context of Education for Sustainable Development (ESD) explaining how such learning environments should be constructed. It consists of five components: a) (direct) action taking, b) students' leadership in their learning and teaching, c) peer interaction, d) community involvement and e) interdisciplinarity. All aspects (can be) met by the SSIBL pedagogy. In the 'action taking', Sinakou et al.'s framework describes two important components: the **impact of action** and the **context of action**. The impact of actions can be direct or indirect (Jensen and Schnack, 1997). Direct actions aim at solving the problem related to the SSI which students deal with (e.g., making healthy drinks for the school canteen, maintaining a school vegetable plot). Indirect actions aim at influencing others to solve the issue under consideration (e.g., write a letter advocating for change addressed to various relevant stakeholders, such as the school headteacher, a company, a government minister or the local authorities; generating a petition; sharing information within their community through means such as YouTube videos, creating posters and infographics, and creating services to support improving personal actions (e.g. avoiding disposal of plastic cups). Direct and indirect actions can be performed individually or collectively, at the private or public sphere (Sass et al., 2021), which would constate the context in which actions are performed (Sinakou et al., 2019).

Teacher support can facilitate appropriate action taking by students through promoting active links with agencies in and beyond school and identifying appropriate opportunities for action. When investigating science teachers' enactment of SSIBL through lesson designs and observations, pre-service science teachers have been found to approach the ACT stage of SSIBL in three different ways:

- a. *Raising awareness* of an issue by exposing students to issues that arise from the implications and applications of science in society;
- b. *Creating an intention to act*, e.g. by providing scenarios where students can engage in hypothetical action-taking and decision-making about an issue (e.g. answering the question 'What would you do if...')
- c. *Taking action*, by devising and executing an action plan engaging students (Amos & Christodoulou, 2018; Christodoulou, Amos, Ottander & Ottander, 2018).

These different ways of interpreting the ACT phase within educational settings might be appropriate depending on contextual factors, such as curriculum, time, teaching experience, and relevance of the issue and can be seen as a continuum of engagement with action as teachers learn to use the SSIBL pedagogy and consider how to incorporate action into their science teaching and curricula.

However, it should also be noted that raising awareness and hypothetical decision-making are low stakes, and although it can support students' development of knowledge of action possibilities, students still need to be supported in developing their 'action taking' skills. If we want students to learn how to formulate and execute action plans, then we need to support them in practicing how to do so. To support competence in taking action, it is important that students deal with real world issues which are relevant to them (such as SSIs) and then take action

themselves; simulations or hypothetical scenarios allow students to engage with real world problems but do not provide opportunities to practise taking action to solve the problems investigated. This means that although a good first step through engaging in hypothetical decision making, teachers need to consider how to move from hypothetical scenarios to real-time scenarios; the focus on localised and personally relevant issues within the school or local community as part of SSIBL can support such a move from simulated to real-time action taking. Engaging with both direct and indirect actions in these localised community-based issues, can support students in developing confidence in their abilities to enact change as a result of seeing the (positive) outcomes of their actions, and make them willing to continue taking action both for that issue, but also for other relevant issues.

5.4 Bringing it all together

In this section we present how the different stages can come together in practice. The SSIBL approach begins with an authentic and relevant scenario (i.e. ‘real life’ issue, which students want to engage with and solve), which has the following characteristics in common:

- Identification of a problem which can be addressed through inquiry
- The problem is genuinely open (does not have one right answer)
- Draws on different types of knowledge (scientific, ethical, cultural, political, economic etc.)
- Connections to relevant science knowledge in the curriculum
- Democratic deliberation of different perspectives
- Liaison with different stakeholders or networks either within or outside the school

Steps that might be helpful in integrating the ASK-FIND OUT-ACT stages in a lesson are depicted below (Figure 9). It shows how each SSIBL stage in the sequence of steps might look like.

1. **Introduction** of dilemma: connect to student’s daily life, interest
2. **Initial opinion-forming** (individually or in small groups)
3. Raise questions: **‘need to know’**
 - content related, social, and/or personal questions
4. **Inquiry**: students answering the raised questions through *social, personal* and *scientific* inquiry
5. **Dialogue**: value clarification & communication
6. **Decision making and action**: formulate solutions which help to enact change
7. **Reflection**: on student’s opinion-forming process and action taking (metacognition)

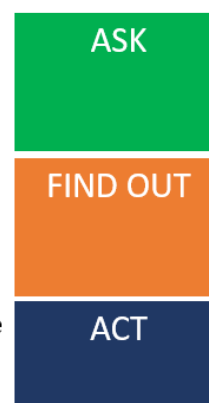


Figure 9. Educational steps that can help design SSIBL lessons (based on: Knippels & van Harskamp, 2018)

Next, we illustrate the steps presented in Figure 9 based on an example from practice (see Table 3), in which a secondary school science teacher chose a real life, local issue to introduce the SSI and contextualize and problematize the issue for the students.

‘Local chemical company DuPont dumped their waste into a river near

the school, introducing the potential carcinogen C8¹ into the environment. The company stayed within boundaries set by the government, but inhabitants did not trust the guidelines. They feared the potential carcinogen was responsible for the inexplicable illnesses from which some of the factory workers suffered.'

The teaching and learning activities implemented in this module exploring this issue arranged by the different steps (linked to the SSIBL phases) are depicted in Table 3.

Table 3. Representation of the seven steps in the lesson module on C8 in river water

SSIBL phase	Educational stages	Teaching and learning activities
	i) Introduction of the dilemma	Watch a documentary on the SSI
ASK	ii) Initial opinion-forming	Answering questions individually during the documentary: <ul style="list-style-type: none"> - Do you think the boundaries set by the government are fair? - Do you think residents have a reason to worry? Students subsequently discussed their views in small groups and formulate questions they have
	iii) Creating a need-to-know	Making students experience the different perspectives of stakeholders, by mapping the controversy
FIND OUT	iv) Inquiry into scientific, social, and personal aspects of the dilemma	<u>Social and personal inquiry:</u> <ul style="list-style-type: none"> • Listed stakeholders in the issue and their motives. Discussed their views (social and personal inquiry) • Controversy line activity: they consider with which stakeholders they identified most strongly by physically positioning themselves on a line in the classroom With this activity, content-related and normative student questions were raised. <u>Scientific inquiry:</u> <ul style="list-style-type: none"> • Students had to seek information on the potential toxicity of C8. • Performing a titration experiment on water samples of the polluted river, both upstream and downstream of the factory. Identifying the (different) C8 concentrations in the river. • Inquire whether there are recent scientific developments that could replace C8 in the production of goods • Inquire the trustworthiness of the set concentration boundaries by the government <u>Social Inquiry</u> <ul style="list-style-type: none"> • Visited the company and interviewed factory workers and board members
	v) Dialogue	Discussion about the dilemma, based on statements mirroring different sides of the dilemma e.g.: <ul style="list-style-type: none"> • Consequence of banning C8 from industry; The financial

¹ C8 chemical contamination refers to the environmental presence of specific compounds within the family of perfluoroalkyl and polyfluoroalkyl substances (PFAS), specifically those with an 8-carbon chain (C8) structure.

		value of human lives, Conflict of interest when companies determine the toxicity of their own processes
ACT	vi) Decision making and action	Looking back on initial opinion and on previous activities by answering reflective questions Based on their findings in the FIND OUT phase, students wrote an advice letter to the local government (indirect action) Moreover, some students discussed this issue at home and or/ decided to stop buying articles that need C8 (PFAS) in the fabrication (direct action)
	vii) Reflection	Answering reflective questions about the steps taken in the learning process (self-monitoring, metacognition)

More practical strategies for implementing SSIBL in the classroom is provided in the [Classroom strategies for implementing SSIBL](#).

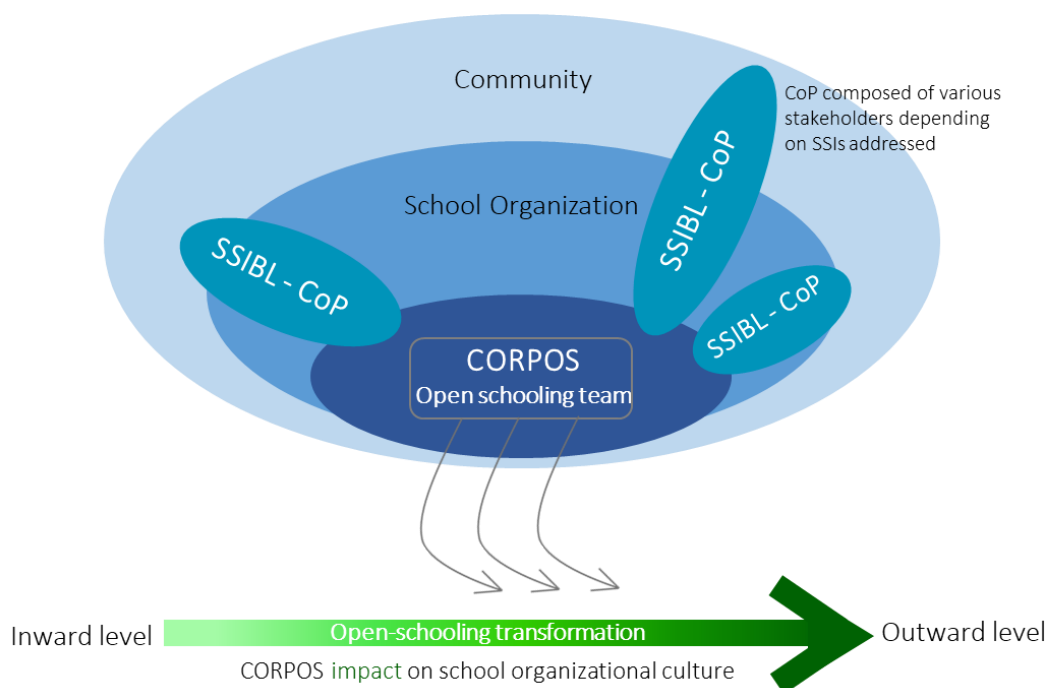


Figure 1a. Components and process of open schooling transformation in COSMOS (integrated)

6. Integration tools

The COSMOS framework has articulated thus far each key concept (Openness dimensions, CORPOS, CoP, SSIBL) separately so that decision-makers and practitioners can gain a deeper understanding of the main components of the COSMOS approach to open schooling. In principle, each concept can stand on its own. One of the main contributions of the COSMOS project is the articulation of the interrelations among the concepts; the connection between school openness, learning in-and-as a community, and inquiry-based learning that aims at addressing socio-scientific issues. All these different elements are integrated in the COSMOS approach.

The COSMOS project has made considerable advancements in the theoretical and practical understanding of how the different concepts/components of open schooling interact and integrate among themselves. In this section, the framework presents integration tools that have been developed during the COSMOS project, either theoretically or as a consequence of our experiences in implementing COSMOS in different school contexts. The integration tools presented here are generic and can be adapted to different contexts. As such these tools offer general principles that can take on different meanings and applications in each specific educational school context. For more detailed and practical guidelines for implementation and professional development, the COSMOS project offers further resources such as the [COSMOS roadmaps](#), [policy briefs](#) and [TPD handbook](#).

The first integration tool connects the Socio-Scientific Inquiry-Based Learning (SSIBL) *pedagogy* with a *community* approach (CoP) (Section 6.1). This integrative work constitutes a necessary step for connecting a community-oriented SSIBL (SSIBL-CoP or Open-SSIBL) to the openness dimensions (Section 6.2). To recall, Socio-Scientific Inquiry-Based Learning (SSIBL) serves as a

pedagogy that fosters open schooling in science education with stakeholders involved collaboratively supporting students in *conducting personally relevant inquiries*. The last integration tool (Section 6.3), exemplifying scenarios, offers decision makers and practitioners a more practice-based tool for implementing SSIBL-CoPs based on COSMOS project implementation experiences.

6.1 Integrating SSIBL and CoP through the three stages of SSIBL (ACT, FIND OUT, ACT)

In Table 4 we elaborate on how the three stages of SSIBL transform when integrated with a community approach to learning (applying the theory of Communities of Practice). This integrative approach complements an open schooling approach to science education and creates opportunities for learning science as, with and for the community.

The three stages of SSIBL (ASK, FIND OUT, ACT) are transformed into a community-oriented approach in the following way:

- **ASK** – CoP members, from teachers, students and (preferably) extending also to external stakeholders, *raise specific investigative questions connected to real-life issues*, and that require the involvement of multiple stakeholders identified;
- **FIND OUT** - all stakeholders involved will collaboratively support all community members in *conducting relevant inquiries* to address the socio-scientific issues identified. The knowledge is acquired from multiple perspectives, taking into account various considerations and interests and that serves as the basis for *working for the community*;
- **ACT** - CoP members, such as students, stakeholders (e.g. families, scientists, companies, science centres), will substantiate their scientific knowledge and skills 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; implement climate adaptation or mitigation strategies in their communities, change school policies on environmental issues, build a school-community garden...) that empower them to contribute responsibly in their communities (ACT).

In the ASK stage, issues can be identified through media reports and students' interests as noted in Section 5.3.1, but community stakeholders can also be involved in this process. For example, community members can create a list of suggested topics that can be discussed with teachers and shortlist some topics that can be used/discussed with students as appropriate. Community members can also be used to introduce the issue (e.g., the local residents' or factory workers' perspectives could be presented by themselves during the ASK stage in the example presented in Section 5.4, Table 3).

The FIND OUT stage is integrated with a community-oriented approach through community members' participation as *experts, stakeholders* benefiting or impacted by the SSI investigated, and as *partners* in the learning process. Drawing on the community's interests, needs and expertise creates affordances for conducting scientific, social and personal inquiry. For instance, in the example presented in Section 5.3 on the issue of river pollution, in addition to conducting interviews with the factory workers, students could approach residents and local stakeholders in

the community to conduct interviews with them to learn more about how they are affected by the issue, what their views are on how the issue could be resolved and why (social inquiry).

At the ACT stage, community involvement and collaboration can strengthen all three dimensions of action competence (Figure 8, Section 5.3.3). Students together with other CoP members can identify several action possibilities that address the SSI in focus. The collaborative nature of identifying solutions in addressing common issues and needs can support students' sense of collective responsibility, empowering them and motivating them to take action, and finally the community can provide a setting for implementing solutions collectively and individually. For instance, students investigating the river pollution issue, could organize a citizen's assembly or town hall meeting to present their findings and solutions to the community and involved parties. Therefore, **the CoP can be leveraged as the context for supporting students' action taking**, as students practise taking both direct and indirect actions in their local contexts and community settings. The action component of SSIBL as implemented through a CoP can in the long run develop students general action competence which might be transferred to other contexts within and beyond science education. **The community dimension of this approach holds the specific potential to foster collective aspect of action competence.**

Table 4. *Socio-scientific inquiry-based learning in, with and for the community in COSMOS*

Stage	SSIBL	SSIBL-CoP
ASK	Identify authentic SSIs mainly through classroom activity engaging teachers and students. Locating questions through mapping and unpacking together the socio-scientific issue.	Identifying authentic SSIs is done together with various stakeholders (beyond teacher-student interactions), including CORPOS members (Open Schooling Team) and possibly other relevant internal and external stakeholders, who together locate questions relevant to their community. One of the main steps is to identify which stakeholders will be core or active members of the CoP and will be involved directly in the ASK process and which will be less active or central to the learning (i.e., peripheral or transactive), yet still involved in productive ways.
FIND OUT	Inquiry takes various forms, including consulting experts and other "external" and relevant stakeholders who can provide information and alternative perspectives concerning the SSI addressed.	Inquiring is a collaborative process in which various stakeholders share knowledge and participate in the co-construction of new knowledge, and collaborative exploration of various perspectives regarding the SSIs in question. Other stakeholders who are instrumental can assist from the outside in addressing the issues and questions.
ACT	Actions, which are grounded on what has been learned throughout the inquiry stage, are taken to address, and to resolve (to various degrees) the SSI. These actions are mostly conducted by the students.	Actions, which are grounded in what has been learned throughout the inquiry stage, are taken to address the SSI. These actions are taken by students and CoP members collectively, engaging both core - active and less active (i.e., peripheral or transactive) CoP members. The community acts as a powerful context for implementing actions and experiencing the outcome of those actions.

6.2 Connecting COSMOS concepts to Openness Dimensions

After articulating the integration of SSIBL and CoP (SSIBL-CoP) in Section 6.1, Table 5 specifies the conceptual connections between the eight openness dimensions and two key COSMOS concepts: CORPOS - Open Schooling team, and SSIBL-CoP. By so doing, the framework explicitly shows how SSIBL-CoP and the Open Schooling team relate to each openness dimension. This tool offers decision-makers and practitioners an understanding of the implications of applying COSMOS at two central levels: the school organisational level and learning community level. Ideally, the two levels are involved in COSMOS, yet they can also be seen as two stages in the implementation process.

Table 5. A summary of the conceptual connections between openness dimensions and key COSMOS concepts

Openness dimension	CORPOS - Open schooling team (school organisational level)	SSIBL-CoP (class or community level)
Shared Governance	The CORPOS, a diverse group of internal and external stakeholders, reach decisions jointly regarding SSIs and the creation of CoPs. CORPOS members promote a culture of openness and shared authority in the organisation	All CoP members (including members who are not school staff) are able to have an impact on the design of the learning process (units) including learning topics, and the questions driving the inquiry. This also includes CoP membership.
Curriculum	CORPOS members have an impact on school curriculum, specifically are able to change pre-designed units (in any discipline) in order to accommodate the emerging needs and interests of learners and staff members	CoP members are able to influence the design of the units once inquiry has been instigated. There is openness to changing the plan/units in accordance to emerging needs and developments throughout the learning process
Inner-school communities	The CORPOS constitutes an inner school community that is composed of diverse stakeholders (beyond science education and school leadership). The CORPOS is conducted as a community that continuously seeks to enhance and deepen school openness including cross-disciplinary representation.	The SSIBL-CoP establishes connection between community members and others in the school community as part of the design and implementation of all SSIBL stages (ASK, FIND OUT, ACT).
Learning communities	The CORPOS constitutes a professional learning community (PLC) dedicated to the understanding of open schooling in the specific context and its ongoing development in the organization.	The SSIBL-CoP is composed of diverse stakeholders who participate in significant ways in the learning process.
Student participation	There is student representation in the CORPOS – perhaps members of the student board. The students are given equal voice on how to promote open schooling and the creation of CoPs in school	Students are active participants in the various stages of SSIBL (ASK, FIND OUT, ACT) and the implementation processes.
Parental involvement	Parents are represented in the CORPOS and are able to provide valuable inputs and insights for SSI selection and the creation of CoPs	Parents are active participants in the various stages of SSIBL (ASK, FIND OUT, ACT) and the implementation processes.
Social Engagement	CORPOS members are actively involved in raising awareness to social issues within school and addressing problems that	The SSIs selected for investigation are meaningful to the community and actions that are taken as part of the

	concern the community (or society at large), by offering SSIs to investigate and themes that deserve attention in the community	SSIBL process are beneficial to the community
Community Collaborations	The CORPOS is composed of diverse stakeholders who are able to collaborate and reach decisions jointly on the development of school openness. Moreover, the CORPOS team is able to engage other community stakeholders (non-CORPOS members) to take an active part in the openness process including suggesting ideas for CoPs and SSIs, which they can later be a part of.	The CoP created engages the community and is able to include the active participation of various community members in the learning process (all stages of SSIBL)

6.3 Exemplifying Scenarios

In addition to the above conceptual integration tools, another way to gain a more integrated and comprehensive understanding of how the different elements of the COSMOS approach interrelate in practice can be established through the use of *exemplifying scenarios*. The framework presents here two such scenarios based on implementations of the COSMOS approach in schools during the COSMOS project (See [Deliverables D3.2](#) and [D4.2](#) for further details). These scenarios display a specific movement outward on the school openness dimensions. Rather than best practices, these scenarios serve to indicate *possible* applications, and thus simply provide inspiration or guiding ideas for how to adapt the COSMOS approach to different contexts; they are not intended to be ideal scenarios. The first scenario focuses on primary school setting (Table 6), and the second scenario (Table 7) focuses on a secondary school setting.

Table 6. An exemplifying scenario of SSIBL-CoP implementation for open schooling in a primary school setting with 7–8-year-old children

SSIBL stage	Community (CoP) & CORPOS (Open Schooling Team) involvement	Description
ASK	The issue (making healthy food choices) was identified by teachers in CORPOS (Open Schooling Team), reflecting on students' and school's needs, and the relevant curriculum. It was thus introduced by the teacher at the start of the teaching unit.	Lesson 1: The teacher introduced the SSI question to the pupils: <i>How can we make our school community healthier?</i>
FIND OUT	Parents as community members invited to	Lesson 2: Students investigated 'What do our bones do' learning about the human skeleton and then thinking about how to keep their bones healthy, linking the lesson to the key SSI question. Lesson 3: Pupils continued their investigations on the human skeleton by designing tests to investigate questions such as 'Can you jump further if your femur is longer?' Lesson 4, with parents: Children and parents worked

**FIND OUT &
ACT**

take part in learning activities with children (*community as learning partners*); CORPOS team co-designed and led the activities together (teachers & external partners)

Parents as community members took part in learning activities with children (Community as learning partners); the activities were led by a local charity, the Saints Foundation, who focus on supporting schools in socioeconomically disadvantaged areas, to promote healthy lifestyles (community members as experts). The CORPOS, led by teachers, facilitated the organisation of this session.

Parents as community members took part in learning activities with children (Community as learning partners); the activities were led by the school's catering services team (community members as experts). The CORPOS, led by teachers, facilitated the organisation of this session.

The CORPOS, led by external partners, facilitated the organisation of this session.

School children and staff as **stakeholders** to benefit from children's investigation

together to draw a full-size outline of a human body and add different organs to it (**science inquiry**), before working with external partners in exploring what it means to be healthy, and coming up with questions for a school-wide questionnaire in order identify how healthy the school community is (**social inquiry**)

Lesson 5: Muscles and Bones – building a model of a human hand (**science inquiry**)

Lesson 6: Learning about teeth and how to keep them healthy; make a pledge on how to keep teeth clean (ACT, *indirect action*)

Lesson 7, with parents: the Saints Foundation (a football club charity promoting active lifestyles) in collaboration with the Open Schooling team, run activities for parents and children to discover together how exercise and sports supports a healthy lifestyle. They designed healthy plates of food based on realistic choices, they discussed barriers to eating healthy and being more active, and how to overcome them, and learned how to work out at home with simple or no equipment (**science, personal, social inquiry**)

Lesson 8: children continued investigations into how to keep teeth healthy (**science inquiry**)

Lesson 9: Children conducted investigations using egg shells to find out how different drinks affect enamel (**science inquiry**)

Lesson 10: Children focused on learning about nutrition and how different nutrients support a healthy body (**science inquiry**)

Lesson 11, with parents: The City's Catering Services, who provide the school's meals worked with parents and children to design healthy food plates, made their own pizzas, and learned about different fruit getting the chance to taste new fruit to them (**science, personal, social inquiry**)

Lesson 12: Children visited an informal science learning centre, where they learned more about how the heart works and explored the Centre's science exhibits (whole day visit, **science & personal inquiry**)

School assembly: During a school assembly at the start of the day, a member of the company supplying food to the school, talked to all KS2 children (Years 3-6) about healthy eating habits, and the Year 3 children

	took part in this school assembly; the activities were led by the school's food supplier company (community as experts). The CORPOS, led by teachers, facilitated the organisation of this session.	were credited for their work on this area for the whole school (<i>commitment to taking action; feeling they are making a difference</i>).
ACT	The school community becomes the context for implementing solutions and taking (indirect) action at a collective level. The CORPOS, led by teachers, facilitated the organisation of this session.	Lesson 13: Children discussed the activities they took part in identified possible actions to respond to the key question (<i>knowledge of action possibilities</i>), and then designed posters including facts about healthy eating and exercise, to encourage their peers to action for a healthier lifestyle. The posters were placed in different school spaces to inform other pupils and staff at the school about how to be healthier (e.g. posters about exercise were placed in the outdoor play areas).

Table 7. Overview of SSIBL-CoP implementation for open schooling in a secondary school setting with 15-16 years old students

SSIBL stage	Community (CoP) & CORPOS (Open Schooling Team) involvement	Description
	The CORPOS (Open Schooling team of science teachers and external partners) co-designed all learning activities, including evaluation activities, to take place during a project day. The activities were led by the teacher, while the external partners assisted in, supported and observed the activities.	Theme: Sustainable school for the future
ASK	The issue ('sustainable school building') was identified by the teachers in CORPOS (they will get a new school building in a few years) and implemented for the grade 11 students.	<p>The teacher introduced the SSI theme to the students. Key question: <i>how can we make our (new) school building more sustainable?</i></p> <p>Intro and exploration of the issue:</p> <ul style="list-style-type: none"> - Teacher introduces the topic by showing a video clip 'Morgenland' about energy transition after which the students play the 'statement game' (Controversy line – taking a position for or against the statement in the classroom and explaining their position) to engage students with the topic of the project day by connecting the issue to their daily life. Statements are related to the (bad) climate in the school (draft, temperature & ventilation problems in classrooms). - Next, an extra dimension is introduced to the statements: whether they want to act or not & whether they think their actions would have an effect (Action Competence). It's a phase of initial opinion forming for the students <p>After a phase of social inquiry (see below) in which the students explored the issue in more depth (perspective</p>

		of the users of the building) the students formulate their own question .
FIND OUT	<p>Teachers, students and the school principal as <i>community members</i> and <i>users of the school building</i>, were invited to take part in the learning activities (<i>community as learning partners</i>)</p> <p>Students define their own question they want do inquiry about</p> <p>Various experts (architect, installer, local municipal councillor for sustainability, school headmaster) as community members took part in the learning activities (<i>community members as learning partners</i>). They were visiting the school during the project day to provide information from their point of view/ expertise and students could interview them in line with their research question. (<i>community members as experts</i>)</p>	<p>Social inquiry: interviewing users of the school building: ‘exploring the issue further’:</p> <ul style="list-style-type: none"> - In groups students prepare interview questions for different <i>stakeholders (users of the building)</i>: teachers, students, principal, school development team and conduct the interviews - Students make an overview of the information gathered so far. They summarizing their interview outcomes and formulate their own opinion about the subject. <p>Raise questions: (ASK)</p> <ul style="list-style-type: none"> - The students discuss which problem (they determined during the personal and/or social inquiry) they want to solve. They discussed which research questions would fit with this problem. <p>Scientific and social inquiry: coached by the teachers and learning materials student conduct research:</p> <ul style="list-style-type: none"> - They make a plan for their inquiry and carry out the inquiry (e.g. scientific data of temperature, CO2 concentration and temperature in classrooms is available in student material). - They interview 4 available experts: school headmaster, architect, installer, municipal councillor. - They analysed their data collections in their group.
ACT	<p>The students’ pitched their advice to the community members and experts (students, teachers, architect, installer, local municipal councillor for sustainability, school headmaster) and got feedback on their advice. As such the school community level becomes the context for implementing the solutions. (Some solutions were taken into practice a week after the project day)</p>	<p>Decision making: Making the case for a sustainable school</p> <p>Students used the outcomes of their personal, social and scientific inquiry to formulate a final advice (e.g. pitch with slides, poster) about how to make their school now and the future school building more sustainable.</p> <p>Groups of students pitched their solutions (advice) to one of the four experts: school headmaster, architect, installer, municipal councillor and answered questions of the experts about their advice.</p>

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